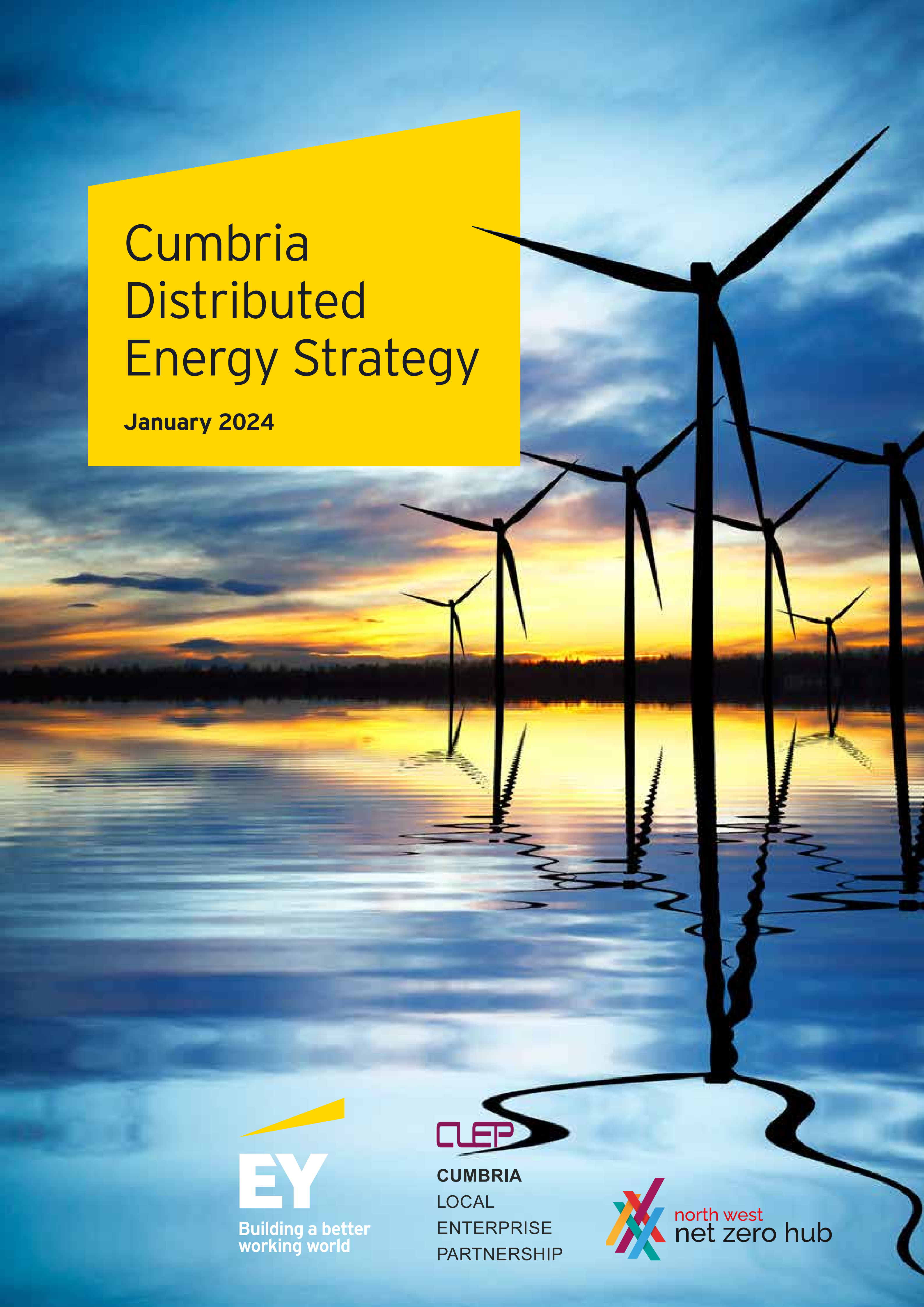

Cumbria Distributed Energy Strategy

January 2024

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EY was appointed in August 2023 by the Cumbria Local Enterprise Partnership (CLEP), with funding from the North-West Net Zero Hub (NWNZH), to undertake a study on the potential of de-centralised energy systems across Cumbria, and the role they could play in accelerating the clean energy transition and driving sustainable, economic growth.

This study was commissioned by the LEP to build on the adopted Cumbria Clean Energy Strategy, published in July 2022, with the aim of expanding the strategy to consider the role of more decentralised renewable technologies.

This study addresses an action in the Cumbria Clean Energy Strategy to further explore wider renewables. Action plans are already in place for the large-scale renewables of offshore wind, nuclear, hydrogen and Carbon Capture, Utilisation and Storage (CCUS).

The purpose of the report is to facilitate discussion with key stakeholders, including local authorities, businesses, investors and other interested parties, with the aim of accelerating investment and delivery of these renewable technologies within Cumbria.

The requirements of the study were to explore onshore wind, tidal and wave, solar photovoltaics, geothermal, heat networks, hydropower and bioenergy, and to undertake the below research against each technology:

1. Establish the current status of the technology in the UK in terms of government policy and deployment to date. Identify areas of best practice.
2. Summarise current level of deployment in Cumbria (if any) and then estimate unconstrained renewable generation potential within Cumbria.
3. Identify relevant constraints on the technology (e.g., Planning, Grid, Public Acceptance) and potential actions to address.
4. Highlight at least 3 areas of strongest potential across the technologies and for each.
5. Identify sites owned by owned by public sector bodies, private companies, major landowners and national parks.
6. Recommend a development approach that could deliver a viable scheme.
7. Produce a strategic outline investment case for these sites.

During the course of the study, and during workshops to agree point 4 – the priority areas for further investigation, a scope change was agreed. This was due to initial technology screening demonstrating high potential across all of the identified range of clean energy generation types. Instead of just focusing on building out three technologies in detail, it was agreed to develop a high-level way forward across all technologies, with a more granular focus on the highest potential technologies, where the LEP could add the most value, notably bioenergy and hydropower. As these technologies are highly distributed, often under 1MW, and have a broad range of potential sites, it was agreed that scope items 5, 6 and 7, focused on specific sites and schemes, would instead focus on building out the overall potential for Cumbria and the criteria for success, wrapped up in an action plan – essentially making this study more strategic in nature. It was agreed this was the approach that would best fit the overall aim to stimulate development interest into clean energy generation across Cumbria, as well as the wider north-west region and the change was approved and actioned during contract governance in November.

The information is correct as at the time of research and it is not the responsibility of EY to keep the document updated. It should not be regarded as comprehensive nor sufficient for making decisions, nor should it be used in place of professional advice. EY accepts no responsibility for loss arising from any action taken or not taken by anyone using this publication.

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Foreword

The energy transition and wider evolution to a greener economy presents significant growth opportunities for the UK. The emergence of more decentralised energy systems represents a significant prospect to also drive economic growth in local communities and more rural parts of the UK. Decentralised energy systems involve a locally focused approach, incentivising local participation and ownership over the energy production process, with smaller scale but more numerous generation sites. This leads to new local energy markets, which provide opportunities for local businesses, creating new jobs alongside developing localised supply chains. Decentralised generation schemes, especially schemes under 1MW, help to avoid the constraints on the grid currently delaying the UK's transition to a renewable powered national grid. Decentralised renewable energy is a great example of an opportunity for improving environmental and social outcomes and enabling more sustainable communities.

Executive summary

The UK transition to renewable energy is one of the most significant infrastructure transformations in recent history, representing a shift towards decentralised energy systems and enabling integration of renewable and low-carbon resources which are more sustainable and environmentally friendly. The transition is critical in achieving UK decarbonisation and a Net Zero 2050 goal, by reducing carbon emissions and building a more sustainable, prosperous, and cleaner economy. The transition will create billions of pounds in economic activity and will fundamentally change the structure of the energy and related sector, creating significant growth opportunities.

With its unique topography and natural resources, and with its existing reputation as an energy leader, Cumbria has an opportunity to position itself as a green energy pioneer, benefiting the economy, local communities, businesses, and the environment as a whole.

Accelerating the clean energy transition through decentralised renewable energy can have a significant positive economic impact on Cumbria, creating local, good quality, sustainable jobs for generations to come. By shifting towards renewable energy sources, clean energy jobs can be created, providing new opportunities for the workforce, supporting the development of local businesses, supply chains and creating entrepreneurial ventures. This will result in sustainable growth and more job prospects across many areas of the Cumbrian economy, as well as the wider North-West. The decrease in the use of fossil fuels could lead to a reduction in energy costs, strengthening the local economy, giving more purchasing power to households and local businesses and helping to reduce fuel poverty and the cost-of-living burden for thousands of families. Encouraging community involvement in these projects will enhance awareness of the clean energy advantages, leading to increased local support creating a sense of ownership and responsibility in the energy infrastructure. By taking a proactive, forward-thinking approach to clean energy projects, Cumbria has an opportunity to position itself as a leader in its field, boosting the economy, employment and prosperity for the entire region.

All renewable technologies play an important role in the decentralised energy model. Applying a decentralised model would enable the market to leverage a combination of several renewable energy technologies leading to greater efficiency as well as an opportunity to harness the unique advantages of each technology, harmonising constraints across the technologies.

Cumbria's natural assets make the region an attractive area for a wide range of renewable generation technologies. Paired with its vibrant industrial and agricultural communities, Cumbria's national parks and wet climate, provide the greatest opportunity to maximise Cumbria's natural resources in their energy generation mix to scale operations in both bioenergy and hydropower in the area. As established technologies, both can be easily assessed for locational suitability and viability of deployment and applied flexibly to suit the deployment need whilst maintaining both a predictable output and cost. Distributed generation is naturally more resilient than centralised energy production, and using a range of different distributed renewable technology can further improve resilience and energy security.

In summary, Cumbria has an exciting opportunity to drive clean, economic growth through accelerated investment and deployment of decentralised renewable generation.

Introduction

Cumbria has made noticeable strides in the deployment of renewable energy solutions over the years. With its abundant natural resources, the region has already commenced on the journey to become a leading hub for clean energy in the UK.

However, there is potential for further development and expansion of its existing renewable energy sources and an opportunity to explore new innovative and sustainable technologies. The UK government is supporting the growth of these energy technology fields through additional investment, with both 2022 and 2023 seeing investment into flagship renewable schemes, including Contracts for Difference, making renewable energy deployments in the UK increasingly attractive of investors and developers. There is significant potential in further utilising the natural resources Cumbria has to offer in a sustainable way. This is catalysed by the potential of emerging technology, combined with the funding and supplementary guidance provided within the UK Government's Net Zero Strategy. This leads to the conclusion that Cumbria could lead the way towards a cleaner and greener future for the UK through the deployment of a distributed renewable energy generation model.

Distributed renewable generation

This study focuses on the potential of distributed renewable generation technology applicable to Cumbria. A distributed renewable technology model refers to a way of generating electricity (or sometimes heat) by using multiple small-scale, locally sited renewable energy systems instead of a single large-scale centralised system. It is a decentralised approach that aims to meet the energy demand of local communities with renewable energy production near to the point of use. Renewable energy generation has been a significant element of the UK's energy mix for a number of years, however the intermittent and largely unpredictable nature of energy generated by sunlight and wind has limited the renewable share in the generation mix. Distributed renewable energy models enable regions to optimise the benefits of each technology whilst minimising the negative impacts, offering a more balanced approach to energy generation.

The UK's distributed model

The UK is increasingly turning towards distributed renewable energy models as a key solution to the challenge of reducing carbon emissions, enhancing energy security and combatting climate change. The distributed renewable energy model is gaining traction in the UK due to its potential to promote greater societal, economic, and environmental benefits. Decentralised generation is more resilient than centralised energy production, and using a range of different distributed renewable technologies can further improve resilience and energy security. Finally, a distributed model reduces strain, capacity and fault levels on the national grid, removing this as a key obstacle in accelerating deployment. The UK is rich in natural renewable energy resources and is well placed for renewable energy development.

Onshore Wind

247 installations accounting for

1.3% of UK energy generations by source

Solar PV

10,936 installations accounting for

0.8% of UK energy generations by source

Bioenergy

32 schemes accounting for

1.5% of UK energy generations by source

Hydro

62 schemes accounting for

0.4% of UK energy generations by source

UK Government Renewable Electricity by Local Authority (2014 – 2022) (National Statistics publication Energy Trends produced by the Department for Energy Security and Net Zero (DESNZ)).

Renewables generation capacity and actual electricity generation 2022

Source	Installed capacity MW end of 2022					Electricity generation in 2022 (GWh)				
	Cumbria	% of Cumbria's total renewable	UK	Cumbria's Share of UK's Total Capacity for Tech	% of UK total renewable capacity	Cumbria	% of Cumbria's total renewable	UK	Cumbria's Share of UK's Total Generation for Tech	% of UK total renewable generated
Onshore wind	214.2	28.90%	14,834.6	1.44%	27.73%	447.0	45.88%	35,237.4	1.27%	26.13%
Tidal and wave			22.4		0.04%			11.2		0.01%
Hydropower	7.2	0.97%	1,890.4	0.38%	3.53%	22.5	2.31%	5,640.2	0.40%	4.18%
Solar PV	120.6	16.27%	14,651.1	0.82%	27.38%	107.1	10.99%	13,282.9	0.81%	9.85%
Bioenergy	61.8	8.34%	5,344.6	1.16%	9.99%	397.6	40.81%	26,807.2	1.48%	19.88%
Total of the covered techs	**403.8**	54.49%	**36,743.1**	**3.8%**	**68.67%**	**974.2**	100.00%	**80,978.9**	**3.96%**	**60.04%**
Other tech total	**337.2**	45.50%	**16759.8**	**2.01%**	**31.33%**	**0**	0.00%	**53,886.1**		**39.96%**
Total of renewables	**741.1**	**100.00%**	**53,502.9**	**5.81%**	**100.00%**	**974.2**	100.00%	**134,865**	**3.96%**	**100.00%**

* Bioenergy includes animal biomass, plant biomass and anaerobic digestion

All data from Renewable_electricity_by_local_authority_2014_2022.xlsx (live.com)

The Role of the UK Government Policy

Between 1990 and 2021, the UK cut greenhouse gas emissions by 48%; faster than any other G7 country and was the first country to sign legislation to reach Net Zero Greenhouse Gas emission by 2050 into UK law. In 2021 the UK Government published the Net Zero Strategy: Build Back Greener, a policy document setting out the Government's vision for a market-led, technology-driven transition to decarbonise the UK economy highlighting the important role that renewable technology will play in both powering Britain and advancing the UK's position in the renewable energy exports market. The UK Government's Net Zero Growth Plan — Powering Up Britain 2023 and the accompanying Powering Up Britain — Energy Security Plan 2023 both respond to the Skidmore review 2022 and set out the strategic growth plan for the UK energy transition and policy, providing funding measures to cement long term investment into new 'green' technologies that will pave the way in developing the vision set out in their Net Zero strategy. By way of addressing the highlighted funding challenges developers face with introducing new technologies to the UK market, the Green Finance Strategy was published in 2023. It identifies the area levers available to mobilise private investment to support the delivery of Net Zero through a series of dedicated roadmaps on the private sector investment required for Net Zero technologies which will continue to be published throughout 2024.

The Decentralised Energy Study

This report will build upon the Clean Energy Strategy completed in 2022 by Cumbria Local Enterprise Partnership providing insight into the remaining eight technologies that are considered within the region for the decentralised energy model: onshore wind, tidal and wave, solar photovoltaics, deep geothermal, 4th and 5th generation heat networks, hydropower and bioenergy. It will identify their current role in both the UK context and the Cumbria region, the opportunity that they bring in developing a more decentralised solution to renewable energy generation in the region and addresses some of the challenges that Cumbria will need to overcome in order to ensure the successful implementation and deployment of the technologies. The final section of the report will summarise the wider opportunity for deploying a decentralised energy model in Cumbria, highlight the challenges that the region will face in deployment and provides an action plan for both the Cumbria Local Enterprise Partnership and landowners to support implementation.

The decentralised technologies

This section of the report will review the eight technologies: onshore wind, tidal and wave, solar photovoltaics, deep geothermal, 4th and 5th generation heat networks, hydropower and bioenergy and the opportunities for each to play a role in the distributed renewable energy mix within Cumbria.

The contents of the next section will review each technology, covering:

- **An overview of the technology:** what it is, how it works and any other contextual information on how the technology could be used.
- **The UK context:** The role of the technology in the UK currently and plan for further deployment.
- **The role in Cumbria:** How the technology is currently deployed in Cumbria.
- **The opportunity:** The opportunity for the technology to be leveraged and deployed further within Cumbria.
- **The challenges:** The challenges that the region and developers would need to overcome to make deployment successful.
- **A summary for businesses:** To highlight our overall assessment of the technology.

Onshore wind

Onshore wind – Technology overview

Onshore wind involves the generation of electricity from wind turbines that are located on land.

The wind turbines convert the kinetic energy of the wind into electrical energy through the use of a generator. The technology is one of the oldest to have been used for electricity generation, with onshore wind capturing and converting wind power in some form since the 1880s. As a result of its technological maturity, it is also one of the cheapest forms of renewable energy sources at £0.04/kWh. It is becoming the leading contributor to the renewable energy mix and compares favorably to others in terms of sustainability, due to low CO_2 emissions, and cost effectiveness. The technology's life span is amongst the shortest at 20-25 years, but they generally require little maintenance. Onshore wind energy has become one of the most widely used forms of renewable energy around the world due to its low cost, high efficiency, and scalability. It is a clean and sustainable form of energy that produces no direct emissions from the energy it generates and releases no pollution into the atmosphere. Additionally, onshore wind turbines can be installed in various sizes, making it possible to generate electricity for individual homes or businesses or for large-scale energy production for entire regions. However, two of the main disadvantages historically have been in obtaining public acceptance for wind farms to be produced and the intermittency of the electricity that onshore wind can produce.

UK context

As one of the cheapest forms of renewable power, onshore wind is more flexible and scalable than other renewable technologies. It has already seen substantial growth in the UK with its total wind capacity increasing by 72% from 8.6GW in 2014 to 14.8GW in 2022. In 2022, onshore wind contributed to 11% of the UK's electricity needs, generating a total of 35,237GWh. The UK is one of the windiest countries in Europe and has a large resource of wind at its disposal. The Climate Change Committee recommends that the UK should almost double its onshore wind capacity from 14.8GW to 29GW by the end of the decade. There are also opportunities for some onshore wind farms to be repowered, which involves existing windfarms having their existing turbines (partially or fully) replaced with more modern, powerful and efficient models. It is expected that more than 20GW of onshore wind farms in the UK will be repowered over the next 10 years. McKinsey & Company completed a report quantifying the benefits of Onshore Wind in the UK in 2019 which stated that Deploying 35GW of onshore wind by 2035 could reduce UK electricity costs by 7%, support 31,000 jobs, lift productivity throughout the UK and enable a £360m export industry.

In September 2023, in its fifth round of the Contracts for Difference (CfD) scheme, the UK supported 24 Onshore Wind Schemes which will add 1,481MW of capacity. In September 2023, the UK Government relaxed the planning permission process to allow locations suitable for new wind farms to be identified in a number of ways rather than only in the area's development plan and also updated the policies for replacing existing wind turbines to no longer be subject to the same planning requirements as new turbines, supporting the process of repowering. In addition, the UK Government amended the law to state that subject to size, some planning applications can now be approved by the Local Planning Authority as opposed to requiring a Development Consent Order (DCO) which requires authorisation from the UK Secretary of State. This could ease the process for permitting applications by smoothing the current bottle necks associated with DCOs.

Current role in Cumbria

Onshore wind has a significant role in Cumbria's distributed clean energy mix. The region houses many wind farms, which supply thousands of homes and businesses with renewable electricity. Wind power has been operational in Cumbria for over two decades, with several established wind farms across the region. These farms contribute significantly to the region's energy output.

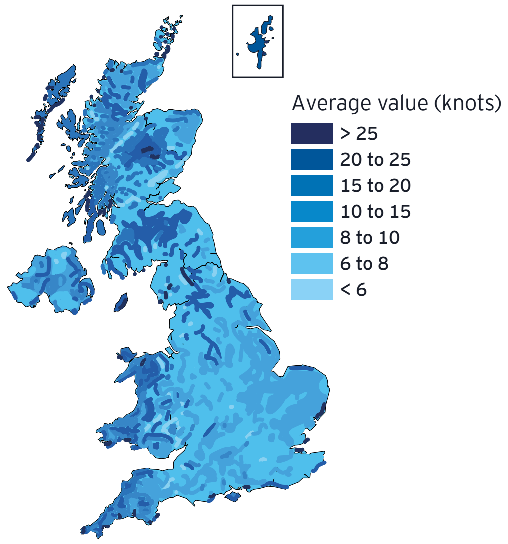
Cumbria has 247 onshore wind sites around the county, generating 447GWh of clean energy, and as of 2022, Cumbria's onshore wind energy accounted for 1.3% of the renewable energy produced through onshore wind in the UK.

CASE STUDY

Baywind Energy Co-operative Ltd is the UK's first community-owned wind energy project formed in 1996 and to date has enabled 1,300 people to invest in two projects in Cumbria. In total, it has successfully raised £2 million through its share offers and has made share interest payments to its 1,300 members, averaging 7% gross per annum since it launched.

The opportunity for Cumbria

Mean UK wind speed map



The location and topography of Cumbria contribute to strong and consistent winds, making it an ideal location for onshore wind energy generation. Due to the prevailing wind direction, the wind resource in Cumbria is greatest on west facing upland sites and along the coast, see Mean UK Wind Speed Map. This generates two main opportunities for developing onshore wind in Cumbria: expansion in line with capacity predictions and repowering existing lines. Electricity North-West model in their Distribution Future Electricity Scenarios paper 2022 that by 2050, the installed capacity for generating wind through both onshore and offshore technologies in Cumbria will have risen to 623MW which suggests an increase of 15% on current capacity in the next 27 years. The low population density of Cumbria makes it ideal for the development of onshore wind farms as the disruption to residents is reduced which will increase the likeliness of community buy-in and engagement in the scheme.

RenewableUK analysis suggests that of 18 operational wind farms in England more than 20 years old, 9 of these are in Cumbria; these could be repowered. This process of 'repowering' requires planning permission but gives the opportunity for existing sites to undergo an upgrade and would enable increased generation of the existing electricity production.

Changes to the National Planning Policy Framework (NPPF) have been made so that onshore wind projects in England that are supported by local people will be approved more quickly. In Cumbria there is an ambition and appetite for community ownership of energy projects, enhancing the potential for onshore wind energy generation. The Developing Local Partnerships for Onshore Wind in England (DESNZ) report references that the BEIS Attitudes Tracker 2023 states that 79% of people support the use of onshore wind and that 43% would be happy for an onshore wind farm to be built in their local area, with 12% unhappy and 32% either unsure or neutral.

The potential challenges for Cumbria

The topography of Cumbria is characterised by hilly and mountainous terrain which can be a challenge for onshore wind generation. High altitudes in some areas cause concerns around the issue of 'ice throw' where ice builds up and is thrown from blades, and sufficiently quick wind speeds can result in the wind turbines wearing out at a faster rate, increasing maintenance costs. Additionally, in some of its rural areas, Cumbria has limited road access and connectivity is poor. This makes the construction and operation of onshore wind turbines difficult and costly due to the need to move heavy equipment and materials to the onshore wind farm sites. There are two national parks within Cumbria: The Lake District in its entirety and a portion of the Yorkshire Dales as well as areas of National Landscape (previously Area of Outstanding Natural Beauty) providing a further challenge for obtaining planning permissions as well as moving materials during construction phases.

Another key challenge is the limited grid capacity of the electricity transmission network in Cumbria. This means that onshore wind generation infrastructure already present is limited by how much it can be expanded, and new projects may not be feasible or may experience a delay in connectivity to the grid. The UK National Grid does not currently have sufficient infrastructure and energy storage systems may be needed in areas extending beyond the current range of their infrastructure; therefore, significant investment would be required to allow for higher demand of this renewable energy in the county. This likely means that smaller onshore wind schemes, typically with an installed capacity of less than 1MW should be prioritised for deployment, as they avoid much of the grid constraint issues.

Permissibility for repowering existing sites presents a challenge to deliver the necessary upgrades to the wind turbines, particularly within the national parks and National Landscape areas (previously Areas of Outstanding Natural Beauty) where conservation efforts now provide restrictions and renewable projects will only be accepted where 'the objectives of designation of the area will not be compromised by the development, and any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by the environmental, social and economic benefits' (North Pennines AONB management plan 2019-2024). Some small-scale projects are able to obtain planning permission more easily, however the planning permissions required for onshore wind deviates across the local authorities.

In summary

The use of wind as a source of renewable energy in Cumbria is set to increase by 15% of its current installed capacity by 2050. The headroom of the Harker substation in north Cumbria will be increased in 2026 with a further 5 sites in Cumbria being reinforced increasing capacity in Cumbria by 246.7MW by 2028. Developers have an opportunity to be part of this growth plan for generating onshore wind in Cumbria. By way of both addressing public acceptance concerns whilst also managing capacity limitations, smaller, community focused schemes, under 1MW of installed capacity offer a route forward and can be progressed now, with larger schemes needing to correlate with improvement works on the grid.

Tidal and wave

Tidal and wave – Technology overview

Tidal and wave power are types of renewable energy that are generated from the ocean's movements.

Tidal power is derived from the rise and fall of ocean tides, which create a force known as tidal energy. This energy can be captured and used to generate electricity, using turbines that are submerged underwater. The turbines use the motion of the tide to turn generators, which convert this energy into electrical power. Tidal energy is a sustainable and renewable energy source, but it is location-specific, requiring areas with large tidal ranges to generate significant amounts of electricity. There are three different means of producing tidal energy: tidal streams, tidal barrages, and tidal lagoons. Tidal streams are fast flowing bodies of water created by tides and turbines are used to generate energy from these. Tidal barrages use a large dam often constructed across tidal rivers, bays, and estuaries. Turbines inside the barrage are able to harness the power of the water flow. Energy generation from tidal lagoons is similar to that of a barrage however they can be constructed across the natural coastline. Tide energy is highly predictable and often complementary to other forms of renewables like wind and solar.

Wave power, on the other hand, uses the motion of ocean waves to generate electricity. Wave energy is captured using a device that is typically located on the surface of the ocean, which converts the wave energy into electrical energy. Wave energy is a renewable source of energy that is predictable, making it a reliable energy source. Like tidal energy, wave power has some location restrictions, as it requires areas with consistent and strong wave patterns. Facilities that generate tidal power have a much longer lifespan comparative to other renewable technologies at 75-100 years.

Due to the challenging conditions the technology must sustain, it is currently one of the most expensive renewable technologies.

The UK context

The UK features the second-strongest tides in the world after Canada. Even though generation is low compared to other technologies, the UK is a leader in tidal and wave deployment and is the third top tidal producing country after South Korea and France.

Tidal and wave power are constant and predictable, making it a more reliable source of power for the UK National Grid. It can provide electricity when sources such as wind power are unavailable, therefore bridging the gap in supply and allowing the UK to operate entirely on renewables. According to UK Government's Department for Energy Security and Net Zero (DESNZ) report (Wave and tidal energy: part of the UK's energy mix) tidal energy has the potential to bring an additional 30-50GW of energy to the UK.

Despite the fact the report states that tidal and wave power have the potential to deliver 20% of the UK's electricity needs, generation from tidal and wave energy only made up 0.004% of the 2022 total. As at the end of 2022, there are 19 tidal and wave energy installations in the UK creating only 22.4MW of capacity, with further schemes currently in various stages of planning, most of them being under 100MW in expected capacity. The UK Government-backed UK Marine Energy Council published a paper in 2020 titled Technological Innovations and Climate Change: Tidal Power in which experts predicted a £25bn export market by 2050 worldwide, and 26,600 marine energy jobs by 2040. In September 2023, in its fifth round of the Contracts for Difference (CfD) scheme, the UK supported 11 tidal energy projects with a record capacity of over 53MW with developments expected to come online from 2027 onwards.

Current role in Cumbria

The country's strongest tides are generated in the Bristol Channel, and along the coast of North Wales and Northwest England – the latter being where Cumbria is situated. The geographic location of Cumbria means it has significant tidal energy potential due to its proximity to the Irish Sea and the strong tidal flows associated with it. Despite the promising conditions and the huge potential for the industry in West Cumbria, there are currently no tidal and wave schemes in operation nor under active consideration.

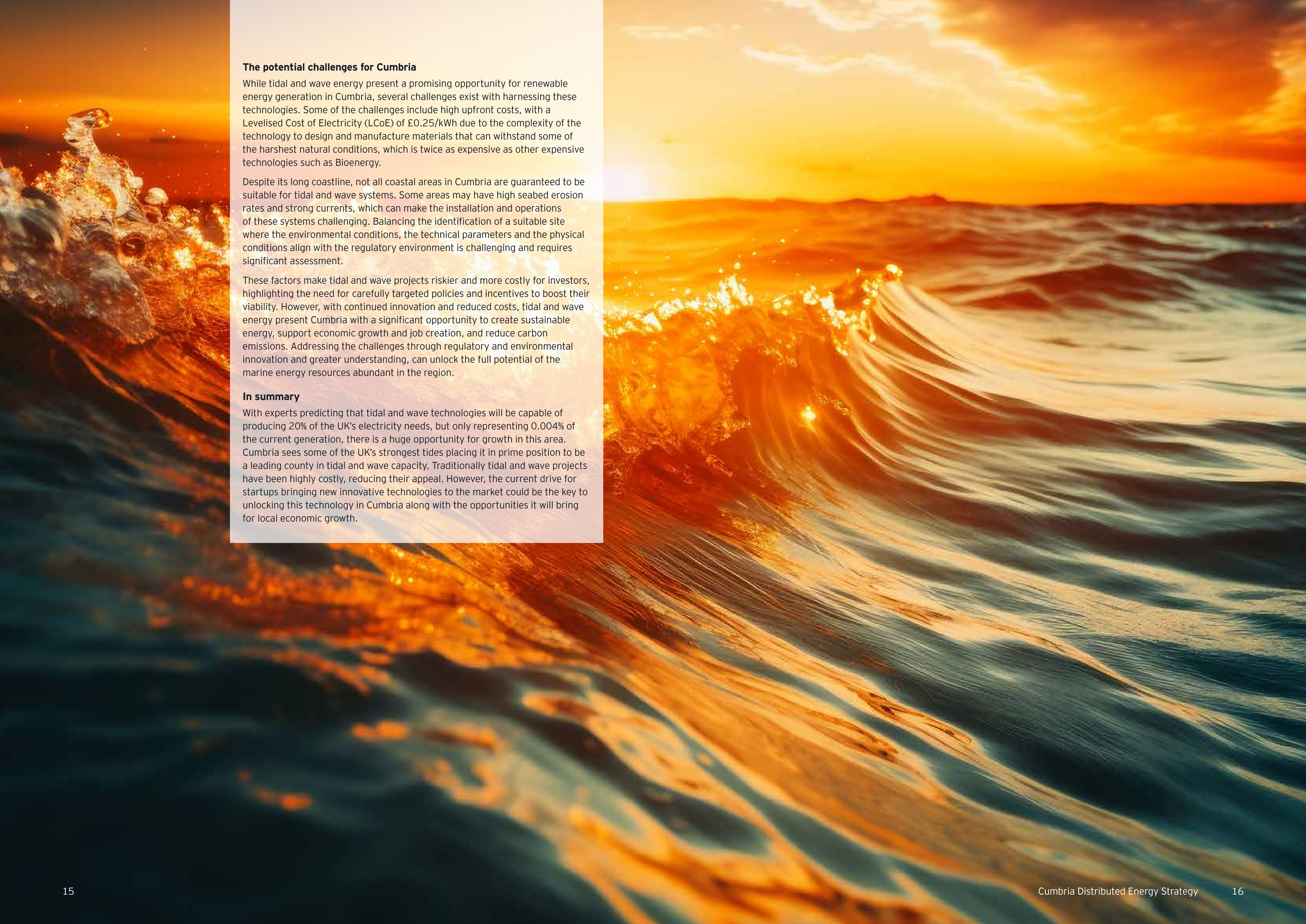
The opportunity for Cumbria

The potential for tidal and wave energy in Cumbria has not yet been exploited and there are currently no implemented projects in Cumbria, despite being sighted as having one of the UK's strongest tides. There is ongoing development work in the region to explore this area in further detail (see case studies). If multiple tidal and wave projects were deployed in Cumbria, the region could generate a significant portion of its electricity demand from these sources. Tidal and wave energy offer significant advantages over other sources of renewables such as solar, wind, and bioenergy, by providing a reliable and predictable source of energy. Although there are challenges to address with the deployment of such projects, if well managed, they could undoubtedly bring significant benefits to the region. Whilst currently in its infancy in the UK, there are already a number of technologies on the market paving the way for new, innovative developments to be established by motivated start-ups. Mocean Energy have developed a compact wave energy converter called the Blue Horizon, which aims to generate up to 50KW of clean energy from offshore wave power. The system is embedded with an energy storage system that produces consistent and reliable power delivery, helping create a highly flexible and stable wave power energy network.

AWS Ocean Energy, another wave energy start-up, has developed a technology that uses the motion of the waves to drive a pump and pressurises water through a turbine, generating electricity. Implementing tidal wave technology could further boost the economy of coastline towns and attract tourists with a study looking at the Severn estuary in Wales estimating that a large tidal barrage in that location could attract around 200,000 visitors per year. The development in new technology demonstrates that the industry is growing at pace which will likely bring down costs in the future.

CASE STUDY

The Wyre Tidal Gateway, located in Lancashire, is a tidal hydro energy plant with an installed capacity of 160MWH, providing power to 80,000 homes in the area from a relatively small estuary. In addition to this, several potential developments in tidal energy along the west coast of England demonstrate the further potential that tidal and wave projects could bring to Cumbria.



The potential challenges for Cumbria

While tidal and wave energy present a promising opportunity for renewable energy generation in Cumbria, several challenges exist with harnessing these technologies. Some of the challenges include high upfront costs, with a Levelised Cost of Electricity (LCoE) of £0.25/kWh due to the complexity of the technology to design and manufacture materials that can withstand some of the harshest natural conditions, which is twice as expensive as other expensive technologies such as Bioenergy.

Despite its long coastline, not all coastal areas in Cumbria are guaranteed to be suitable for tidal and wave systems. Some areas may have high seabed erosion rates and strong currents, which can make the installation and operations of these systems challenging. Balancing the identification of a suitable site where the environmental conditions, the technical parameters and the physical conditions align with the regulatory environment is challenging and requires significant assessment.

These factors make tidal and wave projects riskier and more costly for investors, highlighting the need for carefully targeted policies and incentives to boost their viability. However, with continued innovation and reduced costs, tidal and wave energy present Cumbria with a significant opportunity to create sustainable energy, support economic growth and job creation, and reduce carbon emissions. Addressing the challenges through regulatory and environmental innovation and greater understanding, can unlock the full potential of the marine energy resources abundant in the region.

In summary

With experts predicting that tidal and wave technologies will be capable of producing 20% of the UK's electricity needs, but only representing 0.004% of the current generation, there is a huge opportunity for growth in this area. Cumbria sees some of the UK's strongest tides placing it in prime position to be a leading county in tidal and wave capacity. Traditionally tidal and wave projects have been highly costly, reducing their appeal. However, the current drive for startups bringing new innovative technologies to the market could be the key to unlocking this technology in Cumbria along with the opportunities it will bring for local economic growth.

Solar PV

Solar Photovoltaics (PV) – Technology overview

Solar photovoltaics is a technology that converts sunlight directly into electricity through use of solar panels. The process involves photovoltaic cells absorbing the energy from sunlight, creating a flow of electrons that produce electric current.

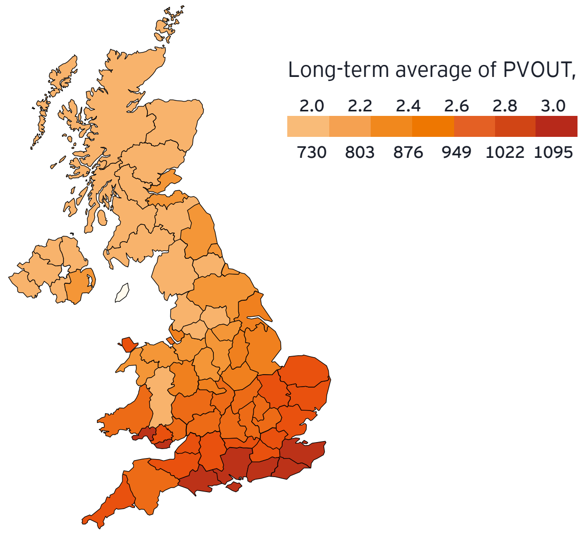
Photovoltaic cells are usually made from silicon which are connected together to form a solar panel. When sunlight hits the solar panel, it dislodges electrons within the semiconductor material, which causes a flow of electric current. The electricity produced can be used on site or fed back into the grid. Contrary to popular belief, this process continues to happen on overcast days, albeit to a lesser degree. Panels operate on three scales: rooftop domestic, rooftop commercial/industrial, and large-scale ground-mounted/standalone Solar PV. All solar panels are "inverter based", leading to low fault levels compared to synchronous generation, making them easier to connect to the grid.

Rooftop panels tend to be for self-supply of electricity "behind the meter", with surplus electricity generated either being stored in a battery for later use or sold back to the electricity grid. These panels usually have a capacity of a few kW.

In contrast, solar farms largely generate electricity to feed into the domestic grid, but electricity can also be stored in batteries if available. Due to their size and scale, they have a larger capacity than rooftop panels, usually between 2MW and 20MW, however it is not uncommon to see installations over 50MW. For every 1MW of solar capacity, approximately 5 acres of land is needed, and every 5 MW installed will power approximately 1,500 homes for a year. A small/community solar farm is categorised as under 5MW, and farms over 50MW are considered large "Nationally Significant Infrastructure Projects" (NSIPs). For this report, a small solar farm will be up to 10MW.

Both groups have a lifespan of approximately 25 years.

A map of the Photovoltaic Power Potential in the UK



Solar photovoltaic systems have the advantage of producing clean energy from a renewable source. Solar panels can be installed on rooftops or open spaces, "making them ideal for both residential and commercial applications. The long lifespan and low maintenance balance of Solar PV coupled with a LCOE £0.04kWh make them a practical and a cost-effective renewable energy solution. As of the end of 2022, there was 14.7GW of solar capacity in the UK across 1,249,511 installations. This accounts for 4.2% of total electricity generation in the UK in 2022.

The UK Government intends to achieve a fivefold increase in solar energy by 2035 to a capacity of 70GW. This will be targeted through the Energy Security Strategy which aims to "ramp up" the deployment of both rooftop and ground-mounted systems. In 2018, the Feed in Tariff (FIT) scheme closed, and was replaced by the Smart Export Guarantee, paying for the power that small-scale solar generators export to the grid. The UK Government Energy Security Strategy is backed by a number of funding opportunities generating significant interest to invest in further research, development in and deployment of this technology. In September 2023, in its fifth round of the Contracts for Difference (CfD) scheme, the UK supported 56 new schemes, adding 1,928 MW of installed capacity by 2028. Electricity North-West predict in their Distribution Future Electricity Scenarios paper, published in 2022, that by 2050, the installed capacity for generating electricity through Solar PV in Cumbria will have risen to 324 MW which suggests an increase of 169% on current capacity.

As a result of government policy and widespread adoption, Solar generation has high economic viability, recovering initial investment cost well within its expected useful life and low complexity of installation resulting in a large supplier base for installation.

Current role in Cumbria

By the end of 2022, Cumbria's installed PV capacity was 121MW, and its electricity generation was 107GWh, both contributing 0.8% to the UK's total solar capacity and generation. There were 120 Solar PV farms in Cumbria as of the end of 2022, with capacities ranging from 0.5MW to 19MW, with a median capacity of 8MW. 'Aspatria' is Cumbria's largest solar farm in the North-West of the county with an operating capacity of 19MW over 87 acres.

The opportunity for Cumbria

While Cumbria is known for its rainy and cloudy weather, it still has considerable potential for Solar PV installations, both in terms of its land area and energy productivity.

According to data from the UK government, the average amount of solar irradiation in Cumbria is roughly comparable to other areas in the UK, generating upwards of 800 to 1200 kWh per metre squared annually. With innovative solar panel technology continually improving, Solar PV installations in Cumbria could generate clean and renewable energy at scalable levels.

Although Cumbria's weather patterns present some challenges, development in solar technology such as high efficiency, and lower light PV modules requiring less solar irradiation, means that improvements are possible to leap ahead. Policies that support research, development and investments will contribute to the potential of solar power in Cumbria's energy transition.

There are two main opportunities for Solar PV in Cumbria: Rooftop Solar and Solar Farms (Ground mounted solar).

One of the most significant advantages of rooftop Solar PV is its ability to reduce electricity costs for consumers and limited additional infrastructure requirements. A standard domestic solar panel installation has the potential to lower a household's electricity bill by up to £400 per year, making it a cost-effective way to generate electricity. In addition, Microgeneration Certification Scheme (MCS) accredited solar enables customers to sell surplus electricity back to the grid, contributing to their overall return on investment.

Solar farms offer an opportunity to benefit from dual-purpose land, which can accommodate sheep grazing or agrovoltaics crops to be grown under panels, offering a flexible and reversible solution, even for Cumbria's hilly terrain.

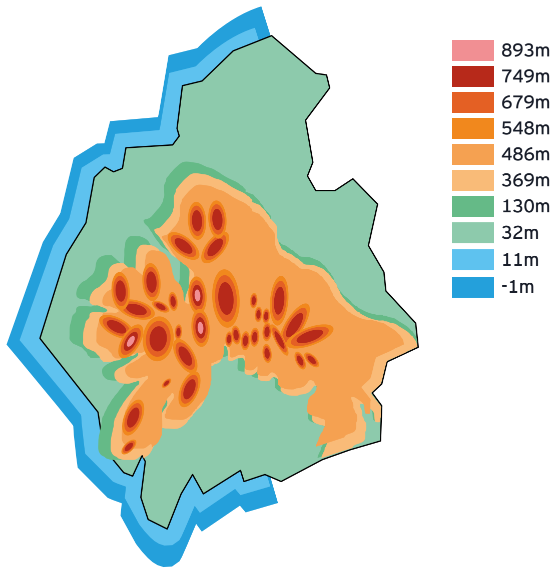
Solar farms also have a short payback period with the typical estimate for a solar farm's payback period ranging from 7 to 10 years. The long-term benefits of investing in solar energy, such as reducing carbon emissions and supporting sustainability goals, alongside the flexibility it brings to land-use and opportunities to expand local economies, make implementing Solar PV installations in Cumbria highly economically attractive and viable.

There are a number of considerations for identifying the most appropriate sites for Solar PV in Cumbria:

1. Cumbria's geography and natural significance

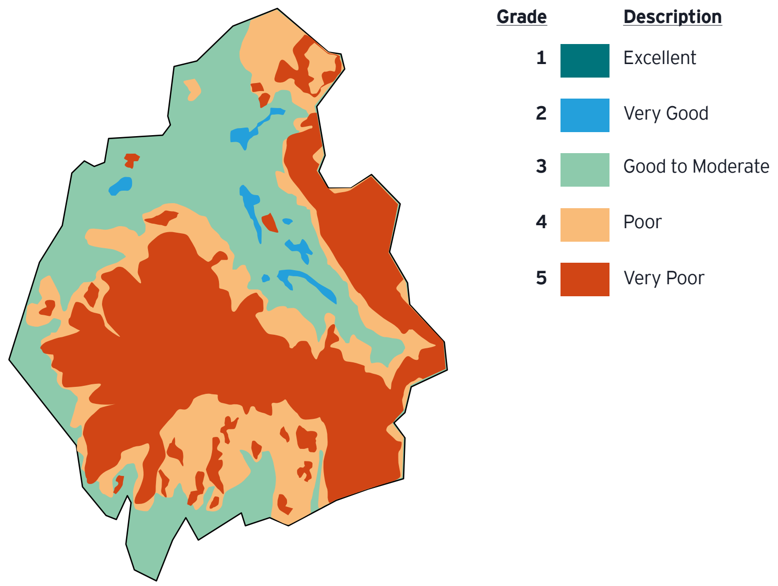
- **Physical criteria** for an appropriate site are a site that is flat (<5˚), south facing, and unshaded. Most of Cumbria is rural and mountainous (with the Lake District and Pennines being expansive and prominent features) ruling out these locations on this basis, notwithstanding considerations of these sites being under degrees of protection. Based on these criteria, the areas that would be the most appropriate are along the west coast with the lowest elevation. In this instance, it is probable that available and appropriate land would be smaller due to proximity to large towns and cities, rresulting in the installation of small solar farms with a capacity of up to 10MW (<50 acres) at more frequent intervals.

A map of the topography in Cumbria



- **Land classification** also affects the potential for solar farm installation in Cumbria. Land in the UK is graded by the Agricultural Land Classification (ACL) scheme as Grades 1 – 5, where grade 1 is most fertile. Most solar farms in the UK are situated on land that is designated as 3b (good to moderate). Grade 1, 2, and 3a land is designated as "best and most versatile land"; it is permitted but not advised to develop farms on this land for food security reasons, and developments may not be granted planning permission. The map below displays Grade 3 land in green; as such, approximately 40-50% of Cumbria's land falls in this classification but considering elevation too (overlaying map above), this again constricts development to the west coast of Cumbria.

The North West Region Agricultural Land Classification Map



2. **Brownfield sites** are ultimately the preferred location for solar farm development as they do not affect crop production, nor further visually impact the environment, and it is likely that planning permission will be more readily provided. Cumbria has multiple sites available that would be suitable for small solar farms. As a representative example, Cumberland has 21.5 acres of brownfield land at the site of a former factory, which could house a 4.3MW capacity solar farm.
3. **Other general considerations** are also significant for Cumbria such as impact on forest environments and general landscape impacts which may limit the size of feasible solar farm installations. These factors are important for all solar farm sizes, and planning permission for solar farms in Cumbria has been declined on these grounds; in 2015, planning permission for a 35 acre (~7MW) site in Workington on the west coast was rejected due to concerns over the impact on wildlife, noise, and the factors mentioned previously. This does not negate the assertion that smaller solar farms are more suitable for expansion in Cumbria as the median solar farm capacity is 8MW, and environmental impacts are likely to be greater with larger solar farms.

Rooftop solar has the advantage of generally not being affected by the factors described above, inherently making it a good choice for a county like Cumbria with a lot of environmental significance. In support of this is the Cumbria Rooftop PV Viability Map, developed by the Cumbria Action for Sustainability group, supporting residences in 11 communities to assess roof suitability for solar panel installation. A particular opportunity lies in rooftop solar on larger roofs, such as non-domestic or commercial buildings, for a few reasons:

1. Solar panels on non-domestic or commercial buildings could contribute over 50% of solar capacity to the UK Government's goal of increasing the installed capacity for Solar PV to 70GW of by 2035 to the DESNZ report ('Untapped potential' of commercial buildings could revolutionise UK solar power) due to the acres of space that could be leveraged for multipurpose use.
2. A 2021 Cumbria Action for Sustainability (CAfS) study mapping potential roof spaces suitable for solar power generation in Alston Moor (Westmorland and Furness) found that the largest 25% of roof spaces could be responsible for generating 57% of the solar power for the area.
3. There are fewer installers for small rooftop projects making commercial installations more attractive.

The potential challenges for Cumbria

A major challenge for expanding solar energy in Cumbria is its dependence on the development of Solar PV technology, which relies heavily on consistent direct sunlight to generate energy efficiently. Current Solar PV installations often provide an intermittent energy source, supplying little to no electricity at night-time. This makes it unpredictable and unreliable as a sole energy source. Cumbria's reputation as one of the wettest counties in the UK means that overcast and cloudy weather make it difficult for Solar PV panels to reach their potential energy output particularly during periods of low light over winter months.

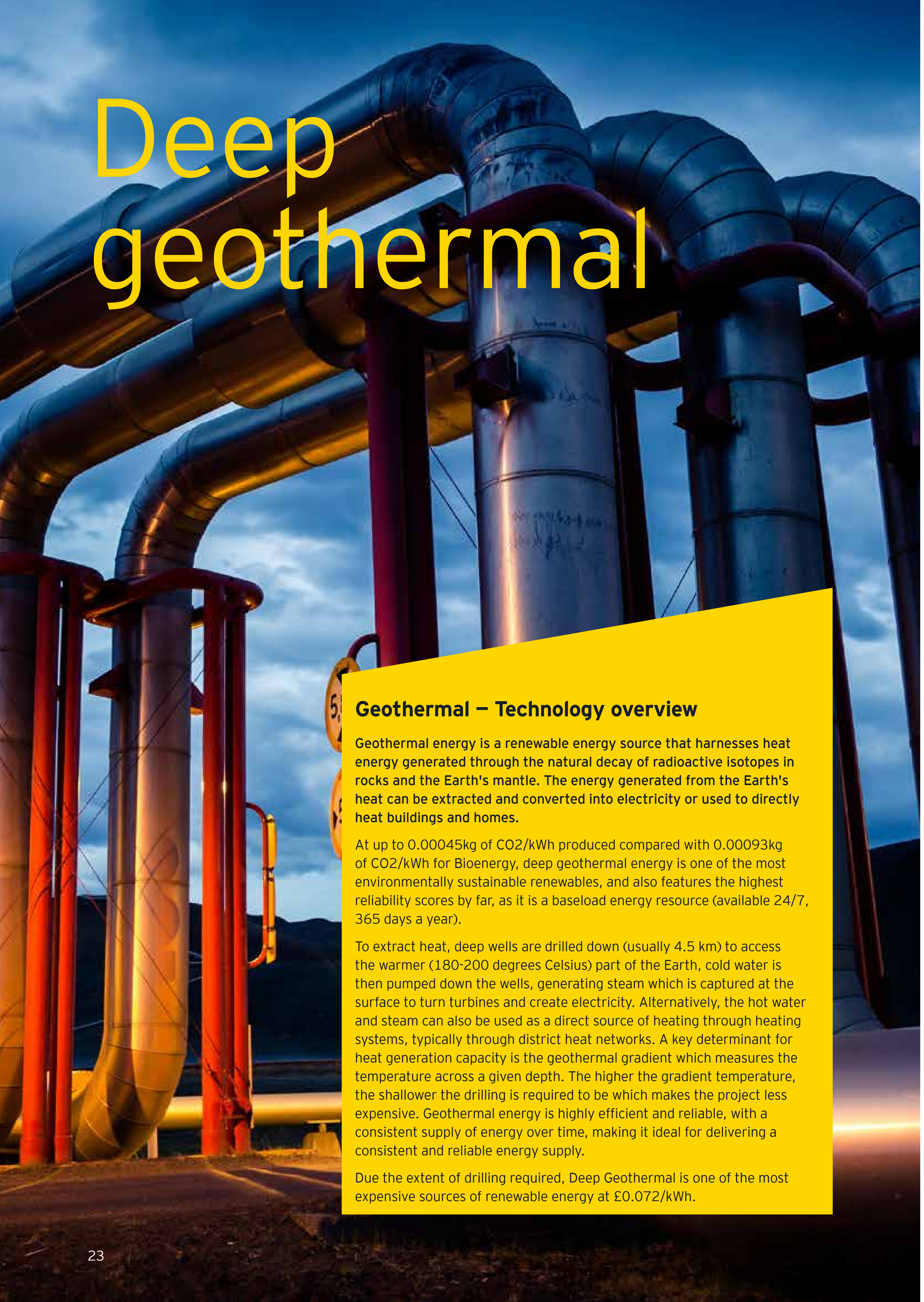
Rooftop solar has high upfront cost of installation, which can be prohibitive for many homeowners. While there are grants available for eligible households in Cumbria to help cover costs, additional planning permission requirements in specific areas further complicate the process. Living in a listed building, a conservation area, or within the Article 4 area of Keswick means that planning permission is mandatory. This can result in discouraging some residents from installing rooftop solar panels.

Solar farms require additional infrastructure, presenting their own challenges, including finding large swathes of land to accommodate installations and capacity to connect to the grid. Cumbria's unique geography, public footpaths, common land, and areas of scientific interest often limit suitable land for solar farms, particularly in very rural communities. Environmental considerations surrounding wildlife habitats, biodiversity and carbon emissions also need to be considered by developers.

Despite these challenges, solar power continues to be an important source of sustainable energy, and with technological advancements and appropriate policies, it has the potential to make a significant contribution to Cumbria's distributed energy mix for the future. In early 2024, Cumbria Local Enterprise Partnership will launch a Base Camp North solar demonstrator scheme that will provide further information to the public and to local businesses regarding the role that solar can play in rural Cumbria.

In summary

The landscape in Cumbria contains many areas that are suitable for Solar PV installations, including farmland, industrial fields, and the rooftops of non-domestic buildings such as commercial, schools, warehouses and car parks, making it possible to diversify the energy mix in the county. Despite the challenges, the rapid development of solar technology means innovations are being made to address the current limitations. Advancements in solar technology are continually making systems more effective at generating electricity, increasing reliability, and offering cost-effective solutions even in low-light environments. Electricity North-West predict an increase of 169% on current installed capacity for Solar PV in Cumbria by 2050 providing a huge opportunity for new investment in this technology. The underlying economic and commercial case for solar is already strong, and there is a significant pipeline of projects in planning and delivery. As such, limited additional activity is required to accelerate deployment of solar across Cumbria.



Deep geothermal

Geothermal – Technology overview

Geothermal energy is a renewable energy source that harnesses heat energy generated through the natural decay of radioactive isotopes in rocks and the Earth's mantle. The energy generated from the Earth's heat can be extracted and converted into electricity or used to directly heat buildings and homes.

At up to 0.00045kg of CO_2/kWh produced compared with 0.00093kg of CO_2/kWh for Bioenergy, deep geothermal energy is one of the most environmentally sustainable renewables, and also features the highest reliability scores by far, as it is a baseload energy resource (available 24/7, 365 days a year).

To extract heat, deep wells are drilled down (usually 4.5 km) to access the warmer (180-200 degrees Celsius) part of the Earth, cold water is then pumped down the wells, generating steam which is captured at the surface to turn turbines and create electricity. Alternatively, the hot water and steam can also be used as a direct source of heating through heating systems, typically through district heat networks. A key determinant for heat generation capacity is the geothermal gradient which measures the temperature across a given depth. The higher the gradient temperature, the shallower the drilling is required to be which makes the project less expensive. Geothermal energy is highly efficient and reliable, with a consistent supply of energy over time, making it ideal for delivering a consistent and reliable energy supply.

Due the extent of drilling required, Deep Geothermal is one of the most expensive sources of renewable energy at £0.072/kWh.

UK National context

Despite the vast potential for geothermal energy to be produced in the UK, only 0.3% of the country's annual heat demand is met by this resource. Low adoption has been due to the high upfront costs (over 75% of which from exploration and drilling), and due to the challenging task of finding or creating permeability at depth.

Geothermal energy is not recognised as a natural resource under UK law, it is not part of the UK Government's 10-point plan for a Green Industrial Revolution (2020), and there are no clear rules for plant ownership, management, and regulation. The high capital expenditure related to equipment, exploration, and drilling is not currently supported by the government at a scale and consistency near the necessary level required to increase investors' confidence to fund deep geothermal projects.

Despite this, in 2021, in association with the industry body for Renewable Energy and Clean Technologies (REA), the UK Government commissioned a new industry report on the economic and environmental importance of UK deep geothermal resource by ARUP Group. The report found that if the UK were to undertake the development of 12 deep geothermal projects by 2025, they could generate heating for 50,000 homes, create 1,300 jobs and generate more than £100 million of EVA for local communities mainly in the North of England, Midlands and South-West.

By 2050, enabled by deep technical expertise transferred from the UK's oil and gas industry, it is estimated that 360 sites could be operational, generating £1.5 billion of investments, 35,000 jobs, 15,000 GWh for over 2 million homes and annual carbon savings of 3 million tons, presenting an exciting opportunity for new market development. In September 2023, in its fifth round of the Contracts for Difference (CfD) scheme, the UK supported 3 new geothermal schemes which will add 12MW of installed capacity to the UK grid by 2028.

Current role in Cumbria

There are currently no deep geothermal power plants in Cumbria, either operational or in progress.

The opportunity for Cumbria

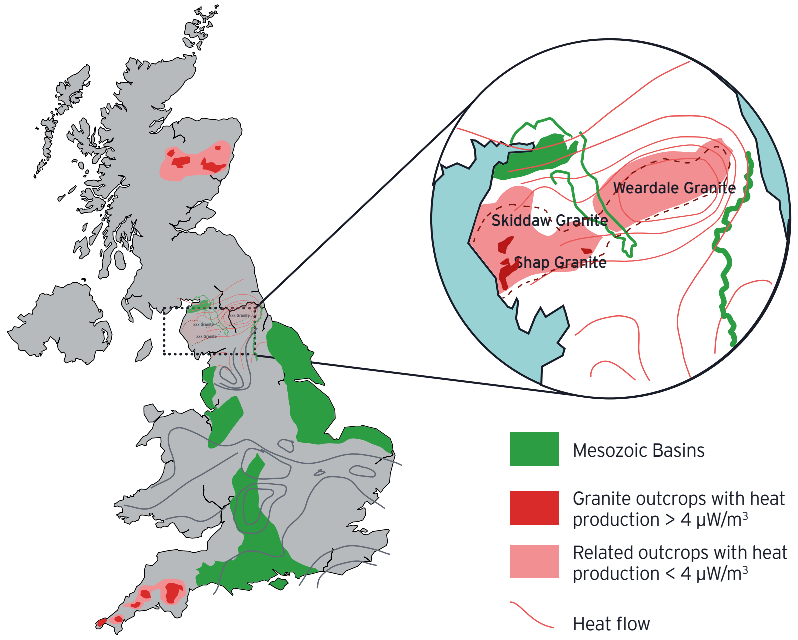
Cumbria is host to lithology such as the carboniferous sandstone in Carlisle and the Granite Batholith in the Lake District, which indicates potential sites for deep geothermal. Carlisle has an average geothermal gradient of 25 degree Celsius/Km (national average is 28C/Km), and the confidence level of this estimate is ranked in the top 4 out of 10 (according to '*Geothermal Energy Opportunities of the UK*') , suggesting that in order to reach an appropriate temperature for utilising geothermal technology, developers would need to drill to larger depths compared to other areas of the country. Despite this, carboniferous sandstone has a softer geological makeup and is comparatively easier to drill. An alternative location for geothermal sites could be within the Lake District which is host to granitic batholiths (according to a sensitivity analysis for deep geothermal in the UK published in Geological Society Publications). Sinclair Knight Merz (SKM) estimates that 2.3GWh of electricity, and 8GWh of heat energy annually, could be generated from the Lake District's granite. In contrast to the carboniferous sandstone, granite's composition presents a larger challenge for drilling, due to its tough lithology.

The technology presents several additional benefits such as stable cost basis since it is not exposed to input cost volatility like other technologies, it is highly accepted across the community as a favourable heat source, there is also an opportunity to leverage the existing skill set in the oil and gas industry which would all contribute towards a low carbon, productive, and highly reliable energy sector.

CASE STUDY

The United Downs Deep Geothermal Power Project, located in Redruth, Cornwall is the UK's first geothermal power plant which will become operational in 2024 and is set to deliver around 3Mwe of renewable electricity for a large housing development site. This project consisted of drilling two deep, directional wells; the production well to a depth of 5275m and the injection well to a depth of 2393m into the area's natural Cornubian granite batholith. Granite is not naturally permeable and thus locating faults and fracture zones that may display enhanced permeability at depth was also required. The site was selected in 2010 partially for its geology, strongly faulted, radiogenic granite. This is the deepest hole ever drilled in the UK.

A Map of the UK Geology



The potential challenges for Cumbria

Deploying deep geothermal energy in Cumbria presents several challenges, notably in geology, cost, environment, infrastructure and regulation. The technology presents the highest capex, is amongst the lowest long-term labour creation prospects, and has the greatest uncertainty with regards to economic viability. Unless geothermal features are visible, it is exceedingly challenging to determine whether a site is viable for energy extraction without incurring significant exploration expenditure. In order to establish the viability of deep geothermal in each area, feasibility assessments would need to be completed which would require drilling at each site. This would be particularly challenging to conduct within the national parks and the National Landscape areas (previously AONB) due to the permissions required and within Carlisle, the area with greatest heat demand, due to the population density of Carlisle.

The unique geology of the Lake District makes it challenging to identify areas suitable for geothermal energy development. Moreover, due to the high upfront cost of deep drilling, financing may be a challenge for smaller projects, alongside potential environmental risks and regulatory compliance and obtaining buy-in from local communities and the Lake District National Park.

Infrastructure development could also prove difficult, with areas of geological potential possibly conflicting with high-value scenic or cultural landscape designations or sensitive historical sites.

In comparison to other technologies, long-term employment generation will be lower due to the labor-light underlying process by which geothermal energy is converted into heat and electricity. Additionally, currently only 1% of Cumbria's households are connected to heat networks, this compares with the national average of 2%. This suggests that geothermal heat would need to also consider large connectivity schemes to be able to supply heat at scale in the area and as such has significant dependencies with the development of 4th and 5th generation heat networks.

In summary

Although challenging, the difficulties associated with geothermal technologies do not make deployment impossible. Geothermal promoters and policy makers are increasingly aware and addressing these concerns, evaluating environmental considerations and the practicality and cost-efficiency of drilling. Deep geothermal energy has the potential to revolutionise regional energy systems by generating renewable and reliable power with a reduced carbon footprint.

Despite the relative immaturity and lack of operational geothermal plants across Cumbria, it's likely to play an increasingly prominent role in generation, due to its reliability and predictability when compared with other more volatile renewable technologies.

Thus, with technological advancements and appropriate policies, the barriers to deploying deep geothermal energy could be alleviated. Planning well-balanced projects, with effective viability analysis and close collaboration with all stakeholders, could pave the way for successful deployment of deep geothermal technology in Cumbria.

This technology should be considered as part of the medium to long term mix in Cumbria, with a short-term objective of securing a pilot project to test viability.

Heat networks

Fourth-generation heat networks – Technology overview

A heat network, also called a district heating network, is a system for delivering heat from a central source to a group of buildings or properties.

Heat networks eliminate the need for each building to generate heat individually, reducing energy consumption, and promoting renewable energy sources. Fifth generation networks introduced shared "chill" and are known as heating and cooling networks.

There are five generations of district heating networks:

1. 1st and 2nd generation: This network primarily uses heat only or combined heat and power (CHP) plants to generate heat and electricity and transmit heat through pipes to nearby buildings. They run at high temperature, leading to thermal losses through distribution.
2. 3rd generation: This network introduces renewable energy sources like geothermal, biomass, and solar thermal energy to produce heat for buildings. They run at high temperature, leading to thermal losses through distribution.
3. 4th generation: Fourth-generation heat networks are an innovative approach to district heating systems that are characterised by their ability to integrate multiple sources of low-carbon heat, including waste heat from industry, geothermal heat, solar thermal energy, and heat pumps. Unlike traditional heat networks, which rely on centralised fossil fuel-powered combined heat and power (CHP) plants, fourth-generation heat networks use a variety of renewable and waste heat sources, which are of varying temperature and quality. The flexibility provided by this design enables fourth-generation heat networks to deliver heat from each energy centre at different temperature levels to meet the specific requirements of each connected building.
4. 5th generation: Fifth-generation heat networks are significantly different to fourth generation and have two major advantages that typically mean they are better for the environment, residents and are more economically viable than their predecessors:
    1. The technology provides both heating and cooling through the use of hot and cold pipes, meaning excess heat can be extracted from e.g., a data centre and transferred into a home and the excess chill extracted from a home back into the data centre – creating an efficient loop of heating and cooling demand, often utilising waste heat e.g., from air conditioning units. They run at much lower temperatures and are typically "topped up" by a water source heat-pump in the building, reducing thermal losses and increasing resilience.
    2. The technology is more distributed and decentralised in nature, hosting many smaller heating and cooling sources, rather than a single major energy centre. This results in reduced investment cost, higher efficiency due to reduced heat loss, and needing less infrastructure and space to deploy, providing a more modular solution to district heating.

Heat networks have the potential to reduce carbon emissions, increase energy efficiency, and provide more affordable and sustainable heating and cooling solutions. By using a central heating source, heat networks can serve multiple buildings at once, which makes them a reliable and efficient option for energy consumption reduction and promoting the adoption of renewable energy sources.

UK National context

In March 2018, there were 13,995 heat networks in the UK, supplying heating to 476,951 customers with 3000 operators mainly in London and other large cities. Relative to the existing size of the heat market, 2% of heat in the UK is generated by heat networks. To reach net zero by 2050, the Climate Change Committee has modelled that 18% of the UK's heat supply will need to come from heat networks.

To facilitate the ease of this nine-fold growth, the UK government is allocating circa £660m in various funding opportunities – heat networks are a key priority for the UK government in the drive to decarbonise heat. There is a 2014 Heat Network (Metering and Billing) Regulation (HNR), and in 2022 the Energy Security Bill was passed, requiring OFGEM to regulate the suppliers of heat networks and the potential for a price cap to be implemented.

Heat zoning regulations will come into force by 2024/2025, whereby if an area sits within one of the identified zones, public sector buildings or new developments will be mandated to connect to a heat network. The scope for growth is huge, with around £80 billion of both private and public investment expected and around 5 million homes to be connected over the coming years.

By 2025 it is expected that 25% of the heat and power used in London will be generated by localised decentralised energy systems and district heat networks connecting to zero carbon and waste energy sources.

Current role in Cumbria

Due to the overall low population density in Cumbria, heat networks have not been employed as much as other areas in the UK. Based on 2021 ONS Census data, population densities range from 26 persons/km² in Eden to 865 persons/km² in Barrow-in Furness with an average of 73 persons/km².

As of 2023, the only planning permission to build an electric heat pump powered heat network has been granted to the University of Cumbria's Carlisle Citadel Campus.

However, the Department for Energy Security and Net Zero (DESNZ) has facilitated a heat network zoning pilot in Carlisle, alongside 27 other English local authority partners, with results due shortly. This pilot aims to develop heat networks in zones where they provide the lowest cost, low-carbon heat to the end consumer through regulation, mandating powers, and market support.

The opportunity for Cumbria

The opportunity for Cumbria is centred around the technology's potential to create local employment. Job creation is likely to be high value adding and long term as it would require specialised skills such as project planning, design engineering, system controlling and maintenance.

Additionally, heat networks will generate heat at low costs, improving living standards in Cumbria. Customers will pay a median annual cost of £300 less a year than gas customers. This would be significant for Cumbria as in 2018, prior to the cost-of-living crisis, Cumbria had a 13% rate of fuel poverty, compared to a North-West average of 12.3% and an England average of 10.2%. However, due to heat networks' supply being commercial as opposed to domestic, operators are not protected by the price cap compared to gas. Through the Energy Security Bill, the price cap is proposed to be extended to heat networks.

There is currently limited scalability due to the majority of households being situated in rural areas, however, it has large potential in more population and heat-demand dense areas. Areas with a large number of new-build flats also pose an opportunity to install heat networks.

The potential challenges for Cumbria

As mentioned, heat networks are best suited to higher-density areas, ensuring that high capital costs can be recouped, and less heat is lost in pipes enroute to buildings. They can play a significant role in towns and cities, new build projects e.g., business parks, and areas close to sources of waste heat. Cumbria has a lower percentage of dwellings that are flats/maisonettes (11%) compared to the rest of the North-West (17%) so if heat networks were implemented, it may be localised to areas of high population density e.g., parts of Carlisle and Barrow-in-Furness. Additionally, as of March 2020, 60% of wards were classified as rural and over half of the population live in rural communities.

Trench excavations for piping may entail having to cross physical barriers such as railways, major highways, and waterways. This is likely to cause disruption to locals and may impact tourism. It also involves applying for planning permission, alongside other permissions, which may extend the project duration and incur greater costs.

In summary

The Climate Change Committee predict that by 2050, 18% of total domestic building stock will be assigned to a heat network. By 2035, 50 TWh of heat will be distributed through low carbon heat networks. 4th generation heat networks as stand-alone technologies are currently cost prohibitive outside of densely populated areas with large sites that can be used as a centralised energy source. The opportunity for 4th generation heat pumps is dependent on the success of the heat zoning pilot that DESNZ is hosting in Carlisle.

Heat Networks (5G)

Heat Networks (5G) – Technology overview

Fifth Generation (5G) heat networks are radically different from 4G heat networks. Heat production is decentralised, using heat pumps in each house or building.

They operate at low temperatures and generally require supplementary immersion heating for hot water. Cooling is integrated via a 2-pipe interchangeable system of heating and cooling between buildings. A typical system may operate with flow temperature of 20-30 degrees Celsius and a return of around 10 degrees Celsius. The heat supply integrates waste heat and renewable energies at low temperatures.

Traditional heat networks are subject to significant heat losses as the heat transfer fluid within the network is often at much higher temperatures than its surroundings, which is a large source of inefficiency.

UK National context

There has been an increasing shift to the latest heat network technology and fifth-generation heat networks now have the potential to improve the thermal efficiency of the heating system while reducing energy costs and carbon emissions through their modular solution. Moreover, the deployment of fifth-generation heat networks provides an opportunity to promote local economic growth and provide stable, long-term energy prices.

Current role in Cumbria

5G heat networks are currently not established in any part of Cumbria due to being a novel technology with very few installations around the UK in general.

The opportunity for Cumbria

5G heat networks as a renewable technology have a number of benefits. They are not constrained in the same way as other heat networks which must supply heat at the temperature required by the most demanding end user. Instead, they are able to generate and supply low temperature and benefit from higher efficiencies, while those requiring higher temperatures are able to meet their own heating needs. They exhibit zero fossil fuels and combustion emission and have no visible infrastructure. Additionally, there are reduced expenses of pipework insulation and reduced installation costs through shared infrastructure compared to individual ground source installations.

5G heat networks have a high scope for growth in Cumbria due to their ability to work in areas that have a lower density of heat demand compared to previous heat network generations, and increased cost efficiencies. This poses an opportunity for areas that will experience a lot of development; this can be seen in Carlisle in 2023 with plans approved for 150+ high specification new homes in the south-east, and a multi-million-pound leisure development in the city centre made of shipping containers. The UK Government's Heat Network Zoning Pilot in Carlisle will generate an approach to identify areas of adequate heat demand and potentially mandate certain buildings to connect to a heat network (if within a zone) within a specific timeframe. This demonstrates the potential of fast growth in application of this technology in the distributed energy mix in Cumbria.

From a socio-economic perspective, the job creation potential is higher than that of 4G; local short-term jobs are created during the construction of the network, and long-term jobs are created to maintain the system, ranging from highly skilled engineering jobs to soft skill focussed roles.

To meet this demand, there is a government-backed £5m Heat Training Grant for heat network skills which would support increasing local employment and the number of Cumbrian residents that are in education or training.

The potential challenges for Cumbria

There are also limitations to 5G heat networks. The infrastructure relies on a decentralised structure that has community buy-in as well as enough qualified technicians to install heat pumps across multiple sites. While 5G heat networks could be a promising and scalable renewable technology for more population and heat-dense regions of Cumbria, efficiently distributing low-carbon heat, the implementation may face challenges in terms of initial infrastructure costs and retrofitting existing systems. This technology is more suited for high energy density areas and heat mapping needs to be undertaken for Cumbria to understand patterns of heat demand and heat sources.

In summary

The huge benefit that 5th generation heat networks offer that their predecessors can't is their ability to be modular. This makes it much more inexpensive to implement as the decentralised nature does not require a number of large energy centres, opening the opportunity for smaller-scale networks across communities that can be added to in a timed and cost considerate manner.

Bioenergy

Bioenergy – Technology overview

Bioenergy is renewable energy that is derived from biological sources, such as organic matter, plants, wood, and agricultural and animal residues. Bioenergy is a form of energy that is produced through various processes, including combustion, digestion, or fermentation of organic materials.

There are different forms of bioenergy, including:

1. **Biofuels:** Biofuels such as biodiesel, ethanol, and biogas are derived from organic matter and can be used to power vehicles or for heating purposes.
2. **Biomass:** Biomass energy is derived from plants or organic matter which can be burned or converted to other forms of energy. This includes wood, crop residues, municipal waste, and dedicated energy crops such as Miscanthus.
3. **Biogas:** This is a mixture of gases produced by the breakdown of organic matter, such as waste, manure, dedicated energy crops or food scraps in anaerobic digesters. The biogas produced can be used as fuel for electricity generation or heating.

Furthermore, according to the type of feedstock, bioenergy is divided into four generations:

- **1st Generation:** food-crops, edible organic matter that would otherwise be consumed as food by people, non-edible organic matter such as certain crops (e.g., Miscanthus, Willow, and Poplar)
- **2nd Generation:** non-food feedstock, waste (animal and plant-based), and by-products such as used cooking oil
- **3rd Generation:** algae
- **4th Generation:** genetically engineered feedstock

The most economical feedstock options are first and second generation, and therefore dominate as bioenergy inputs, and are expected to continue to do so throughout the next decade and to the 2050s as cost-sensible alternatives are not expected to be successfully scaled up any sooner due to technological challenges.

According to the UK Parliament Post – Biomass for UK Energy, when combined with carbon capture and storage (BECCS), bioenergy may deliver negative emissions. The Climate Change Committee (CCC) expect demand for biomass in the UK to rise significantly in the coming decades to supply bioenergy with carbon capture and storage (BECCS).

UK National context

There are over 200 large biomass power stations in the UK, and bioenergy generated by anaerobic digestion, animal and plant waste supplied 7% of total UK electricity during 2022. The technology is key to the UK's aim to reach net zero, and the government has recently issued its UK Biomass Strategy (2023) showing support for the technology, and for the development of carbon capture technologies to offset emissions through 2050.

Anaerobic digestion (AD)

Anaerobic digestion (AD) is a process in which organic materials, such as food waste, animal manure, sewage, and agricultural residues, are broken down by microorganisms in the absence of oxygen to produce biogas and digestate.

The process occurs inside a sealed tank where the organic material is broken down by bacteria and other microorganisms into biogas, a mixture of methane, carbon dioxide, and other gases, and digestate, a nutrient-rich by-product that can be used as fertiliser.

There is a significant number of different biomasses available, each of which is derived from either plant-based organic matter, animal waste, or other waste, and the characteristics of each biomass, determine its suitability for the creation of either one or more of the 3 final outputs: electricity, heat, and transport.

Electricity:
In the UK **74%** of renewable electricity produced from biomass is produced using plant-based biomass.

Heat:
In the UK **54%** of the heat input from biomass is plant-based.

Transport: Fuel, mainly comprised of biodiesel and bioethanol. In the UK biodiesel is mainly produced from food waste and by-products (**96%**), bioethanol is mainly derived from sugar beet and wheat.

Currently, the UK imports around 31% of the biomass used in its power plants, despite the fact that the Department for Environment Food and Rural Affairs cited in the UK Food Security Report 2021 that 71% of the UK's viable farming land is currently used for agricultural production, of which 72% was grassland and 26% was cropland, demonstrating a huge opportunity to develop biomass internally. At £0.14/kWh, bioenergy has the third lowest LCOE (leveled cost of electricity) among the 8 technologies studied. In 2022, most plant-based biomass produced was used for electricity, accounting for 29% and 37% of total UK renewable inputs for electricity and heat respectively, which is a growth of 227% and 155% respectively from their 2010 total UK renewable input. At the same time, the MW installed capacity to process plant-based biomass has increased 1,328%, to 4.7GW from 2010 to 2022, with actual generation trailing this growth close behind and rising 1,312% to 23,416GWh during the same period.

While half of the biodiesel production is exported and derived from food waste and food by-products (over 90%), bioethanol is 100% reused in the UK's transport industry, with 77% going to road transport. A key question is whether miscanthus is a suitable alternative to current biomass used for biodiesel (food waste and by products) and bioethanol (sugar beet and wheat). As the government moves to minimise the impact on food security, biodiversity, and soil carbon-store value, food and feed crops are subject to higher regulations than waste products. In fact, the latter enjoys double reward for the supply of waste-based fuels compared to food and crop-based biomass. There is also a

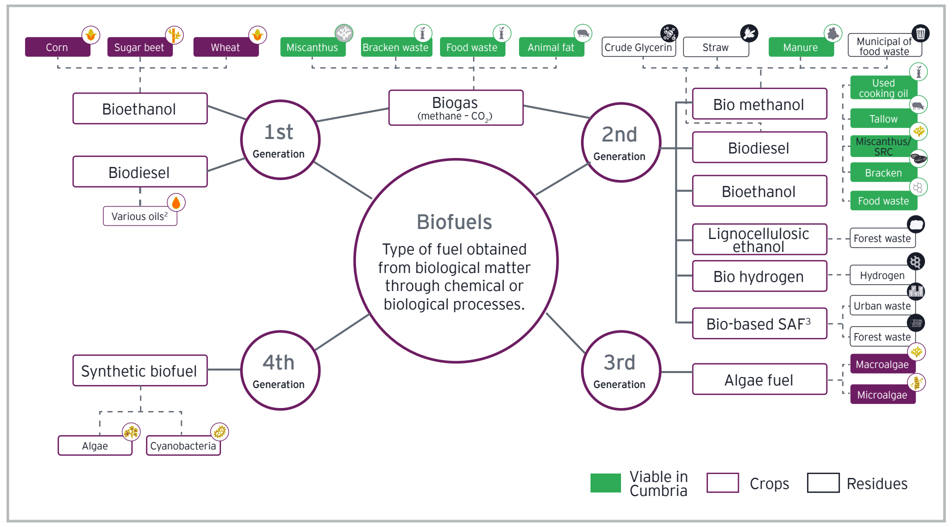
4% limiting cap on the amount of crop that will be counted towards renewable transport targets, this target will recede to 2% by 2032 of total fuel supply by supplier which reduces the competitiveness and therefore demand for these crops as a result.

Miscanthus

Miscanthus is a tall perennial grass that is primarily grown for biomass and bioenergy production. The plant grows to heights of up to 12 feet, making it one of the tallest perennial crops available, meaning it can produce significant biomass per hectare, making it a highly efficient crop for energy production. In addition, the plant is relatively easy to grow, requiring minimal irrigation, fertilisation, and pest control. Moreover, it is tolerant to a range of soil types, from poor quality uplands to arable lands, enabling

In 2022, the bioenergy industry in the UK received £37m in government funding to support innovative biomass projects, and the sector is expected to reach £10bn in market size by 2030, growing at 7% compound annual growth rate (CAGR) from 2023 levels. 46,000 jobs have been created in the UK bioenergy market to date, and as many as 54,000 additional jobs are expected to be created by 2050 (Department for Business Energy & Industrial Strategy).

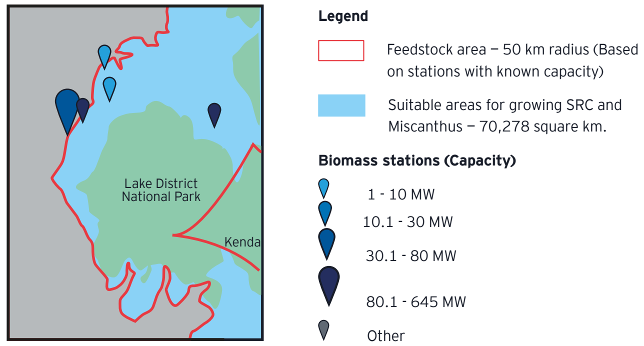
A map of the four generations of biofuels (EY 2023 diagram)



Current role in Cumbria

Cumbria has five biomass stations, with an estimated combined capacity of approximately 100 megawatts (see Miscanthus map below).

Map showing the suitable locations for Miscanthus Cumbria



Cumbria has a population density of 73 inhabitants per Km^2, far lower than the national average, which increases the number of sites suitable for biomass production, refinement, and potentially fuel, electricity and heat production at scale without jeopardising social welfare through pollution or noise risk.

The opportunity for Cumbria

There are two main options for bioenergy development in Cumbria to be considered: generation of biomass or biogas through either second-generation crop such as Miscanthus or second-generation waste material such as bracken waste or farm waste from materials such as manure.

First-Generation Bioenergy in Cumbria

Map imagery (see above) suggests that Cumbria has vast, suitable areas for growing Miscanthus, particularly around the Lake District national park, in Carlisle, Cockermouth, Workington, Whitehaven, and Barrow in Furness.

According to the Climate Change Committee, these areas have the highest potential in terms of income generation for rural communities, and thanks to Cumbria's 5,000 farms, it makes the county an ideal place for decentralised feed stock and bioenergy production.

Miscanthus is a perennial crop, which means that it does not need annual replanting. The crop reaches optimal yields capacity 2-3 years from initial plantation where it can produce 15-20 t/ha at 20% moisture content. Its growth potential depends on climate temperature, water availability within the soil, and the rainfall levels, therefore sunlight and moisture are important.

Soil: Miscanthus tolerates wide PH levels, with optimal ranges being between 5.5 and 7.5. Because it is harvested in late winter/early spring, it is important that the site does not get excessively waterlogged during the period which can cause damage to the soil structure and prevent harvesting machinery from operating. Generally, avoid heavy clay soils.

Temperature: the cutoff point is 6 degrees celsius , below this temperature the plant stops yielding, however, genetically modified clones of the Giganteus (Miscanthus species) can survive temperatures as low as -14.

Water availability: this is split into two components, rainfall, and soil water retention.

Both factors are strong determinants of Miscanthus yields. Care is advised when selecting the optimal density of rhizome planting as high canopy density levels could prevent rainfall from reaching and infiltrating the soil, resulting in yield losses as high as 90Kg/ha for each millimeter of soil water deficiency.

Furthermore, given that the crop will grow to heights of up to 3.5m and live for at least 15 years, other factors such as visual impact, wildlife, archeology, and public access must be considered when selecting the plantation site.

Miscanthus has several advantages over other non-food crops. For instance, as a rhizomatous plant, nutrients are naturally translocated from the above-ground biomass to the underlying rhizomes, reducing the amount of fertilizer needed for subsequent seasons, which is a significant cost advantage. Another advantage over SRC is that it can be harvested earlier after plantation (2-3 years, vs 4-5 years for SRC), building on the yield capacity's superiority to give Miscanthus projects a much faster payback period. Based on an estimated high-level investigation, if Cumbria were to utilise its 508,000 ha currently used for its traditional farming operations (79% of which is livestock based), to grow Miscanthus instead, local farmers may be able to generate a higher £790/ha in operating profit, compared to the traditional farms' £362 (118% higher), see table 1 below.

Table 1 – EY Analysis demonstrating an estimated high level income comparison of Miscanthus and traditional Cumbria farms (data taken from DESNZ – Digest of UK Energy Statistics Annual data for UK, 2022)

Farm type	Mischantus farm (£)	Cumbria farms (£)
Total revenue	530,572,635	1,144,000,000
Total cost	130,825,764	960,000,000
Totalprofit	399,746,871	184,000,000
Revenue/ha	1,044.43	2,251.97
Cost/ha	257.53	1,889.76
Profit/ha	786.90	362.20

Second-Generation Bioenergy in Cumbria

Modern biomass technologies have made it possible to extract energy from waste materials such as animal manure and bracken waste, transforming them from sources of waste into valuable and sustainable resources. Approximately 35,000 acres (6% of the total area) of the Lake District is covered by bracken, which is suitable for creating bioethanol, and could create up to 227,000 tons (377,000 for year 1) of fresh biomass annually and could create over 300 jobs, and £10 million in revenue (on a long-term basis) at a profit margin (before tax) between 28% and 40% in Cumbria. As for the long-term viability of the resource, 1 cutting per year for 3-4 years will reduce the annual yield output to 60% of the initial output, and cutting more than once a year will reduce the yield capacity significantly after 3-4 years. Despite the higher operating costs related to cutting, transport and equipment, studies have shown that the venture could experience payback as early as 4 years and yielding up to 32% in IRR.

Given the invasive nature of bracken, with strong links to negative health effects on animals and humans, as well as destruction of biodiversity and toxicity to the water system, its managed removal could result in sustainable income generation, which is likely to achieve government support as the invasiveness of the fern does not currently have a sustainable remedy, and it is reducing biodiversity throughout the UK at alarming rates. Moreover, because it is classed as waste, it would receive double the incentive of food-stock and feedstock to produce biofuels, and the restrictive limits of the RTFO rules would not apply.

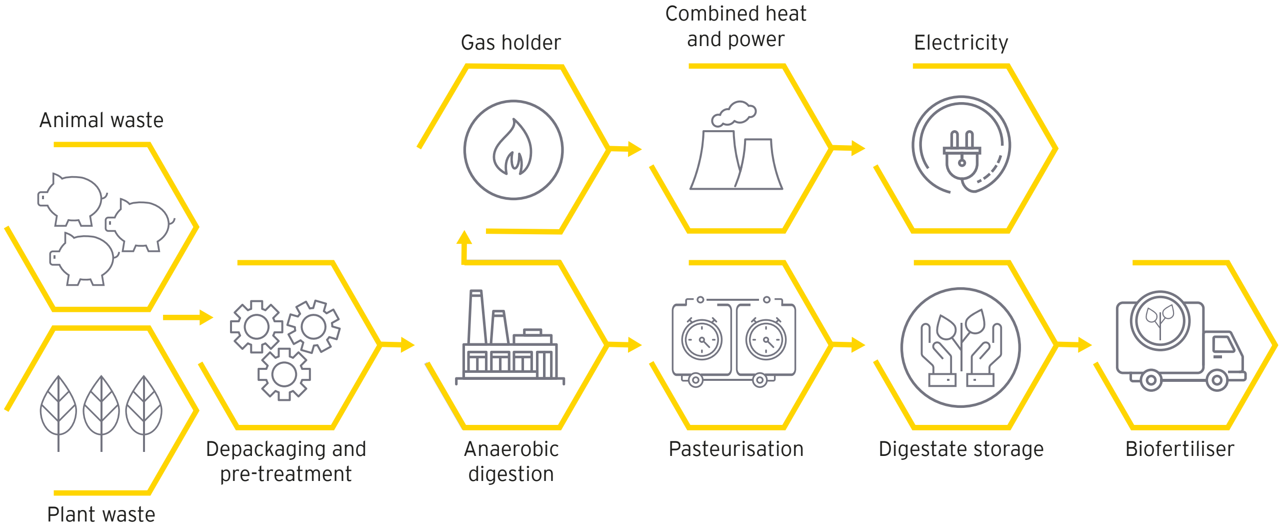
Biofuels

Both First and Second-generation materials pose a good opportunity for Cumbria to develop their biofuel market, creating either biomass pellets or biogas.

Biomass pellets are made of compressed organic waste materials, such as wood or agricultural waste, that are generated from various sources such as sawmills, paper mills, and agricultural activities. Power plants that use biomass pellets to generate electricity are becoming increasingly common in the UK. These facilities burn biomass pellets in high-temperature conditions, generating steam that drives a steam turbine connected to a generator, producing electricity.

Biogas currently makes up 10%, 4%, and 8% respectively, of the UK's electricity, heat, and fuel output from renewables, and after years of technological advancements, and due to the more recent geopolitical development in Eastern Europe, biogas is now cheaper than natural gas by approximately 30%. In the UK, most biogas is derived from anaerobic digestion (46%), landfill gas (38%), and sewage gas (16%). Anaerobic digestion (AD) is the process employed to break down organic matter such as animal, food, and plant waste to produce biogas, biomethane, and biofertilisers.

Biomass production diagram (EY)



Another by-product of anaerobic digestion is digestate, a biofertiliser, which has high potential for exports as the world moves away from Russian fertiliser and would allow local Miscanthus growers to use it as fertiliser.

There are now 650 operational AD facilities, up from 68 in 2011, and the estimated capex for AD plants is close to £4.9 million/MWe capacity installed (£4,900/KWe) which are usually part-funded by a mix of capital providers, a significant one being the government through schemes such as GGS and RHI.

Funding

The UK Government's Net Zero Strategy recognises Bioenergy as a priority technology for deployment in the UK. The bioenergy industry in the UK is currently funded using various mechanisms aimed at promoting and supporting the production and utilisation of biomass. Some of these mechanisms include:

1. **The Net Zero Innovation Fund:** This innovation fund was announced in the UK Government's 10 Point Plan for a Green Industrial Revolution and provides a dedicated pot of £1billion to priority technologies such as Bioenergy.
2. **Renewable Obligation Certificates (ROCs):** ROCs are financial incentives provided by the UK government to promote the generation of electricity from renewable energy sources, including biomass. Biomass generators earn ROCs for each megawatt-hour of electricity produced, which can be sold to suppliers who are required to purchase a certain number of ROCs every year.
3. **Contracts for Difference (CfDs):** CfDs are long-term contracts that provide price guarantees to developers of new renewable energy projects, including biomass. A CfD guarantees a fixed electricity price over a certain period of time, regardless of wholesale prices in the market.

The potential challenges for Cumbria

The main risks associated with Bioenergy include CO2 emissions, creating a future role for introducing Bioenergy with Carbon Capture and Storage (BECCS), other polluting effects, the reliance on imports, exposure to the associated commodity prices volatility, and the exposure to complex, global supply chains which increase costs (and emissions) and reduce reliability. The main direct implication is the risk of the polluting effects on the air quality which could be severely affected by feedstock processing, for instance the release of PM2.5 particles (the most harmful pollutant to human health) shortens lifespans, increases respiratory and cardiovascular illnesses in nearby areas. This can result in increasing healthcare costs for the local community. Moreover, some by-products from biomass crops such as digestate, if not carefully managed can lead to dangerous levels of ammonia and nitrogen being released and can lead to loss of biodiversity and ecosystem function in more sensitive habitats.

An additional challenge that may restrict the application of bioenergy in Cumbria is the restrictive lease covenants in Cumbria which prevent scope changes of the land and equipment leased. Even though only 14% of Cumbria farms are wholly tenanted, it is a risk-factor that should be considered when selecting areas and farms for testing pilots and projects.

In summary

Cumbria has an opportunity to both leverage waste materials, transforming them into energy, reducing waste volumes and proving a significant opportunity to play a critical role in Cumbria's distributed energy mix. Growing energy crops such a Miscanthus and providing an improved use for farming waste can also provide local farming communities with a diversified income stream, whilst proving a fully circular approach to resource utilisation in the region.

Hydropower

Hydropower – Technology overview

Hydropower is a renewable technology that uses the power of moving water to produce electricity. The energy generated by hydropower is derived from the kinetic energy of moving water, such as rivers or waterfalls.

Hydropower works by channelling water through a dam or other water-retaining structure, which creates a controlled flow of water. This water is then passed through turbines that convert the movement of the water into electrical energy. The electrical energy generated by this process is either stored for later use or transmitted immediately to the electric grid.

There are three primary types of hydropower:

1. **Conventional hydropower:** This type of hydropower uses the flow of water to turn a turbine, which then generates electricity. Conventional hydropower typically requires a dam to regulate the flow of water and maintain a consistent water level for the turbine. This method is the most common type of hydroelectricity generation used globally but has large associated costs as well as a number of environmental challenges.
2. **Pumped storage hydropower:** Pumped storage hydropower works by pumping water uphill from a lower reservoir to an upper reservoir during times of low electricity demand, then releasing it through a turbine to generate electricity when demand is high. This method is essential in balancing the grid during intermittent renewable energy generation periods, like from solar and wind. This form of hydropower relies on high-head topography and traditionally is associated with larger-scale projects although some case studies now example community-led projects.
3. **Run-of-river hydropower:** Run-of-river hydropower tends to be smaller in scale and are installed on rivers and streams with a typical capacity of fewer than 10MW. These systems can be used to power off-grid locations like farms or remote communities and also for domestic purposes like powering homes. Small hydropower plants usually operate in a run-of-river mode where water is directly sourced from the river as it flows downstream, rather than from dammed reservoirs. This option is considered the most environmentally friendly of the three due to its less invasive mechanics.

UK National context

Hydropower offers a consistent and predictable source of energy to the UK energy mix. By the end of 2022, the UK had 1,576 Hydro powered installations with a capacity of 1,890MW offering 1.8% of the total energy produced in the UK in 2022. Renewable energy sources like wind, solar and bioenergy have received significant attention in the UK, but Hydropower is often overlooked based on the associated high costs with applying large scale schemes in the UK. While large-scale hydropower projects require large and costly dams or reservoirs, small-scale hydro (between 100kW to 5MW installed capacity) can be harnessed from smaller streams and rivers without major alterations to the landscape, making them a viable option for the UK distributed energy mix.

Small-scale hydro offers a highly predictable and consistent solution to the energy generation mix in the UK whilst removing a lot of the adverse effects to the local environment that are often found with large scale hydro. The benefits of which offer a flexible and reliable energy source which can supplement the baseload provision as required.

Current role in Cumbria

As of 2022, there were 62 hydropower schemes implemented in Cumbria with an installed capacity of 7.2MW of energy, representing 0.4% of the UK's hydropower installed capacity. During 2022, 22.5 GWh of electricity was generated in Cumbria.

The opportunity for Cumbria

Cumbria is known for its extensive network of rivers, lakes and streams, providing a consistent source of flowing water. Its abundant water resources, mountainous terrain and topography provide a set of unique geographical and environmental characteristics that present a number of opportunities for community-level hydroelectricity projects.

Cumbria is home to several lakes with a substantial water volume and potential energy that could be harnessed as energy storage or efficient energy generation solutions. The Lake District National Park could be considered as a host for Pumped Storage Hydropower or Hydroelectric Dams. In addition, there are a number of lakes with that have fast flowing rivers and streams entering them at height, making them potential candidates for Run-of-River Systems. As a UNESCO World Heritage Site, any hydro projects considered would need to be environmentally sensitive and well-integrated into the natural landscape. The national parks and National Landscape status brings traditionally challenging conditions to meet in order to obtain planning permission, de-incentivising large-scale pumped storage and run-of-river hydro projects. However, the park's ambition to reach net zero by 2037 along with the opportunity to promote sustainable tourism here, offering a sustainable solution to the energy demand fluctuations due to the seasonal tourism that the sites exhibit, creates an opportunity for compromise for small-scale hydro projects to provide a balance between site preservation and localised energy generation.

Run-of-River projects

Despite the permissibility challenges that the national parks bring, there are already a number of small-scale run-of-river projects set within the Lake District National Park that have an installed capacity of 5MW of energy with an additional 20 sites within the park identified as feasible locations for similar style projects.

Cumbria has a network of rivers and streams, as well as tributaries to the larger rivers, such as those near Kendal and other towns, that could be considered to develop small-medium sized Run-of-River projects to generate electricity.

CASE STUDY

Combe Gill is a small-scale hydro low head site located in the Lake District National Park that is currently under construction and is set to produce 230KW of electricity. This demonstrates that planning permission for small scale hydro in the Lake District is becoming more obtainable and that small-scale projects are a suitable technological solution which creates minimal disruption to the local environment.

Pumped storage

Pumped storage facilities offer an energy storage solution and work like a giant rechargeable battery, helping to smooth out variability in energy supply from intermittent renewable energy sources, such as wind and solar. Small-scale pumped storage (100kW – 5MW) could help to provide stability to the renewable energy generation mix in Cumbria.

While there aren't currently any pumped storage hydro schemes in Cumbria, the region does have the potential for several new projects in the future, particularly in disused quarries or other suitable locations. The combination of hills, mountains, and lakes make Cumbria an ideal location for pumped storage schemes.

Cumbria has several locations that could be suitable for pumped storage projects. Some of the potential sites include:

1. The Lake District: The Lake District has a number of reservoirs and lakes that could be used for pumped storage projects.

2. West Cumbria: The hills and mountains in West Cumbria provide potential sites for Pumped Storage projects. There are several existing water reservoirs in the area that could be used for Pumped Storage.

3. Abandoned quarry sites: Quarry sites are an additional location that could potentially be repurposed for Pumped Storage facilities. There are a number of quarry sites dotted across Cumbria, offering a starting point for feasibility assessments.

These sites show that there are several potential areas where small-scale Pumped Storage projects could be developed in Cumbria, utilising either existing lakes or nearby hills and mountains for the necessary head.

Short term prospects for hydropower in Cumbria

Due to the significant restrictions that grid connectivity brings, most hydropower schemes would not be viable as part of a short-term energy proposition. Instead, Cumbria could consider deploying multiple small-scale Run-of-River schemes that generate under 1MW to avoid both the long wait times to process applications to connect to the national grid, as well as any restrictions and delays caused by low substation capacity. Based on the current data, all sub-stations in Cumbria could cater for a small-scale Run-of-River connection, however further consideration would be needed if multiple small-scale schemes required connectivity into the same sub-station. Small-scale Run-of-River schemes also benefit from reduced costs on implementation, maintenance and environmental impacts.

Long term prospects for hydropower in Cumbria

There are a number of opportunities to leverage the natural topography of the region and deploy larger hydropower schemes such as Pumped Storage in a number of locations across Cumbria. Along with the permissions and permits associated with larger sites, Pumped Storage projects would need to consider the potential wait for connectivity to the national grid which can be up to 10 years. There are however a number of sites that could be considered for Pumped Storage and depending on the size and location of the facility, connectivity wait times could be considerably lower.

The potential challenges for Cumbria

While small-scale hydropower projects are generally considered to have less environmental impact than large-scale projects, they can still have both ecological and environmental challenges as well as regulatory and connectivity restrictions that must be carefully considered.

Environmental and ecological assessments to ensure preservation and protection

1. **Habitat fragmentation:** Small-scale hydropower projects can lead to the fragmentation of river systems and the disruption of local ecosystems. Fish populations and other aquatic species may be impacted, which can have knock-on effects on other species that rely on them for food.
2. **Water quality:** Small-scale hydropower projects can impact water quality in some situations. Turbines and other equipment can cause sedimentation and other changes that impact water clarity and quality. This can negatively impact aquatic species and downstream water users as well as increasing flood risk.
3. **Flow variability:** Hydropower projects can alter the natural flow of rivers and streams, which can impact local ecosystems. Flow variability can impact the migration of fish, sediment transport, and other important ecological processes.

Regulatory and permitting requirements

The Environment Agency is responsible for regulating the water-related environmental permits in England. When planning small-scale hydro projects, developers will need to obtain the relevant permits; an Abstraction licence (relating to water abstraction), an Impounding licence (relating to a diversion of watercourses and discharges into the water bodies), A Fish Pass Approval (if you plan to modify the way that fish pass through the body of water) and An Environmental Permit for flood risk activity (when you build in, over or next to main rivers) to ensure that that the project's environmental impact complies with the water quality standards, habitat protection, and other environmental regulations. Any projects that intend to use weirs or upland watercourses are restricted to building weirs that exceed 1.5metres in height. Hydropower projects face Environment Agency's increase in fees for permits up to £13,392 to get a licence from April 2023, up from the previous cost of £1,500 which is an increase of c800%, significantly hampering the economic viability of small-scale schemes.

Grid connection

Cumbria is in a slightly unique situation in comparison to most of the rest of the UK in that its local energy generation exceeds its demand. There are a number of projects underway to upgrade the capacity of the grid at different locations across Cumbria which will be completed in the next 10 years. There are also long connectivity wait times for new schemes that intend to generate above 1MW of energy, including a lengthy permissibility four step process via National Grid to be considered ahead of connectivity. Due to which, these issues could increase the time to see return on investment and thus may constrain the scale of the scheme in which developers choose to progress in the short-term.

In summary

Cumbria's abundant water resources, natural elevation and rich history of hydropower provides an opportunity for Hydropower to play a significant role in Cumbria's distributed renewable energy strategy. Hydropower can provide a sustainable and reliable source of energy that complements other technology sources such as wind and solar, whilst promoting economic growth, stimulating regional development and generating local jobs. By taking advantage of the potential for hydropower, Cumbria can establish a more resilient energy system.

Conclusion

Cumbria has an opportunity to become a leading example of how environmental sustainability and economic growth can be achieved in tandem with accelerating investment and delivery of distributed renewable generation at a local level. In order to maximise its natural advantages and accelerate the clean energy transition to a more distributed model, there are three areas of focus to develop further:

1. To streamline the connectivity application process

There are a number of challenges across the UK in connecting to the National Grid. One difficulty that is generating further delays is correctly navigating the planning and permitting requirements in a timely manner. In the coming months, National Grid will adopt a new process to review the existing backlog of projects awaiting connectivity and will push back on any projects lacking appropriate governance. Thus, working with the local authorities and the Environment Agency to streamline the planning and permitting process for renewable energy projects in Cumbria could help to accelerate the deployment of new renewable energy projects in the region. This will create a quicker route to implementation, which can help to make the investments more reliable and reduce uncertainty and risk for potential investors.

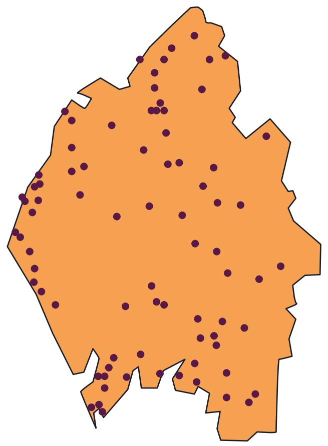
To support improved integration of distributed renewable technologies going forward, Cumbria should encourage the use of emerging technologies like energy storage, smart grids, and demand-response systems to improve the integration of distributed renewable energy sources into the grid. As research and investment into these emerging technologies grow, our ability to better utilise machine learning to create a more integrated and predictive platform for distributed renewable energy generation will support the grid to maximise the energy mix. Cumbria can encourage the use of these technologies to empower households and businesses to better manage their energy usage and reduce their dependence on fossil fuels.

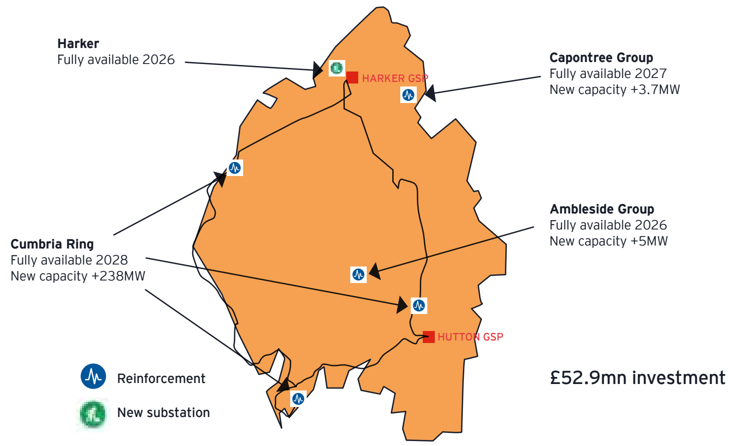
2. To encourage stakeholder alignment

In order to overcome the challenges associated with receiving permissions and permits for each form of technology deployment in Cumbria, key stakeholders should convene to align on the strategic direction of renewable energy deployment in Cumbria, unifying the approach and goals of the region. This is especially important in relation to emerging markets, where limited or no supply chain exists, like bioenergy.

This is particularly relevant for collaborating with Electricity North-West to ensure that Cumbria LEP are well informed and updated on the timings of the planned upgrades to the network, which is generating long connectivity waiting lists. This will support the reduction of connectivity waiting lists, whilst streamlining both design and planning of future work, enabling more informed decisions earlier in the project design phase.

The Cumbria ring substation and planned upgrades maps (Electricity North-West)





3. To promote methods for securing investment

There are a number of public funding options readily available in Cumbria, designed to incentivise and promote renewable energy projects. By taking advantage of these opportunities, developers can significantly reduce the financial risk associated with renewable energy projects, promote economic growth and development in Cumbria, and accelerate the transition towards cleaner energy sources such as:

Grant funding and loans:

1. **The UK Government's Department for Department for Energy Security and Net Zero (DESNZ) and The Department for Business and International Trade (DBIT):** DESNZ has several schemes aimed at reducing the carbon footprint in the UK such as:

    I. **The Net Zero Innovation Fund:** As part of the UK's 10 Point Plan for a Green Industrial Revolution, the Net Zero Innovation Portfolio was formed which provides a funding solution of £1billion to a portfolio of priority technologies and systems to accelerate the commercialisation of low-carbon technologies.

    II. **The Clean Growth Fund:** A £20million commercially run venture capital fund, which aims to speed up the deployment of innovative clean by making direct investments in companies seeking to commercialise promising technologies.

2. **UK Infrastructure Bank (UKIB):** UKIB is a government-owned policy bank created in 2021 that offers competitive and tailored low-rate loans with flexible payback options to the private sector to finance the green industrial revolution.

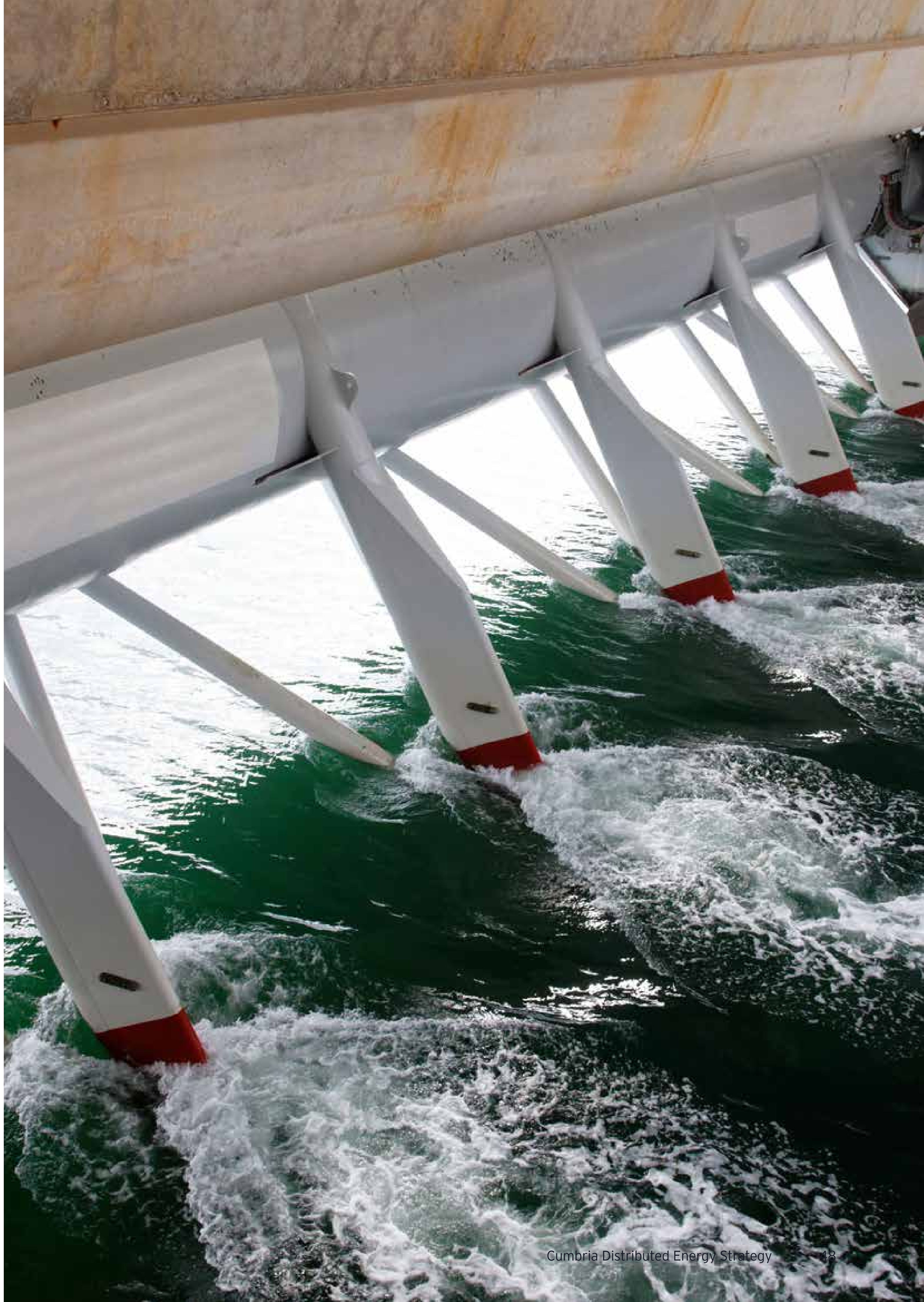
3. **The North-West Net Zero Hub:** The North-West Net Zero Hub has recently launched a new Community Energy Fund, providing communities with the opportunity to launch new small-scale renewable energy projects in their local areas.

Public sector collaboration:

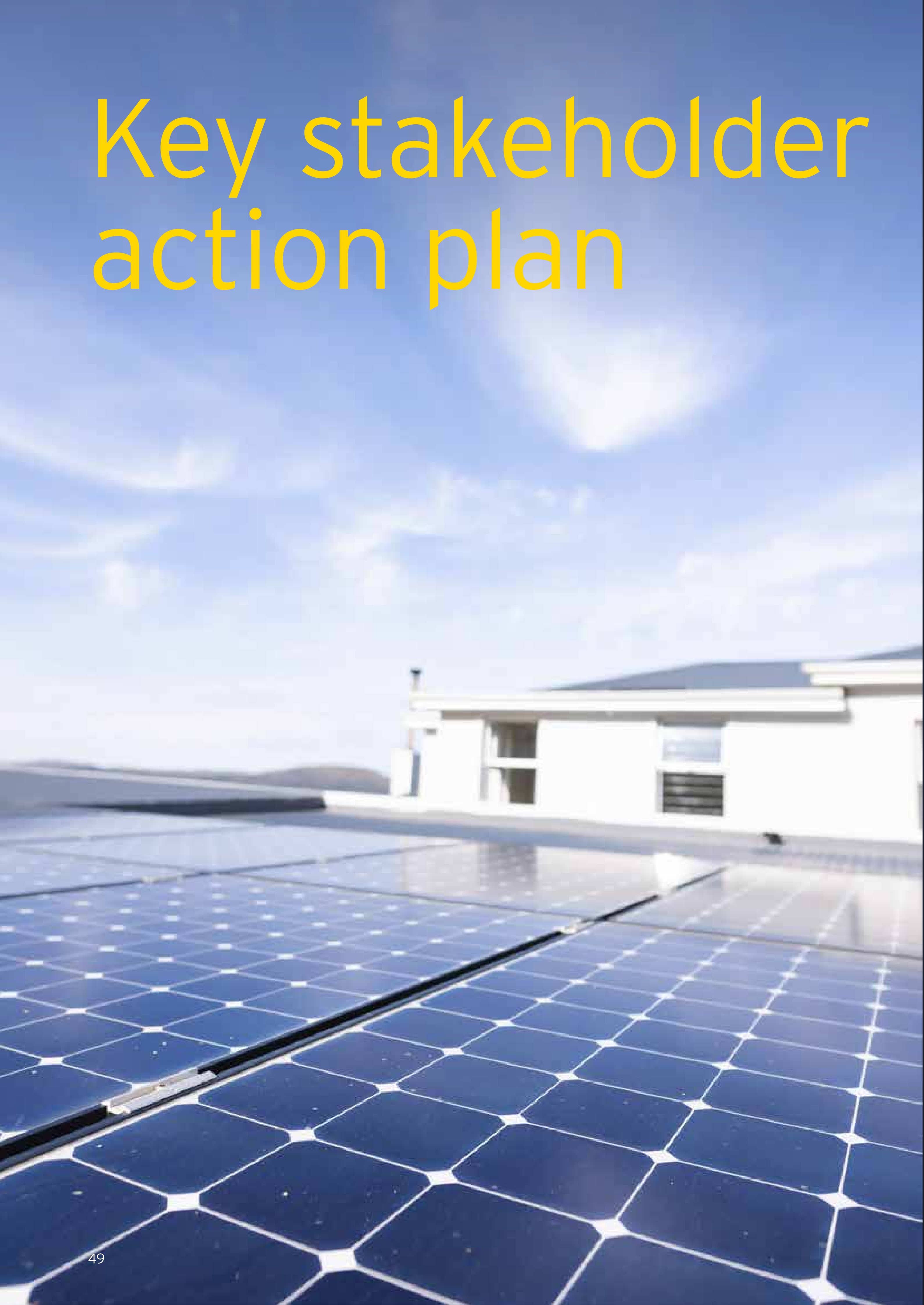
4. **The Green Premium:** There is an opportunity to collaborate with local authorities to support the build of business cases that highlight the green premium associated with deployment of new renewable technologies in the local area, making a case for the wider cost benefits associated, unlocking financial support directly from the local authorities.

Securing private sector investors:

There are a number of opportunities to unlock private investment in deployment of renewable technologies if the opportunity can be de-risked sufficiently. Insetting provides an opportunity for private sector firms to offset their carbon emissions by investing in local green projects.



Key stakeholder action plan



Cumbria has a unique opportunity to play a leading role in introducing a decentralised, distributed renewable energy mix of technologies to the energy generation for the region. There are a number of technologies that offer promising advantages by leveraging the topography of the region. The next section provides an action plan for both landowners and the Cumbria Local Enterprise Partnership to undertake in order to enable delivery of the technologies across the region.

Actions for landowners and businesses

1. **Be curious:** join events, sign up to newsletters and interact with the opportunities to develop your understanding of the local opportunities and upcoming projects that are launching.
2. **Understand your potential opportunities:** Look at the land that you own, consider how each technology could be deployed there, consider the benefits and challenges for each and use the materials signposted by both the Cumbria Local Enterprise Partnership and Local Authorities to develop robust business cases for your priority technology.
3. **Understand your local energy demands:** keep up to date with the way in which energy is being developed in the local area. Know where your local substations are and identify any connectivity challenges and upgrades that will reduce these.
4. **Maintain engagement with key stakeholders:** Keep engaged with all key stakeholders such as the CLEP, Local Authorities, the local energy distribution network and any relevant community groups to leverage knowledge and insight whilst sharing any lessons learned.

Technology	Potential for Cumbria	Actions for Cumbria Local Enterprise Partnership
Overarching activities	Distributed energy presents a significant opportunity for Cumbria to accelerate the transition to cleaner energy and create economic and social value for residents and local business. It is however a broad area, and prioritisation and focus is required. The LEP and local government partners will need to play a key convening and enabling role if deployment is to be accelerated.	1. Launch the Decentralised Energy Strategy and engage with key stakeholder groups, including local and central government, industry leaders and investors. 2. Consider establishing community forums or similar, to engage at a more local level, recognising how critical local support is in delivering distributed energy schemes. 3. Develop standardised collateral, including opportunity templates and plans, to enable various stakeholders' groups to develop their own proposals. 4. The LEP to develop a portal or online tool to allow for tracking and proactive support of local indicatives, playing a key convening role, and matching off-takers and suppliers to derisk investment at a local level, and support the DNO to prioritise its support.
Hydropower	1. The development of small-scale hydropower schemes across the region as a means of short-term generation	I. Convene with key stakeholders such as the British Hydropower Association, The Lake District National Park, the Environment Agency, Local Authorities, The National Trust and Forestry England as well as other local major landowners such as farmers to develop a strategic view and prioritisation list of potential sites for development. II. Promote hydro feasibility studies as part of the NW NZ hub Community Energy scheme. III. Collaborating with the key stakeholder to promote the use of existing schemes as case studies to demonstrate the elements required to implement a project, agreeing with stakeholders a guide to develop a hydropower scheme in Cumbria with clear signposting to each element.
	2. The development of Pumped Storage as a means of long-term energy storage	IV. Maintain sight on small-scale Pumped Storage projects developed across the UK to provide case studies for deployment.

Bioenergy	1. The development of First-Generation bioenergy utilising the growth of bio crops such as Miscanthus to develop either bio pellets or Biogas	I. Identify areas for energy crop cultivation: Assess areas in Cumbria suitable for energy crops such as miscanthus, identifying land availability and the potential impact on surrounding ecosystems. II. Develop a convening stakeholder partnership: Including the Local Authorities, The Environment Agency, the Farmers Union and local landowners to share knowledge and ensure integration across economic growth, energy strategies, environmental regulations are aligned.
	2. The development of Second-Generation bioenergy utilising Cumbria's waste materials such as manure or bracken waste to produce biogas	III. Assess waste resources: Conduct a comprehensive inventory of the amount and types of waste materials generated in the region. This assessment should include waste from agriculture, forestry, and other industries. IV. Identify case studies both inside and outside the county to deliver each form of bioenergy to use and establish the process involved, lessons learned, and both the signposting and support required to enable future schemes at scale. V. Align with this key stakeholder's group to agree which type of bioenergy is most appropriately aligned with the overall strategic ambition of the area.
Onshore wind	To develop more wind farms in line with Electricity North-Wests' 2050 projection for onshore wind	I. Whilst awaiting the upgrade to Harker & Hutton GSP sites that will generate more capacity in 2028, the Cumbria Local Enterprise Partnership can engage with new developers to better understand how the role of the supply chain could support deployment. II. Cumbria Local Enterprise Partnership should support the development of partner organisations to increase awareness for landowners across the region of roof top solar opportunities. III. Collaborate with the local authorities to develop a strategy for supporting small-scale deployment and connectivity locally.
Solar	Consider deployment on rooftops and brownfield sites	I. Whilst awaiting the upgrade to Harker & Hutton GSP sites that will generate more capacity in 2028, the Cumbria Local Enterprise Partnership can engage with new developers to better understand how the role of the supply chain could support deployment. II. Cumbria Local Enterprise Partnership should support the development of partner organisations to increase awareness for landowners across the region of roof top solar opportunities. III. Collaborate with the local authorities to develop a strategy for supporting small-scale deployment and connectivity locally. IV. Develop solar together schemes to increase the energy storage capacity for solar, whilst increasing installed capacity.
Tidal and wave	Maximise the natural coastal region and strong currents in Cumbria to deploy tidal and wave technology	I. Engage with the Local Authorities to understand the role of the Local Enterprise Partnership as the technology develops further. II. Maintain links with existing case study developments across the UK such as Merseyside Tidal project through the Offshore Energy Alliance and Cymru Egino to seek opportunities to develop a similar delivery model for Tidal & Wave projects in Cumbria.
Deep geothermal	Maximise on the natural geology of Cumbria to explore potential sites for deep geothermal deployment	I. Maintain sight on the live Geothermal study in Cornwall in order to maintain awareness of the technology and keep up to date with any developments that might support deployment in Cumbria. II. Engage with the Local Authorities to understand the role of the Local Enterprise Partnership as the technology develops further.
4th generation heat network	Deployment in population dense areas such as Carlisle and Barrow-in-Furness	I. Once the findings of the UK Government's Heat Network Zoning Pilot in Carlisle which will generate an approach to identify areas of adequate heat demand is released, convene with key stakeholders to understand the role of the Local Enterprise Partnership in supporting deployment.
5th generation heat network		II. Engage with new developers to understand how the role of the supply chain and local skills could support deployment.

Now:

1. Convene with key stakeholders to understand the approach to investment, delivery and building new value chains.
2. Integrate with both Cumberland Council and Westmorland & Furness Council to ensure that each Council's economic strategies both align and compliment the signposting and information that Cumbria Local Enterprise Partnership provide.
3. Collaborate with Electricity North-West, The Environment Agency and the local communities to identify potential sites for developing small-scale hydropower and bioenergy projects.
4. Conduct detailed feasibility studies to identify the areas suitable for developing bioenergy and hydropower projects to determine the more economical sites along with the social, economic, and environmental impacts of projects at each location. The CLEP leading the development of the first few pilots will unlock further investment and de-risk the opportunities for partners.
5. Complete hydrological assessments to evaluate the water flow patterns, determine the most appropriate sites to implement hydropower schemes as part of the site feasibility assessments.
6. Promote the framework for developing and implementing community-led small scale energy projects along with the funding options available such as the recently launched North-West Net Zero Hub Community Energy Fund, and how to apply.

Next:

1. Develop policies and incentives to promote the adoption of bioenergy and hydropower energy in Cumbria, including providing financial incentives, such as feed-in tariffs and grants, for energy generation from these sources.
2. Encourage the adoption of bioenergy across the farming community and provide information on how farmers could transition their business focus.
3. Foster public-private partnerships to fund hydropower and bioenergy projects in Cumbria.

Then:

1. Increase the percentage of energy generated from bioenergy and hydropower in Cumbria's energy mix by implementing a target to increase these renewable energy sources by 2030.
2. Invest in research and development to advance technologies related to bioenergy and hydropower energy generation to support innovation that will ultimately improve efficiency and reduce costs.
3. Work towards a long-term goal of becoming a trailblazer in an established distributed energy regional market, driving the local economy and retaining the local population.

Glossary of terms

Agrovoltaics: Agrovoltaic energy, also known as agrophotovoltaics, consists of using the same area of land to obtain both solar energy and agricultural products.

Bioenergy and Carbon Capture (BECCS): involves capturing and permanently storing CO2 from processes where biomass is converted into fuels or directly burned to generate energy. Because plants absorb CO2 as they grow, this is a way of removing CO2 from the atmosphere.

Cumbria Action for Sustainability (CAfS): A local climate change charity in Cumbria.

Contracts for difference: The Government's primary mechanism for supporting new low carbon power infrastructure.

Development Consent Order: Under the Planning Act, a Development Consent Order (DCO) is the means of obtaining permission to construct and maintain developments categorised as NSIPs.

Department for Energy Security & Net Zero (DESNZ): is a ministerial department focused on the energy portfolio from the former Department for Business, Energy and Industrial Strategy (BEIS).

Distributed Renewables: is the term used when electricity is generated from renewable energy sources, near the point of use instead of centralised generation sources from power plants.

Electricity North-West: is the local distributed network operator (DNO) for Cumbria region.

Installed capacity: the maximum net generating capacity of power plants and other installations that produce electricity.

Levelised cost of electricity (LCoE): a measure of the average net present cost of electricity generation for a generator over its lifetime.

Local Planning Authority (LPA): is the local government body that is empowered by law to exercise urban planning functions for a particular area.

Microgeneration Certification Scheme (MCS): an industry-led quality assurance scheme, which demonstrates the quality and reliability of approved products and installation companies.

National Planning Policy Framework (NPPF): sets out the Government's planning policies for England and how these should be applied.

National Landscape (formally Area of Outstanding Natural Beauty or AONB): areas of countryside that have been designated for conservation due to their significant landscape value.

Net Zero: the balance between the amount of greenhouse gas (GHG) that's produced and the amount that's removed from the atmosphere.

North-West Net Zero Hub: is a regional programme to promote investment in energy projects. It works with public sector organisations to improve the business case for their energy schemes. The North-West Net Zero Hub supports communities to take action and participate in the climate agenda.

Repowering wind turbines: removing old turbines and replacing them with newer, more efficient models with a greater wind turbine power output. Since newer models tend to be more efficient, repowering allows each wind farm to generate more electricity.

Renewable generation: energy derived from natural sources that are replenished at a higher rate than they are consumed.

Solar irradiation: the power per unit area (surface power density) received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument.

Solar together: Solar Together is a unique group-buying scheme for solar photovoltaic (PV) panels and battery storage.

Annex

Data: All technology installed capacity and generation data sited within this report has been extracted from the National Statistics publication, Energy Trends which was produced by the Department for Energy Security & Net Zero (DESNZ) 2022. All Contract for Difference data was extracted from the UK Governments Contract for Difference Allocation Round 5 (AR5) results which covered applications received between March 2023 and September 2023.

Maps: All maps have been created by EY relying on publicly available secondary sources.

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- Renewable UK

Private papers referenced:

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