4.2.10 United Kingdom of Great Britain and Northern Ireland

International Center on Small Hydropower (ICSHP)

KEY FACTS

Population	67,215,293 (2020)[1]
Area	248,531.52 km^2
Topography	The United Kingdom of Great Britain and Northern Ireland (UK) is divided into the hilly regions of the north, west and south-west and low plains of the east and south-east. Scotland in the north is almost entirely rugged, characterized by the northern Scottish Highlands and the Southern Uplands that are separated with a narrow Midland Valley region. Northern Ireland is a western continuation of the topography of Scotland but elevations tend to be lower. Wales also has a predominately rugged terrain due to the northern and central Cambrian Mountains. England is lower and flatter in comparison with the exception of the Pennines Mountains towards the north. The southern and south-eastern regions are mostly low-lying plains. Of the top 10 highest peaks, all are located in either Wales or Scotland. The highest point is Ben Nevis reaching 1,343 metres located in the Scottish Highlands.[2]
Climate	The UK has a temperate climate, with both polar and tropical maritime influenced weather. The polar winds in the winter cause cold, sometimes below 0 °C temperatures in Scotland, while southern England experiences slightly more moderate winters. Tropical maritime and continental winds in the summer cause temperatures to often reach 32 °C, especially in the south.[2]
Climate Change	The UK has already experienced increasing temperatures with an average increase of 0.8 °C since the 1960s and all 10 of the hottest recorded years have been since 1990. In the upcoming decades heat waves are expected to become more prevalent and intense, the rise in sea level caused by melting artic ice will cause increased coastal erosion and rainfall patterns are expected to become more dramatic with a drier dry season and a wetter wet season with concerns of flooding.[3]
Rain Pattern	The mountains of Wales, Scotland, the Pennines in northern England and the moors of south-western England are the wettest parts of the country. Some of these places receive over 5,000 mm of rainfall annually making them some of the wettest locations in Europe. Other parts of the country can be very dry with the southern and south-eastern regions receiving an annual average of less than 800 mm. The wettest months tend to be October and December while the driest months are May and June, but rainfall can be evenly distributed throughout the year in some areas. In winter months, especially in the northern regions, precipitation often comes as snow.[2]
Hydrology	The longest river is the Severn (354 km) flowing through both Wales and England and the second longest is the Thames (346 km).[5] Other major rivers in England and Wales include the Humber, Tees, Tyne, Great Ouse, Mersey and Trent Rivers. The river system of Scotland is largely separate from that of England characterized by many shorter, faster flowing rivers. The two major rivers of the Midland Valley of Scotland are the River Clyde and the River Forth. The longest river in Scotland is the River Tay (188 km).[2] As a result of its industrial history, the UK has an extensive system of canals, mostly built in the early years of the Industrial Revolution.

ELECTRICITY SECTOR OVERVIEW

Electricity infrastructure in the United Kingdom of Great Britain and Northern Ireland (UK) is well developed with a 100 per cent electrification rate.[4] In 2020, total installed capacity was 75,810 MW, of which approximately 30 per cent was with renewable energy and 70 per cent with non-renewable energy. Gas-fired plants accounted for 34,781 MW (46 per cent), wind power accounted for 10,529 MW (14 per cent), nuclear power for 8,141 MW (11 per cent), biomass for 7,945 MW (11 per cent), coal for 5,361 MW (7 per cent), hydropower for 4,372 MW (6 per cent), solar power for 2,289 MW (3 per cent), oil for 1,126 MW (1 per cent) and the remaining 1 per cent was split between 679 MW of dual fuelled plants and 589 MW of other fossil fuels (Figure 1). Total installed capacity has been decreasing since its peak of 90,393 MW in 2010, almost entirely due to the closing of several coal plants amounting to over 18,000 MW and oil plants amounting to over 4,000 MW. Capacity of renewable energy sources has been increasing during the same time, although at a lower rate, with the largest increases in wind (more than 8,000 MW) and solar power (more than 2,000 MW).[5]

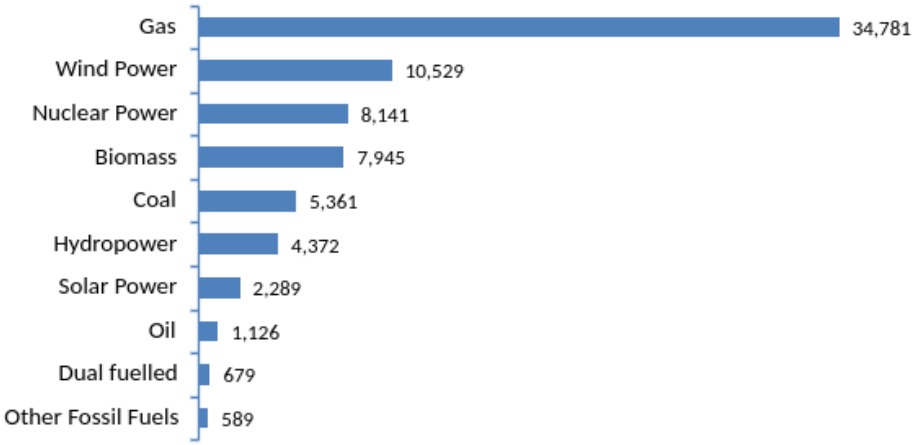

Figure 1. **Installed Electricity Capacity by Source in the United Kingdom in 2020 (MW)**
Source: DUKES[5]

In 2020, total electricity generation was 311,997 GWh, of which renewable energy (including renewable thermal energy) accounted for 43 per cent. Gas-powered plants generated 111,431 GWh (36 per cent), wind power generated 75,380 GWh (24 per cent), nuclear power 50,278 GWh (16 per cent), biomass 39,311 GWh (13 per cent), solar power 13,158 GWh (4 per cent), hydropower 8,156 GWh (3 per cent), other non-renewable sources 7,943 GWh (2 per cent), coal 5,504 GWh (over 1 per cent) and oil 835 (less than 1 per cent) (Figure 2). To satisfy total demand of approximately 329,900 GWh in 2020, the UK imported 17,900 GWh worth of electricity from other parts of Europe. Of the electricity generated, the residential sector consumed 33 per cent, industry consumed 25 per cent, the commercial sector 20 per cent, the energy industry 15 per cent (which includes electricity used for generation and 8 per cent in losses), and the remaining 7 per cent was consumed by public administration, transport and agriculture (Figure 3).[5]

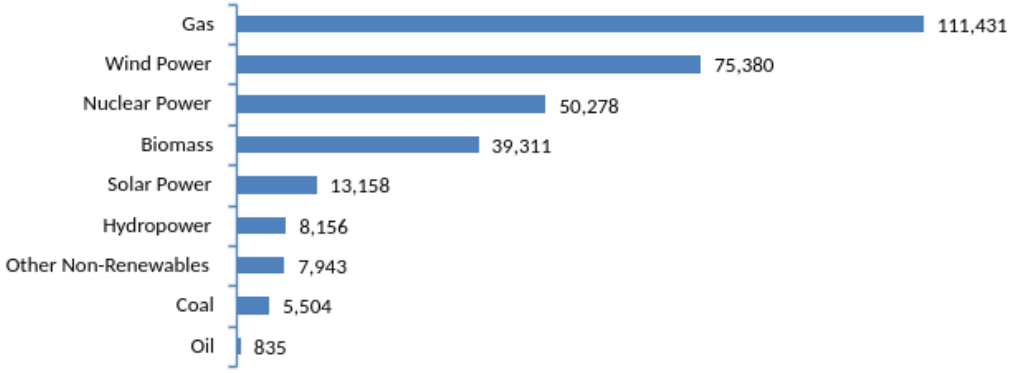

Figure 2. **Annual Electricity Generation by Source in the United Kingdom in 2020 (GWh)**
Source: DUKES[5]

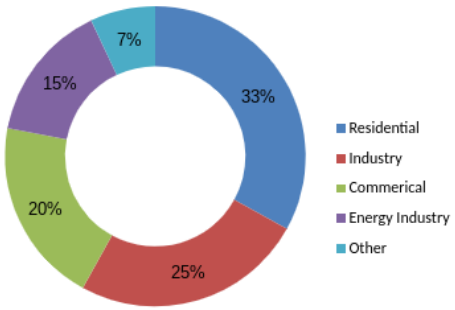

Figure 3. **Electricity Consumption by Sector in the United Kingdom in 2020 (%)**
Source: DUKES[5]

The electricity sector in the UK is fully liberalized, a process that began with the Electricity Act of 1989 and completed in the following years. Electricity suppliers buy electricity from the wholesale market or directly from generators and arrange for it to be delivered to the end customers, who can choose any supplier to provide them with electricity. The market is regulated by the Gas and Electricity Markets Authority, which operates through the Office of Gas and Electricity Markets (Ofgem).[6] Ofgem issues companies with licences to carry out activities in the electricity and gas sectors, sets the levels of return which the monopoly networks companies can make and decides on changes to market rules.

Currently, there are approximately 40 companies in the UK supplying electricity. For several years, there were six major companies that dominated the industry collectively known as the Big Six: EDF, Centrica (British Gas), E.ON, RWE nPower, Scottish Power and SSE plc. However, in 2019 E.ON acquired nPower and the Ovo Group acquired SSE and thus some refer to them now as the Big Five, but an official name is ungiven.[7] National Grid plc is responsible for the transmission network in England and Wales. In Scotland, the grid is split between two separate entities: SP Energy Network (a subsidiary of Scottish Power) is responsible for southern and central Scotland and SSE plc is responsible for northern Scotland. National Grid plc, however, remains the system operator for the whole UK grid. Nine Distribution Network Operators (DNO), operating in 12 separate regions, distribute electricity from the transmission network.[8]

Electricity costs vary across suppliers and regions. In 2021, the national average electricity tariff was 0.164 GBP/kWh (0.20 US$/kWh), similar to the years prior.[9] However, due to the global gas price increase in 2022, average electricity tariffs have increased accordingly. For example, the average tariff for British Gas in April 2022 was 0.28 GBP/kWh (0.35 US$/kWh) and the average tariff for E.ON Energy was 0.27 GBP/kWh (0.33 US$/kWh).[10,11]

SMALL HYDROPOWER SECTOR OVERVIEW

In the UK, small hydropower (SHP) is generally defined as up to 10 MW. In 2020, installed capacity of SHP was 405 MW.[12] Total potential capacity is at least 1,179 MW, indicating that approximately 34 per cent has been developed. It is worth noting, however, that the estimated potential figure is based upon studies with minimum installed capacity limits meaning that sites with capacities below these limits were not included and the total potential should be higher. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019,* installed capacity has increased by 15 MW and potential capacity has remained the same (Figure 4).

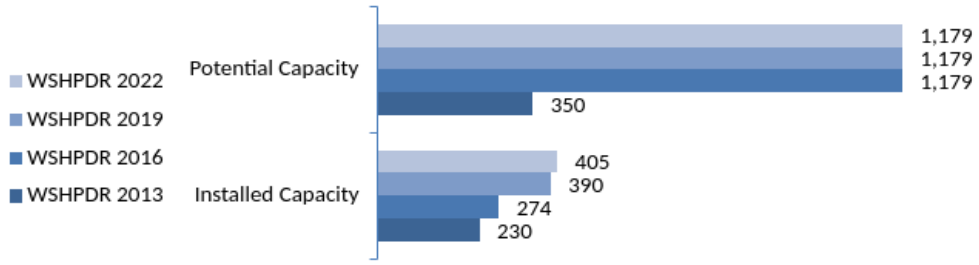

Figure 4. **Small Hydropower Capacities in the *WSHPDR* 2013/2016/2019/2022 in the United Kingdom (MW)**
Sources: DUKES,[12] *WSHPDR 2019,*[13] *WSHPDR 2016,*[14] *WSHPDR 2013*[15]

SHP capacity represents just under 10 per cent of total hydropower capacity in the UK. Due to its wet climate, mountainous terrain and plentiful rivers, the large majority of hydropower plants, including SHP plants, are located in Scotland, followed by Wales.[16,17] SHP development in the UK saw expedited growth in the decade since 2010 due to a feed-in tariff (FIT) implemented by the Government that was ended in October of 2019. These FITs, called the Microgeneration Certificate Scheme, were offered to SHP plants under 5 MW. Between 2010 and October of 2019, 1,216 SHP plants with a combined capacity of more than 224 MW were commissioned through this scheme.[18] A list of selected SHP plants is shown in Table 1.

Table 1. **List of Selected Small Hydropower Plants in Operation in the United Kingdom**

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Glen Noe	Scotland	2.0	RWE Npower	2021
Grudie	Scotland	2.0	RWE Npower	2017
Cia Aig	Scotland	3.0	RWE Npower	2016
Derrydarroch	Scotland	2.0	Temporis Capital	2015
Upper Falloch	Scotland	0.9	Temporis Capital	2015
Maldie	Scotland	4.0	RWE Npower	2013
Black Rock	Scotland	3.5	RWE Npower	2012
Allt Fionn	Scotland	2.1	Osspower Ltd	2012

Osspower	Scotland	2.0	Temporis Capital	2012
Selset	North England	0.8	RWE Npower	2010
Inverlael	Scotland	2.5	RWE Npower	2009
Carnoch	Scotland	1.4	RWE Npower	2009
River E	Scotland	3.0	RWE Npower	2008
Douglas Water	Scotland	3.0	RWE Npower	2008
Fasnakyle	Scotland	7.7	SSE Group	2006
Kiedler	North England	6.0	RWE Npower	2006
Inverbain	Scotland	1.0	RWE Npower	2006
Kingairloch	Scotland	3.5	SSE Group	2005
Garrogie	Scotland	2.4	RWE Npower	2005
Braevallich	Scotland	2.3	RWE Npower	2005

Sources: DUKES[16]

Due to the costs and concerns about its environmental impact, further large-scale hydropower development potential is limited, however, there is scope for exploiting the country's remaining SHP resources in a sustainable way. The good quality most financially viable sites have already been utilized or lie in protected regions of the Scottish Highlands and Snowdonia, Wales. The 2010 England and Wales Hydropower Resource Assessment Report has identified approximately 1,692 potential sites in England and Wales with combined capacity of between 146 MW and 248 MW.[19] A separate study of Scottish SHP potential carried out in 2008 modelled 36,252 separate sites that were deemed practically and technically feasible. Of these, 1,019 sites with a potential of 657 MW were deemed financially viable. More than half of these sites were estimated to have a capacity between 100 kW and 500 kW (Table 2).[20] Both studies, however, had lower limits in terms of the potential capacity of sites that were included. For the England and Wales study, a lower limit of 25 kW was set for remote sites and for the Scotland study there were limits of 100 kW for sites in the north of Scotland and 25 kW in the south. This means that a number of pico-hydropower sites were not included, in particular old water mills that could be modernized to generate electricity. With some estimates suggesting there could be 20,000 old water mill sites in England alone, there remains significant potential unaccounted for.[13]

Table 2. **Potential small hydropower plants in Scotland by capacity (MW)**

	<100 kW	*100 kW–500 kW*	*500 kW–1 MW*	*1 MW–5 MW*	*5 MW–10 MW*
Number of sites	6	537	300	170	6
Potential capacity (MW)	0.45	150.4	193.2	276.6	36.2

Source: SISTech et al.[20]

RENEWABLE ENERGY POLICY

National Renewable Energy Action Plan of 2009 set a target for 30 per cent of electricity be sourced with renewable energy by 2020, which was met on time.[21] Having achieved its own target of 31 per cent by 2013, Scotland set the ambitious renewable electricity target of 100 per cent by 2020. This target was almost met, with over 97 per cent of electricity consumption from renewable sources in Scotland in 2020.[22] The Energy White Paper of 2020 states that the UK plans to have 100 per cent renewable energy penetration and a fully decarbonized economy by 2050. However, a year later in October of 2021, the Government announced that the plan to be decarbonized should be achieved by 2035 instead.[23]

Major polices that have been passed in the past decade relating to renewable electricity generation include: the Renewable Obligation (RO), the main support mechanism for large-scale renewable projects; FITs for smaller-scale renewable projects; and Contracts for Difference (CfD). FITs for renewable energy were announced as part of the Energy Act 2008, came into effect in April 2010 and were ended in October 2019. The tariffs applied to electricity generated from plants of no more than 5 MW utilizing hydropower, solar photovoltaics (PV), wind power or anaerobic digestion with an eligibility period of 20 years. Micro combined heat and power (CHP) installations of 2 kW or less were also eligible. After their introduction, the FITs were slowly reduced at regular intervals until they were ended at the end of the decade.[13,18]

For plants greater than 5 MW, the RO was introduced in England and Wales in 2002 and in Northern Ireland in 2005. In Scotland a different but similar policy, Renewable Obligation (Scotland), was also introduced in 2002. The RO requires electricity suppliers to source an increasing proportion of electricity from renewable sources. In order to demonstrate they have met their obligation, suppliers must obtain Renewable Obligation Certificates (ROCs), which are issued to operators of accredited renewable energy plants. Where suppliers do not present a sufficient number of ROCs to meet their obligation, they must pay an equivalent amount into a buy-out fund. In March of 2017, the Government closed down ROCs for new generating capacities in favour of the new CfD scheme, but they are still in place for those using it prior to closure.[24]

The CfD scheme was introduced in 2013 and constitutes a contract between a low-carbon electricity generator and the state-owned Low Carbon Contracts Company (LCCC). According to the scheme, generators are paid the difference between the price for electricity given the cost of investing in a particular low-carbon technology and the country's average market price for electricity. According to the Government, the aim of the new scheme is to give generating companies more exposure to market forces in order to encourage greater efficiency, to reduce uncertainty of revenues and to protect consumers from paying higher costs.[25]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

All hydropower projects must obtain three permissions prior to construction and operation: an environmental licence granted by the relevant regional environmental agency, planning permission granted by the local council or National Park Authorities and accreditation to generate and export electricity provided by Ofgem. To build a new hydropower plant, the developer has to apply to the Environment Agency (environmental licence) for:

- an abstraction licence — if water is diverted or taken from a river or watercourse;
- an impoundment licence — if it is planned to build a dam or weir to hold back the flow of an inland water, or if it is planned to change an existing weir or structure as part of the scheme;
- a fish pass approval — if it is planned to install or modify fish passes as part of the scheme;
- an environmental permit for a flood risk activity — when the developer builds in, over or next to main rivers (for rivers and watercourses that are not main rivers the developer must apply to the lead local flood authority for consent).[26]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Barriers to SHP development in the UK include:

- Investment in new SHP plants is limited despite the renewable energy policies;
- The ending of the FIT scheme in 2019 without replacing it with other incentives to small-scale electricity generation;
- Various administrative deliverables needed including the initial financial outlays for the build and for the economic and environmental feasibility studies amongst others.[13]

Enablers for SHP development in the UK include:

- A liberalized sector allows for any company to begin generating electricity, no matter how small;
- There is still undeveloped potential in the country including the old water mills that can be modernized and incorporated into the grid;
- With the newly announced ambition to have a decarbonized energy sector in less than 15 years, SHP can be a key tool towards this goal as it has lower start-up costs and faster construction times than large projects.

REFERENCES

1. World Bank (2020). *Population, total – United Kingdom.* Available from https://data.worldbank.org/indicator/SP.POP.TOTL?locations=GB (Accessed 9 May 2022).
2. Encyclopædia Britannica (2022). *United Kingdom.* Available from https://www.britannica.com/place/United-Kingdom (Accessed 9 May 2022).
3. Government of the United Kingdom (2014). *Climate Change Explained.* Available from https://www.gov.uk/guidance/climate-change-explained (Accessed 9 May 2022).
4. World Bank (2020). *Access to Electricity (% of population) - United Kingdom.* Available from https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=GB (Accessed 10 May 2022).
5. Digest of UK Energy Statistics (DUKES) (2021). *Chapter 5: Statistics on Electricity from Generation Through to Sales.* Available from https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes (Accessed 10 May 2022).
6. Liu, J., Wang, J., & Cardinal, J. (2022). Evolution and reform of UK electricity market. *Renewable and Sustainable Energy Reviews*, 161, 112317. Available from https://www.sciencedirect.com/science/article/pii/S1364032122002313 (Accessed 10 May 2022).
7. The Sun (2021). *Who Are the Big Six Energy Suppliers?* Available from https://www.thesun.co.uk/money/16229912/who-big-six-energy-suppliers/ (Accessed 10 May 2022).
8. WSHP-19
9. EDF (2022). *You Pay your Electricity Bill but Do You Know the Real kWh Cost?* Available from https://www.edfenergy.com/for-home/energywise/what-is-kwh-guide (Accessed 10 May 2022).
10. E.ON Energy (2022). *Our Tariff Prices.* Available from https://www.eonenergy.com/gas-and-electricity/our-product-prices.html (Accessed 10 May 2022).

11. British Gas (2022). *The Energy Price Cap Has Increased.* Available from https://www.britishgas.co.uk/energy-price-news.html (Accessed 10 May 2022).
12. Digest of UK Energy Statistics (DUKES) (2021). *Chapter 6: Statistics on Energy from Renewable Sources.* Available from https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes (Accessed 12 May 2022).
13. CHENG, X., WANG, X., and Kremere, E., eds. (2019). *World Small Hydropower Development Report 2019.* United Nations Industrial Development Organization; International Center on Small Hydro Power. Available from www.smallhydroworld.org.
14. CHENG, X., Singh, P. R., WANG, X., and Kremere, E., eds. (2016). *World Small Hydropower Development Report 2016.* United Nations Industrial Development Organization; International Center on Small Hydro Power. Available from www.smallhydroworld.org.
15. LIU, H., Masera, D. and Esser, L., eds. (2013). *World Small Hydropower Development Report 2013.* United Nations Industrial Development Organization; International Center on Small Hydro Power. Available from www.smallhydroworld.org.
16. Digest of UK Energy Statistics (DUKES) (2021). *Chapter 5.11 Power Stations in the United Kingdom Operational at the End of May 2021.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1006721/DUKES_5.11.xls (Accessed 12 May 2022).
17. UK Electricity Production (2022). *Hydroelectric Plants.* Available from https://electricityproduction.uk/plant/hydro/ (Accessed 12 May 2022).
18. Digest of UK Energy Statistics (DUKES) (2019). *Monthly Feed-in Tariff Commissioned Installations.* Available from https://www.gov.uk/government/statistics/monthly-small-scale-renewable-deployment (Accessed 12 May 2022).
19. Department of Energy and Climate Change (DECC) (2010). *England and Wales Hydropower Resource Assessment.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47950/753-england-wales-hydropower-resource-assess.pdf (Accessed 12 May 2022).
20. Scottish Institute of Sustainable Technology (SISTech), Nick Forrest Associates Ltd and Black & Veatch Ltd (2008). *Scottish Hydropower Resource Study Final Report.* Available from https://www.webarchive.org.uk/wayback/archive/3000/https://www.gov.scot/Resource/Doc/917/0064958.pdf (Accessed 12 May 2022).
21. Government of the United Kingdom (2009). *National Renewable Energy Action Plan for the United Kingdom.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47871/25-nat-ren-energy-action-plan.pdf (Accessed 13 May 2022).
22. Government of Scotland (2021). *Energy Statistics for Scotland Q4 2020 Figures.* Available from https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2018/10/quarterly-energy-statistics-bulletins/documents/energy-statistics-summary---march-2021/energy-statistics-summary---march-2021/govscot:document/Scotland+Energy+Statistics+Q4+2020.pdf (Accessed 13 May 2022).
23. Department for Business, Energy & Industrial Strategy (2021). *Plans Unveiled to Decarbonise UK Power System by 2035.* Available from https://www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035 (Accessed 13 May 2022).
24. Office for Gas and Electricity Markets (Ofgem) (n.d.). *Renewables Obligation (RO).* Available from https://www.ofgem.gov.uk/environmental-and-social-schemes/renewables-obligation-ro#:~:text=Renewables%20Obligation%20Certificates%20(ROCs),they%20have%20met%20their%20obligation. (Accessed 13 May 2022).
25. Department for Business, Energy & Industrial Strategy (2022). *Contracts for Difference.* Available from https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference (Accessed 13 May 2022).
26. Environment Agency (2016). *New Hydropower Scheme: Apply to Build One.* Available from https://www.gov.uk/guidance/new-hydropower-scheme-apply-to-build-one (Accessed 13 May 2022).