Journal of Environmental Dynamics and Geo-Sciences

GLINT OPEN ACCESS

Volume 1, Issue 1

Research Article

Date of Submission: 28 October 2025
Date of Acceptance: 25 November 2025
Date of Publication: 02 December 2025

Approach Towards a Total UK Environmental Energy Master Plan for Clean Renewable Energy, Reviewing the Incompleteness of The British Energy Security Strategy After Brexit, and Embracing Tidal Waters and Other Innovative Sources

Version information

- Original version posted as preprint (SSRN): 13 June 2024
- Author-revised version completed: October 2025

Robert Castle Kempton[1]*
The Institution of Civil Engineers, Great George Street, London, UK.

***Corresponding Author:** Robert C Kempton, The Institution of Civil Engineers, Great George Street, London, UK.

Citation: Kempton, R. C. (2025). Approach Towards a Total UK Environmental Energy Master Plan for Clean Renewable Energy, Reviewing the Incompleteness of The British Energy Security Strategy After Brexit, and Embracing Tidal Waters and Other Innovative Sources. *Jor Environ Dyn Geo-Sci*. 1(1), 01-29.

Abstract

The British Isles, as an Island State, has a unique location on this planet, sitting at the top of the North Atlantic current, along the edge of the continental shelf and at the transition interface of two massive ocean masses. Vast kinetic energy resources are available for mankind, once additional methodologies have been developed, including also for near future projects. In addition, there are huge quantities of tidal energy linked to the present two main methodologies, which are conspicuously omitted from the present British Energy Security Strategy.

The incompleteness of the 'British Energy Security Strategy' requires a structured 'National Energy Master Plan Model', to adjust and transpose the UK approach, to introduce an effective 'high energy yield' power production, embracing clean energy requirements, and with linkage to the National Grid system, through a resilience approach towards energy storage, over a sustained 125-year life Span. This to include an Environmental Model 'Co-ordinate Programme' based on proven advanced project management solutions (APMS), to support all the country's energy requirements, coupled with the adaptation of present legal services regulations.

Keywords: Clean Renewable Energy, Biodiversity Ecosystem Exchange Procedures, Environmental Legislation Regulations, Environmental Financial Structure Plan, Additional Innovative 'Harnessing' Methodologies, Project Management

Introduction

Following Brexit, the UK has become an Island State, located at the northern tip of the Atlantic Gulf Stream, which has massive potential for a multiple number of large renewable energy projects, around the irregular shaped coastline and smaller Islands. Tidal energy is a clean, renewable, and totally sustainable resource, not influenced by weather conditions, not dependent on fossil fuels, but triggered by the permanency of the moon and earth cycles. Water's density far outweighs that of air, providing hugely more powerful energy than infrequent wind forces.

The west coast of the UK has one of the highest tidal ranges (up to 14metres), recorded in the world, with 8 No[2] schemes reaching protracted outline planning stages. A United Kingdom 'national structure plan framework' is proposed to manage a Master Plan for 'high energy yield' power production, embracing clean energy requirements over a 125-year life. This to encompass the environmental approach towards 'exchange balance biodiversity replacement' methodology techniques.

It is essential to harness the Wave Energy[3] around the British Isles, to embrace all the natural resources. An environmental Model 'co-ordinated programme' to be set up, structured, and developed, to embrace the eventual staged replacement of power stations at present in operation, and ensure a plentiful supply of clean energy for the nation.

Near future maritime Projects to be included in the Master Plan, to cover the research work for the additional tidal harnessing methodologies: along the Slope Current, located around the edge of the continental shelf.
This should also embrace the causation factor to erosion along the east and south coasts of England, and investigate methods of coastal protection, including 'Reef shield' protective measures.

Various important methodologies to harness these natural tidal waters around the UK require a National Structure Plan, to analyse and present real opportunities for a complete 'assessment/review'. Three important methods already identified include 'tidal range', 'tidal stream' and 'coastal barrage'. Additional ideas and methodologies should be investigated to the bathymetry of the UK Coastal waters, and between the numerous natural narrow channels of the small islands around the main UK coastline.

A National Environmental Impact Structured Assessment (EISA) to be considered for all UK Waters, to identify all prospective energy resources. This structure to embrace the full review of identified schemes, together with comparisons for long term replacement of existing power stations, based on the carbon zero approach and linked to suitable new regulatory measures.

Approach

The identification of main obstacles to, and resistance of, achieving the important UK Energy requirements, must be highlighted, and addressed. They are as follows:

- sustainability for an acceptable biodiversity ecosystem 'exchange', embracing local areas of coastal waters
- strong environmental regulations in support of future anthropogenic projects and

- providing a satisfactory financial structure for those projects. See Table 1.

UK Tidal Range Projects	Target Power Capacity (GW)[4]
Swansea Bay Lagoon	0.32
Wyre Barrage	0.1
Mostyn Docks	0.13
Severn Barrage	8.6
West Somerset Lagoon	2.5
Mersey Barrage or Lagoon	0.7
North Wales Lagoon	2.3
Morecambe Bay and Duddon Estuary	4

Table 1.

A structure plan for biodiversity and the ecosystems must be set out. This requires as a minimum, an acceptable 'exchange ecosystem and biodiversity' structure for the proposed environmental anthropogenic footprints, embracing the shallow waters. The present mapping and assessment of ecosystems and their services was issued through the european commission, as a mainly landlocked block, in 2020.

Following Brexit, it is now important to undertake a new strategy for the 'mapping and assessment' for the British Isles as an Island nation.

Strong environmental regulations are essential in support of the changes, and adaptations, that are required in support of future anthropogenic projects. It is proposed, as a first step, to formulate a framework for a 'Suite of EIA handbooks', to be used as essential tools for future work and policies. Reference Environmental Charts, Figure 2.

New environmental legislative powers are necessary, including adaptation to the Environmental Act 2023, which must be carefully linked into this approach, to allow for any necessary adjustments, together with inclusion for further 'climate change' and important but essential new 'plastics-policies'.

The important limb to identify the preferred approach for a strong 'Financial Structure Plan' must embrace the present security strategy to adopt the 'nuclear energy requirement', which is an important long-term measures.

England and Scotland have different approaches, though it must be recognised that the populations differ around tenfold. Consequently, the UK approach to ensure their security is a sensible decision, although coastal tidal power is conspicuously omitted, which demonstrates incompleteness. Indeed, once man has gained sufficient knowledge, to identify all important methodologies to harness the tidal waters and beyond[5], then the UK will have a plentiful supply of energy.

The present ongoing Nuclear Power Station remains the most expensive environmental energy project. The proposed string of 'small modular reactors' (SMRs), are at a fraction of the cost, and indeed are necessary as bridging projects, to provide that security strategy.

Table 2: UK Nuclear Power Stations.

Presently generating Power Stations:
Hinckley / Dungeness / Sizewell / Wylfa (Anglesey) / Heysham / Hartlepool / Torness (Scotland) / Hunterston (Scotland)
Confirmed new sites:
Hinckley / Oldbury / *Bradwell / Sizewell* / Wylfa / Heysham / Sellafield / Hartlepool.

The approach now presented, does not accept nuclear energy as the 'long term / permanent' strategy, and insists on a future founded on available clean energy. See Addendum D, the details of which are outside the scope of this paper.

Climate Change

Over a decade ago, the UK put into force the Climate Change Act [CCA] 2008[6], setting targets for a reduction of Greenhouse Gases [GHG] by 2050, to provide for a system of carbon budgeting[7] for the purpose of limiting GHG in the atmosphere. The Act established "The Committee on Climate Change[8]" [CCC] to assist in 'carbon management', to monitor, advise and report with 'carbon budgets', and on 'monitoring / control' procedures towards the 2050 target's[9] for reduction of GHG. Reference the environmental chart – History of Climate Change', section 8, Figure 3.

Carbon Management:
The British Standards Institute (BSI) fast tracked their specification for 'carbon management in Infrastructure,[10] in May 2016, to enable accuracy transparency, consistency, relevance, and completeness of carbon management and GHG emissions quantification. *"The scope of PAS 2080 is about carbon management as part of the wider climate change mitigation; it is not about wider environmental or sustainability issues"*[11]

Under the specification the management of 'whole life carbon' in UK infrastructure is defined as embracing the 'transport', 'energy', 'water', 'waste', and 'communication' sectors[12]. This management services covers the assessment, removal, and reduction of GHG emissions measured as 'carbon dioxide equivalent', which relates to and covers for the 6 gases quoted in the Kyoto protocol[13].

The methodology control procedures for the 'practitioner' calculating Infrastructure GHG emissions, is covered in the specification[14], which were responsible for **over half of the UK's GHG consumption in 2010 emissions**. (Table 3.)

CO_2e is a unit for comparing the radiative forcing of a greenhouse gas to carbon dioxide[15] and is calculated using the mass of a given GHG, multiplied by its global warming potential. 'GWP' which is the factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to an equivalent unit of CO_2 over a given period[16]. In 2019 the Climate Change Committee (CCC) Report, 'Net Zero - The UK's contribution to stopping global warming'[17], led to committing the UK Government by law *to reduce greenhouse gas emissions by at least 100% of 1990 levels by 2050, which relates to 'net zero'.*

Emissions soared **32 percent** between 2000 and 2010, and in 2020 totalled: 34.81 billion metric tons.

That year the outbreak of COVID-19 subsequently caused emissions to plummet.

UK GHGs *[Greenhouse Gases]*
Total Green House Gas) emissions in 2010:
UK Carbon emissions, including imported emissions… . 981Mt CO_2e.
UK Carbon emissions, excluding imported emissions 635Mt
UK Infrastructure emissions 515Mt CO_2e
UK Energy part ……303Mt CO_2e UK part
Transport UK part Transport…… 160 Mt CO_2e
UK part Water ……. 25 Mt CO_2e
UK part Waste …… 19 Mt CO_2e
UK part communications …… 8 Mt CO_2e
All figures sourced from Infrastructure review in Million tonnes CO_2e / year.

Table 3 – Emissions

The 'Office of Environmental Protection'[18] (OEP) is now responsible for Environmental governance, including environmental targets, environmental improvement plans, environmental monitoring, and importantly to embrace compliance with the five main environmental principles[19] recorded in the Environment Act 2021[20].

The environmental mechanisms for Climate Change is covered in detail in separate later papers.[21]

UK Ocean Currents

Legal definition of a continental shelf differs significantly from the geological definition. **UNCLOS**[22] states that the shelf extends to the limit of the 'continental margin', but no less than 200 nmi (370 km; 230 mi) and no more than 350 nmi (650 km; 400 mi) from the baseline (territorial waters). [nmi – nautical miles]

A **continental margin** is the outer edge of the continental crust abutting oceanic crust under coastal waters. It is one of the three major zones of the ocean floor, the other two being **deep-ocean basins** and **midocean ridges**. The continental margin consists of three different features: the **continental rise**, the **continental slope**, and the **continental shelf**.

The Rockall Trough (RT), located contiguously west of the British Isles, accommodates the warmest and saltiest branch of the North Atlantic Current, and discharges water from the Gulf stream into the marine environment around western Europe. In addition, the European Slope Current (ESC) carries warm water northward along the eastern boundary of the RT, and exchange between the ESC and the continental shelf, is a dominating factor in determining the oceanographic conditions around the British Isles[23].

Also, on the 'continental slope', tides cause a large wave to form on the thermocline and this breaks when it hits the continental shelf, causing mixing and nutrients to be brought closer to the surface. These features vary seasonally but are important sources of heat and nutrients and enhance plankton growth in the waters around Scotland. They form important habitat for fish which are the subject of commercial fisheries2[24].

The 'slope current' flows in a poleward direction along the edge of the continental slope with speeds in the range of 15 to 30 cm/s and centred approximately over the 400-500 m depth contour[25].

The bathymetry of the **continental slope** acts as a barrier between the open ocean and the shallow shelf sea systems. Mixing processes between these huge water masses are complex and not properly understood at present. *All along the west coast the major run-off from the estuaries, rivers and lochs significantly reduces the salinity of the shallow waters.*

The main tidal current circulation around the British Isles is clockwise[26], passing around the north-west coast of Scotland, and between Orkney / Shetland / Faroe cluster of Islands, and through to the Norwegian Trench which feeds into the North Sea. The circulation in the North Sea is generally anticlockwise[27].

Several localised areas experience very strong tidal currents: these include the area between Orkney and Shetland, the Pentland Firth[28], off the Mull of Kintyre and Hebrides[29]. The Scotland Government has endorsed a *'Tidal Stream' Project located between Stroma Island and the N/E end of Scottish mainland, at Pentland Firth.*

Tidal currents are mainly influenced by winds, difference in water density, sea level and planetary rotation. *Upon interaction with the UK bathymetry, tidal currents are magnified, particularly through the narrower passageways, Lochs and Firths of northern Scotland.*

Irish Sea

The semi-diurnal tides are the dominant physical process in the SEA 6[30] region, propagating into the Irish Sea from the Atlantic Ocean, through both the North Channel and the St. George's Channel[31].

The Irish Sea consists of a deeper channel in the west, with shallower embayment' in the east. The channel is open-ended, forming part of a loop connected at both ends to the Atlantic Ocean. Hence the Irish Sea receives Atlantic water and influences through both entrances[28][32].

The Irish Sea has a deeper channel about 300 km (190 mi) long and 30–50 km (20–30 mi) wide on its western side and shallower bays to the east. The depth of the western channel ranges from 80 metres (260 ft) to 275 m (900 ft). Cardigan Bay in the south, and the waters to the east of the Isle of Man, are less than 50 m (160 ft) deep[33].

In June 2020, Ireland's Government recognised *the enormous Blue Carbon potential that the Irish Sea has to offer in tackling climate change[34].*

North Sea

Most waters from the North Atlantic that enter the North Sea do so between Orkney and Shetland, around the north-east of Shetland and through the deep Norwegian Trench[31]. The non-tidal circulation in the North Sea is predominantly anticlockwise.
These currents form an anticlockwise (cyclonic) circulation around the shelf sea, with most of the outflow occurring via the Norwegian Trench.

At the southern end of the North Sea, a small inflow is via the English Channel through the 'Dover Strait' for approximately 6 hours (Flood Tide) to spread out in the North Sea, then

ceases and flows back from the North Sea for approximately 6.5 hours (Ebb Tide) back out again.

Identify Research into various methodologies to harness tidal energy

Present Methodologies.
The present recognised methodologies to harness tidal energy are classified under two main headings, Tidal Range and Tidal Stream.

Tidal Range projects generally cover surface waters across river estuaries or fencing off coastal strips, to form lagoons. In the UK the following present, but protracted schemes are, and remain under review, namely, Seven Barrage / Morecambe Bay and Dutton Estuary / Mersey Barrage (Lagoon) / Wyre Barrage. The only project example, so far in operation for the North Atlantic is the 'La Rance Tidal Power Station' in Brittany, which was opened in November 1966. See Appendix 3.

Tidal Stream projects harness the shallow waters under the water surface, around and contiguous to the UK coastline.
The 'MayGen Tidal Power Station', located in Scotland, is now under construction and an initial phase has commenced commercial operation. Ref: Comments Sheet in Appendix 4.
A major international 'tidal stream' proposal for the energy resources along the Kuroshio current in the northern Pacific Ocean, was investigated by Japan.

Next Generation Methodology Approaches

Arctic Ocean Deepwater current reaction to the continental bathymetric profile, contiguous to the continental shelf, is identified for research, to harness the massive potential energy resources. [Arctic Ocean Currents]

Initial investigations involving APMS tools [*Ref: Explanatory Note: Appendix 2.],* embracing 'Fluid Mechanics' and Oceanography disciplines, are under consideration for analysis, together with the 'mapping and assessment of ecosystems'[35], and bathymetric profile measurement equipment tools along the 'Slope Current' around the British Isles.
For the 'Slope Current'[36]**:** also refer to Japan's Kuroshio currents.[37]

Reefs: Ideas of 'offshore Reefs' for creation of energy collection buffers / 'potential' conversion of 'kinetic' energy techniques. Possible exploration locations, Jurassic Coast.

Other Innovative Energy Opportunities under Investigation – Ref: 'Tidal and other Innovative Methodologies for harnessing Earth's Energy'. Ref: Appendix 1.

Near future legislation for the High Seas, under the BBNJ Agreement[35]. This will open methodologies embracing the perpetual cycles of motion of the ocean masses.

Capture of coastal seas: The Irish Sea & North Sea, to create important wetlands areas. (Example: Zuider Zee)

Energy and Power Supply Statistics.

The analysis of Energy, Energy Storage and 'Carbon Capture Usage and Storage' (CCUS)36, is outside the scope of this paper, although it is important to record necessary

facts in the Addendum Index and 'Information Sheets'. *Reference to later paper on "A Concept of Energy, embracing Earth's Environmental Mechanisms."*[38]

Energy may be defined as the ability to do work. Mankind is learning how to transpose energy from one form to another to use it to do work.

Forms of known Energy are **Light / Chemical / Gravitational / Motion / Thermal / *Electrical / Magnetic***.

CCUS – Carbon Capture Utilization refers to a suite of technologies that enable the mitigation of carbon dioxide (CO2) emissions from large point sources, such as power plants, refineries and other industrial facilities, or the removal of existing CO2 from the atmosphere[39].

What is the role of CCUS in clean energy transitions? CCUS can be retrofitted to existing power and industrial plants, allowing for their continued operation. It can tackle emissions in hard-to-abate sectors, particularly heavy industries like cement, steel, or chemicals. CCUS is an enabler of least-cost low-carbon hydrogen production, which can support the decarbonisation of other parts of the energy system, such as industry, trucks, and ships. CCUS can remove CO2 from the air to balance emissions that are unavoidable or technically difficult to abate[40].

CCUS Example 1: World's first demonstration of underground CCUS, Norway[41].
CCUS Example 2: ***(Proposal):*** Net Zero Teesside Power's proposed combined cycle gas turbine electricity generating station, to have an electrical output of up to 860 megawatts (MW) of low carbon electricity, enough to power up to 1.3m homes per year. [From the power plant alone, the proposed carbon transportation and storage infrastructure will capture and store up to two million tonnes of CO2 a year.[42]] These types of proposals may help support the UK government's commitment to fully decarbonize power system in the UK by 2035.

Approach towards New Priority Legislative Regulatory Powers.
The UK government published its new British Energy Security Strategy[43] for renewable energy after Brexit. The strategy is aimed at a faster decarbonization with the approach to seek earlier energy security and independence.

The energy renewables targets included: offshore and onshore wind power / solar and related technologies / Nuclear / Hydrogen. The glaring omission was tidal power, as huge amounts of tidal energy await to be harnessed around the complete jagged coastline of the new UK Island State; enough energy to provide for the whole Nation and export to the neighbouring EU States as well, once the additional methodologies have been identified.
Urgent action is required for adjustment and change of the existing Energy Policy. This requires new priority legislation for a new long-term sustainability Energy Master Plan for fast tracking tidal high-yield energy power projects.

Tidal waters provide regular and reliable energy needs, as wind power is much less reliable. This fact has been recognised with Scottish Policy not including any new nuclear power

projects and instead relying on the rich energy resources around its Coastline and Islands. This is in the form of 'tidal stream' projects utilising the submerged tidal flows. However, the high-yield tidal energy opportunities mainly exist along the whole west coast of England, with the North Atlantic flow current providing 'high yield' green energy Tidal Range opportunities.

Present Government Policy will need complete overall and change, to allow for near future high-yield Tidal Energy Projects to proceed and end the protracted period of planning deliberations. At present 8 No. major 'Tidal Range' Projects along the west coast of England remain at the outline planning stage because of uncertain policy considerations. The cost of present nuclear power projects is higher than the proposed 'tidal stream' and 'tidal range' projects. ***Important Environmental Policies must be amended*** to allow for adjustment and alteration to the local footprints of proposed tidal power projects, to allow changed and acceptable alternative ecosystems. This is necessary to suit man's requirements for a *'new ecological equilibrium'*, as demonstrated in the 'La Rance' Tidal range power station[44] in Brittany. This Anthropogenic approach must embrace the need for the long term sustained environmental balance, around the nation's full coastal area for ecosystems and biodiversity.

It is equally important to embrace new legislation[45] covering the Agreement under 'UNCLOS, on the Conservation and Sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ)[46], which went into force on the 19th of September 2025 and awaits ratification. The BBNJ Agreement will come into effect after the 60th day of ratification[47] and directly relates to the High Seas. This paper proposes for the necessary inclusion of 'regional high seas' zones to be legalised, beyond the Continental Shelves and their Margins, to allow for renewable energy projects[48] which must embrace the passage of Ships, sailing vessels, and other forms of alternative 'wind energy converters'. New legislation regulations and project management tools (APMS) will be required to cover for marine genetic resources (MGR)[49], (MPAs)[50], and for capacity building[51] and technology transfer.[52]

The energy to travel the high seas, and for the kinetic energy forces harnessed from the movement of shipping, may be included in near future projects for energy collection, capture, and containment storage. The relentless movement of the ocean masses of the planet can provide ample energy, once Man's intelligence has identified such methodologies in near future projects.

An amendment to the Environment Act 2021[53] is required to add a new Part for 'Renewable Energy'[54], which is necessary following Putin's war in eastern Europe and its immediate effect on EU and UK policies.
A new legislative structured programme will need to be developed using the latest APMS (*'advanced project management* by solutions*)* by process, to determine the most effective approach to same.

Summary

Three limbs of the main obstacles to tidal energy for UK are discussed in this paper: sustainability for acceptable 'biodiversity / ecosystem exchange system' / strong

environmental regulations to support anthropogenic projects, coupled to a financial structure plan.

The management of whole life carbon in the UK energy sector, embraces the Carbon Management Services covering the methodology for the reduction of GHG emissions, measured as carbon dioxide equivalent.

The arctic ocean deep water current, contiguous to the continental shelf, along the 'slope current', is awaiting initial research, to cover essential bathymetric survey and mapping systems.

Energy research work, around the UK western coastal areas, along the 'Slope Current', is required to benefit from the plentiful potential energy forces available in and around the Rockall Trough. [55]

Several other near future projects mentioned in this paper, include Irish Sea Wetlands and International methodologies related to the high seas.

A Nuclear Energy Security Strategy Framework Model to be proposed for a run-down in 50 years, and a return for Total UK Clean Energy Policy in being developed. Near future opportunities, once the International BBNJ Agreement[56] is in force, should also be embraced within the Security Strategy.

The adaptation for new UK environmental legislative regulations, to embrace renewable energy and Climate Change, with amendments to the Environment Act 2021.

Conclusions

A Global Organization must be structured to replace Man's present fragmented and evolving systems, cluttered with a mix of multiple cultures, religious extremes, and comprising an erroneous patchwork of divisive boundaries denoting nations territories around the world. 'Population Growth' and 'uncertain principles' are further driving mankind's intention away from true Anthropogenic principles.

A National 'Environmental Impact Structured Assessment' (EISA) set of procedures are required to cover the Environment, including for UK Waters. A structured Suite of EIA handbooks to be introduced, to provide an effective tool for the monitoring / control set of procedures of these environmental services.

The introduction of a 'national project co-ordinate programme', aimed at the gradual relaxation of the security strategy, to return to the 'clean energy total plan' within 50 years, and embracing the target for a supply of 'total renewable clean energy' in 125 years. A UK Energy Model structured framework to be developed, to explore and identify new energy methodologies for harnessing of Tidal Energy, including other Innovative identified solutions to embrace Earth's plentiful supply of the Oceans' perpetual energy resources.

References

Table of Legislation (& related topics.)

Oceans and Law of the Sea, Division for Ocean Affairs and the Law of the Sea, United Nations Convention on the Law of the Sea of 10 December 1982. / Ibid, PART II, Territorial Sea and Contiguous Zone, Sections 1-4, Articles 2-33. / Ibid, Part VII, High Seas, Sections 1-2, Articles 86-120.

UNCLOS, BBNJ, Article 68 – Entry into force 1. *The Agreement shall enter into force 120 days after the date of deposit of the sixtieth instrument of ratification, approval, acceptance or accession.*

EU Commission, Global ocean conservation treaty enters into force, 20 sept 2025 https://ec.europa.eu/commission/presscorner/detail/da/ip_25_2151

UK Government, House of Commons Library, Biodiversity Beyond National Jurisdiction Bill [2024-25}, Research Briefing, 14 October 2025, By Elena Ares , Patrick Butchard.

Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ), New York, 20 September 2023 (BBNJ ratified 19 September 2025).

Energy Act 2023, UK Public General Acts, 2023 c. 52, Schedule 16 – Mergers of energy network enterprises.

Environment Act 2021, UK Public General Acts > 2021 c.30

Environmental Charts

1. Environmental Strategy for development of Energy Projects
2. Environmental Chart for Core Structure of Suite of EIA Handbooks
3. Chart – History of Climate Change

Appendices

1. Tidal and other Innovative Methodologies for harnessing Earth's Energy.
2. Explanatory Note: Advanced Project Management Services Solutions. [APMS]
3. Facts Sheet: 'La Rance Tidal Power Stations.'
4. Information Sheet: 'MayGen Tidal Power Project.

Addendum.

Not within the main scope of this Article
For reference / record purposes only, and linkage to referenced articles / papers.

A. Information Sheet. Energy, 'Energy Information – Organization –Regulations.
B. Information Sheet. Energy Storage.
C. Statistics'. - Power Consumption.
D. Nuclear Strategy Facts.

Environmental Charts:

Skeleton Spine Framework Chart

Environmental Strategy for the development of 'high energy yield Projects' to achieve carbon net zero target, review financial capital works costs and set out regulations, using advanced project management services tools.

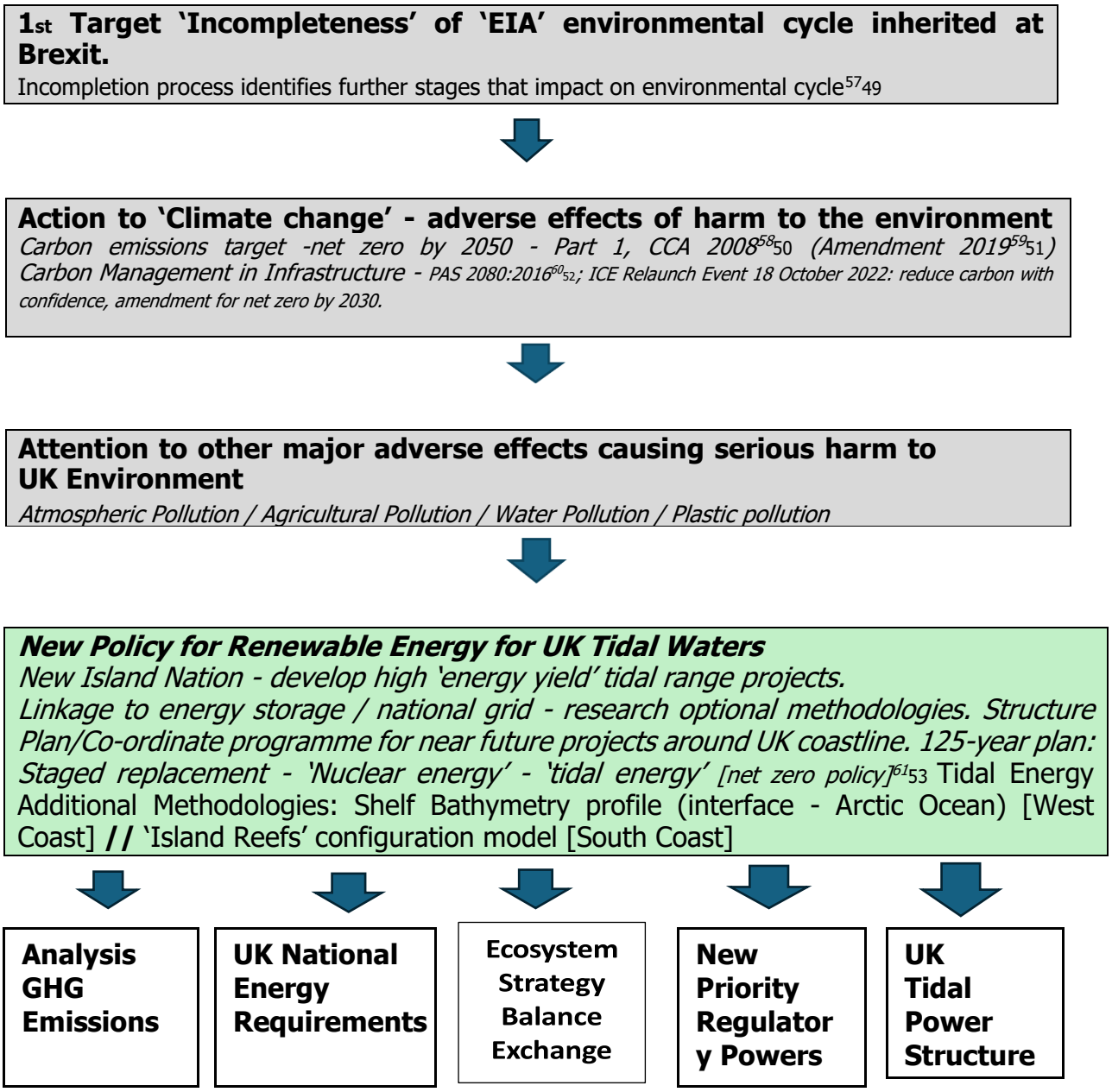

Figure 1

Environmental Chart for Core Structure ofSuite of EIA Handbooks

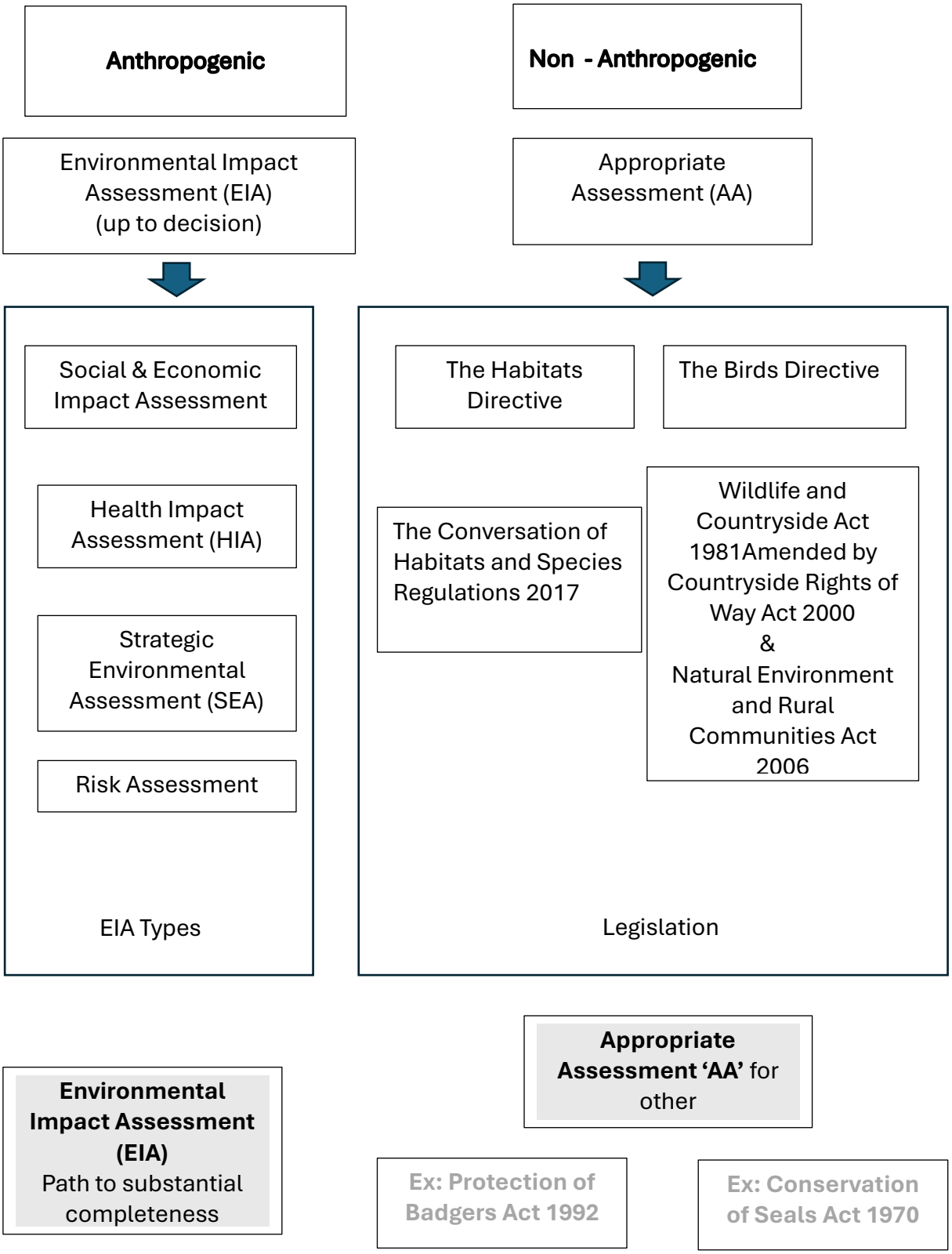

Figure 2

Chart – History of Climate Change

Figure 3

Appendix 1

Tidal and other Innovative Methodologies for harnessing Earth's Energy

Tidal Energy is predictable compared to **wind energy**, though its 'peaks and troughs' vary significantly, resulting in peak power requirements conflicting with high / low tides.
To ensure an even flow of electricity is fed to Nations Power distribution network, effective energy storage facilities must be provided, for short periods, to store peak energy flow, for dissipation at peak energy grid requirement.
Effective Methodologies for the development of 'high energy storage' techniques, is the key to unlocking the UK's future energy Projects.

Pumped hydro-electric facilities are presently the most common form of energy storage to the grid (presently over 95% of the storage in use today). During off-peak times, water turbines pump water to higher level reservoirs, later release the water to flow through the turbines to produce the electricity. The location(s) for such high-altitude reservoirs are the critical design feature criteria for this method. ***[Pumped hydro-electric energy storage (PHES) / Pumped-storage hydroelectricity (PSH)]***

In 2009, world pumped storage generating capacity was (Placeholder1)*104 GW,[27] while other sources claim 127 GW, which comprises the vast majority of all types of utility grade electric storage.[28] The EU had 38.3 GW net capacity (36.8% of world capacity) out of a total of 140 GW of hydropower and representing 5% of total net electrical capacity in the EU. Japan had 25.5 GW net capacity (24.5% of world capacity).[27]*

In 2010 the United States had 21.5 GW of pumped storage generating capacity (20.6% of world capacity).[29]

in 2020 in the United States, PSH contributed 21,073 GWh of energy, [62]***but −5,321 GWh (net) because more energy is consumed in pumping than is generated.[30]***

Nameplate pumped storage capacity had grown to 21.6 GW by 2014, with pumped storage comprising 97% of grid-scale energy storage in the United States. As of late 2014, there were 51 active project proposals with a total of 39 GW of new nameplate capacity across all stages of the FERC licensing process for new pumped storage hydroelectric plants in the United States, but no new plants were currently under construction in the United States at the time.

Thermal design systems[63], using heating and cooling systems to store and release energy.

Example: [64]Sand Battery: *The first commercial sand battery in the world is in a town called Kankaanpää* ***Tidal and other Innovative Methodologies for harnessing Earth's Energy****, Western Finland. It is connected to a district heating network and heating residential and commercial buildings such as family homes and the municipal swimming pool. The district heating network is operated by an energy utility called Vatajankoski.*

Grid-connected Renewable Energy Systems - (energy saver)[65]
Balance on system equipment requirement: power conditioning & safety, plus meters and equipment/ instrumentation

Appendix 2

Explanatory Note:
Advanced Project Management Services Solutions. [APMS]

[APMS] Proven projects are those which have been completed to satisfactory performance levels both in the UK, and Internationally, and carried out under Contract Law procedures, with the use of 'advanced project management services' solutions (APMS), in line with and supported by fiscal government policy, may be defined as:

"Advanced Project Management Solutions (APMS) are an integrated set of project management tools, which have been used in an integrated and co-ordinated way and proven on a number of major Projects to achieve good performance standards over a number of years".

Examples of proven performance standard.

1. The ***Salford Quays Project*** covered the reclamation and redevelopment of a redundant inner city brownfield site, with contaminated land and water areas[66]. Once Salford City Council (SCC) had presented a comprehensive 'Project Co-ordinate Programme'[67] to the 'Department of the Environment' (DoE), 'derelict land grant funding'[68] was released for the five-year programme (1989 – 1993) of works and attracted EU and other support funding packages. The full project embraced over 100 No. Infrastructure Contracts and attracted over 20 separate development projects. It was completed without any major claims. The *'project co-ordinate programme'* is one such integrated APMS document tool, which achieved proven performance for the City Council (SCC) and the (DoE).

2. **The International *Islamabad Sewage Treatment Plant[69]*** *Project* covered the construction of an integrated Sewage Treatment Plant carried out under a French Soft Loan (2005 - 2008) for the Capital Development Authority (CDA), Islamabad. A Taking-Over Certificate was issued for the Whole of the Works, on 18th August 2007 to timescale and budget, despite the major Earthquake in the region in early October 2005. A 'Project Supervision Structure Plan' was adopted for this Project.

3. In the ***Fethiye Sewerage Project****, Supervision Services* APMS tools were used, including: 'Tests on Completion (TOC) Structure Plan', 'Project Coordinate Programme' and 'monitoring / control procedures', to achieve the Municipality (FESKI)[70] requirements for '*early commercial operation'* for their new Wastewater Treatment Plant[71], in December 2003. This was achieved prior to Turkey's National Elections in 2004. The project ceased the discharge of raw sewage to the Mediterranean Sea prior to the start of the Tourist season in 2004, for this popular holiday resort location.

4. ***The 'Greater Irbid Environmental Project',*** for the City of Irbid, in Jordan, and

the adjacent town of An-Nu'ayyima and collecting villages, embraced the construction of new Wastewater Treatment Plants for 'Wadi Arab' and 'Wadi Hassan'. 'APMS' tools were used and included: 'Project Supervision Structure Plan', 'Tests on Completion Structure Plan' and an 'Approach towards the target Project Completion', in order to recover the heavily delayed project comprising of 7 No. separate Contracts, to achieve a completion of the *Wadi Arab Project*[72], to an adjusted timescale deadline, for the soft opening by Prince Hassan of Jordan and President Roman Herzog of Germany, during the commissioning period in 1999/2000. Project Completion Reports were submitted and endorsed to the satisfaction of the Employer, ''Water Authority of Jordan' (WAJ) and 'German Financing Agency'[73](KfW).

5. **Eldoret Water Supply Project (1992 – 1995):** APMS tools were adopted in the summer of 1993, to ensure the timely completion for this Project in northern Kenya. This, environmental project provided all water supply needs for an area of northern Kenya. APMS tools were adopted in 1993 for the construction of an Earth Dam, new Water Treatment Plant complex, 50km pipeline aqueduct, service Reservoir and reticulation system for the township of Eldoret, (KfW funding), with commercial operation achieved in 1995, through local consultant 'Mangat IB Patel and Partners'.

Appendix 3

Facts Sheet
La Rance Tidal Power Station[74]

Tidal Energy Capacities & Parameters

Peak Rating: 240 MW with av. 96MW & annual output approx. 600 GWh. 24 Turbines
0.012% France's power demand
760 m. long (W) / Brebis point to Briantais point (E)
332.5M long power plan portion.

- World's 2nd biggest tidal power station. Opened 26 November 1966.
- Located on Rance river Estuary, Brittany, Fr.
- Tidal range of 8.2m av. / 13.5m maximum
- Reservoir: 184,000,000m^3 / 22km2 footprint / max^{im} flow 9,600m^3/s
- Construction Period: January 1961: September 1967
- Operated by EDF

Environmental points *on record through construction / early operation period*:

- Barrage caused progressive silting of Rance ecosystem.
- Sand Eels and plaice have disappeared / sea bass & cuttlefish have returned.
- Tides still flow in estuary & EDF adjusts level to minimise biological impact.
- Full scale evaluation of ecological impact during years of operation.
- Significant impact during construction phases and closing of river with disappearance

of flora and fauna.

- *"New ecological equilibrium established in 10 years but remains fragile";* this linked to degree stability of abiotic conditions.
- *"By 1976, the Rance estuary was considered again as richly diversified: a new biological equilibrium was reached, and aquatic life was flourishing again"*[75].

Appendix 4

Information Sheet
MeyGen tidal power project[76]

Tidal energy project expected to generate power for 175,000 homes. *Location*: north-east tip of Scotland, 3.5km length in Pentland Firth, Stroma Island to mainland. Water flows North Sea to Atlantic. (Among fastest flowing waters in UK
MeyGen, (Atlantis Resources subsidiary) secured Agreement for Lease from UK's Crown Estate for tidal energy development of 398MW IN 2010.

Phase 1A: installed capacity 6MW, commissioned in April 2018
four horizontal axis underwater tidal turbines: 1.5MW capacity
Phase 1B: expected capacity 4MW, programmed for 2020.
Phase 1C: expected capacity 73.5MW
Phase 2: planned capacity 252MW
Phase 3: planned capacity 398MW

Lead in Period for Phase 1A.

- *Scottish Government awarded consent for the construction and operation of phase one with installed capacity up to 86MW in 2013*
- *marine license was granted in January 2014*
- *award construction contracts for Phase 1A in September 2014*
- *onshore construction works started January 2015, followed by start offshore works October 2015.*
- *Offshore installation works for initial 6MW project completed October 2016*
- *electricity to grid in November 2016*

Phase 1A consists of four horizontal axis underwater tidal turbines:
one Lockheed Martin-designed AR1500 turbine from Atlantis Resources three AH1000 MK1 turbines from Andritz Hydro Hammerfest.
18m-diameter rotor, each turbine rated capacity of 1.5MW speed of 3m/s.
turbine foundation: three-legged foundation wt. approx. 350t, each leg supported by two 200t ballast blocks (horizontal stability).

Electricity generated by each turbine brought onshore to power conversion centre at Ness of Quays via horizontal directional drilling.

Low-voltage supply converted into 33kV at conversion centre before connection into local grid network.

Phase 1B: installation of 2 No. AR2000 turbines (developed by Atlantis and GE), each with 2MW output at 3,05m/s.

Project Stroma also includes a Subsea connection hub at the site, allowing for multiple turbine connections to the single power export cable.

Phase 1C: Installation of 49 No. under-water turbines total capacity 73.5MW. Phase 1C Project estimated at £420M.

Contractors Design / Build Information:

Atlantis /GE: Performance validation -AR2000 Tidal Generator system (September 2018)

Phase 1A project: ABB main contractor for onshore construction activities and grid-connection. Civil Works subcontractor John Gunn & Son.

James Fisher Marine Services main contractor for offshore construction works, including installation of tidal turbines and subsea cables. Also selected as the (O&M) service provider for the Phase 1A tidal turbines for a period of five years, in September 2016.

Andritz hydro Hammerfest and Atlantis Resources provided three AH1000 MK1 turbines and one AR1500 turbine, respectively.

JDR Cable Systems designed / supplied subsea cable for the project. O'Connor

Utilities horizontal directionally drilled (HDD) bores.

Phase 1B: GE's Power Conversion selected as preferred supplier for electrical systems including power converters (June 2019).

Phase 1B: ETA (subsea cable specialist) contracted to design and deliver the subsea tidal turbine connection system. (February 2019)

Addendum A

Information Sheet
Energy: Information - Organization – Regulations.
Energy Act 2023 – UK Public General Acts > 2023 c. 52. Table of Contents

Classification types: Potential (stored) / **Kinetic** (working force).

- **Light:** Photosynthesis
- **Chemical Energy**: is energy stored in the bonds of chemical compounds, such as sugar and gasoline.
- **Gravitational Energy**: is the energy stored in an object due to its height, above a base; surface of Earth.
- **Thermal Energy**: Chemical energy comes in different forms and may be released during a chemical reaction, usually in the form of heat.

Photosynthesis: Chlorophyll is a pigment that gives plants their green colour, and it helps plants create their own food through photosynthesis.
*- the **Chlorophyll** molecular structure consists of a 'chlorin' ring (4 nitrogen atoms), surrounding a magnesium atom; it has several other side chains and a hydrocarbon tail.*
[Chlorophyll a-C58H12O5N4Mg // Chlorophyll d- C54H70MgO6N4 // Phytol-C20H40O]
Analyse the Process and prepare a structured methodology[77].

Energised Carbon[78]:
Preferred carbon comes from near the Arctic Circle, in the peat bogs of northern Canada. It contains no heavy metals or additional salts, making it a pure, quality source.
Activated with food-grade potassium hydroxide: *Unprocessed carbon granules and powders are ineffective.* Extracts of pure carbon from raw material activates with food-grade potassium hydroxide.
This produces a 'humic'[79] that benefits plants and soil microbes.

ESO Strategy – 2024 - The new organisation will be operational in Summer 2024 Major component of last Autumn's Energy Act moving forward at pace
The new organisation will be known as *"National Energy System Operator"* (NESO)
A public corporation, NESO will be an independent, expert, and impartial organisation.
NESO will be responsible for coordinating across the whole energy system and considering the connections between energy vectors and their relationship with the wider system.

Organization – Bodies - Regulations:
UK: Ofgem is the Office of Gas and Electricity Markets.
https://www.ofgem.gov.uk/#:~:text=Ofgem%20is%20the%20Office%20of%20Gas%20and%20Electrici ty%20Markets.
Electricity System Operator (ESO) regulation: National Energy System Operator (NESO) will be a new, independent, public corporation that will be responsible for planning Britain's electricity and gas networks and operating the electricity system.

References (PNNL Contacts) https://www.pnnl.gov/explainer-articles/types-batteries Oxford University: Chemical Storage / Electrochemical Storage[80]

Energy Act 2023 – UK Public General Acts > 2023 c. 52. Table of Contents
Content Structure:
Explanatory Notes: Text created by the government department responsible for the subject matter of the Act to explain what the Act sets out to achieve and to make the Act accessible to readers who are not legally qualified. Explanatory Notes were introduced in 1999 and accompany all Public Acts – *Reference Policy & Legal Backgrounds.*
More Resources: *Access essential accompanying documents and information for this legislation item*

Introductory Text: An Act to make provision about energy production and security and the regulation of the energy market, **including:**

- **provision about the licensing of carbon dioxide transport and storage.**
- **about commercial arrangements for carbon capture and storage and for hydrogen production and transportation**,
- new technology, including low-carbon heat schemes and hydrogen grid trials.
- the Independent System Operator and Planner; about gas and electricity industry codes.
- financial support for persons carrying on energy-intensive activities.
- heat networks.
- energy smart appliances and load control.
- the energy performance of premises; about energy savings opportunity schemes.
- the resilience of the core fuel sector.
- offshore energy production, including environmental protection, licensing, and decommissioning; the civil nuclear sector, including the Civil Nuclear Constabulary and pensions; and for connected purposes. [26th October 2023]

Energy Act 2023: Structured format:
Part 1 Licencing of Carbon dioxide transport and storage [regs 1-55]
Part 2 Carbon Dioxide capture, storage etc and hydrogen production, transport, and storage. [regs 56-129]
Part 3 Licencing of hydrogen pipeline products. [130-142]
Part 4 New Technology [143–160]
Part 5 Independent System Operator and Planner. [161-181]
Part 6 Government of gas and electricity industry codes. [182-201]
Part 7 Market reform and consumer protection. [202-215]
Part 8 Heat Remarks. [216-237]
Part 9 Energy smart appliances and load control. [238-253]
Part 10 Energy performance of premises. [250-253]
Part 11 Energy Savings Opportunity Schemes. [254-266]
Part 12 Core fuel sector resilience. [267-289]
Part 13 Offshore wind electricity generation, oil, and gas. [290-301]
Part 14 Civil nuclear sector. [302-329]
Part 15 General. [330-335]
Schedules
Schedules 1 – 22
1 Interim power of Secretary of State to grant licences.
2 Procedure for appeals under section 20.

3 Enforcement of obligations of licence holders.
4 Transfer schemes.
5 Amendments related to Part 1.
6 Carbon dioxide storage licences: licence provisions
7 Permitted disclosures of material obtained by OGA.
8 Caron storage information and samples.
9 Independent System Operator and Planner: transfers.
10 Independent System Operator and Planner: pensions.
11 Minor and consequential amendments relating to Part 5.
12 Governance of gas and electricity industry codes: transitional provision.
13 Governance of gas and electricity industry codes: pensions
14 Minor and consequential amendments relating to Part 6.
15 Competitive tenders for electricity projects.
16 Mergers of energy network enterprises.
17 multi-purpose interconnectors: consequential amendments.
18 Heat networks regulation.
19 Licences of activities relating to load control.
20 Enforcement Undertakings.
21 Petroleum licences: amendments to model clauses.
22 Accession to Convention on Supplementary Compensation for Nuclear Damage

Addendum B

Information Sheet

Subject: Energy Storage

UK, BESS (Battery Energy Storage System)[81]

Battery Energy Storage Systems, or BESS, are rechargeable batteries that can store energy from different sources and discharge it when needed. BESS consist of one or more batteries and can be used to balance the electric grid, provide backup power, and improve grid stability.

BESS - Types of Cables[82] Eland cables offers a range of cables, such as the FHL2G and FHLR2GCB2G cables compatible with battery storage including:

- **LFP battery**: lithium iron phosphate battery (LiFePO battery or LFP battery). Common applications include vehicle use, utility-scale stationary applications including domestic PV installations, and backup power.
- **Sodium Nickel battery**: Sodium-nickel chloride battery (Na-NiCl2) with applications in EVs, HEVs (hybrid electric vehicle), trucks, buses, and vans, as well as stationary field and distributed renewable generators (micro wind turbines and large PV plants).
- **NMC battery:** Lithium nickel manganese cobalt oxides (abbreviated Li-NMC, LNMC or NMC) used widely in major car manufacturer EV brands including BMW i8, Audi e-tron GE, BMW i3, Chevrolet Bolt, Hyundai Kona Electric, Jaguar I-Pace, Nissan Leaf, Renault ZOE, and the VW e-Golf.
- **NCA battery**: Lithium nickel cobalt aluminium oxides (NCA): Used by Tesla in their EV model traction batteries.

Pacific Northwest National Laboratories (PNNL): Researchers. Next generation batteries to improve reliability and resilience of electric grid in a decarbonised, electrified future. Flow Batteries provide long-lasting, rechargeable energy storage, particularly for grid reliability.

New EU Batteries Regulation, EU Batteries Regulation 2023/1542, 17 August 2023 replacing the EU Directive. EU Batteries Regulation 2023/1542 covers the whole life cycle of batteries from production to reuse and recycling.
1st EU Legislation: EU Directive on Batteries and Accumulators [2006/66/EC]
The Regulation covers five battery types [not 3] differentiated by application and weight: Portable Batteries / Electrical. Vehicle [EV] batteries / Industrial batteries, with sub-category: stationary battery energy storage systems / Light means of transport [LMT] batteries / Starting, lighting and ignition [SLI] batteries.
New Regulation is divided into 14 chapters and addresses topics including: sustainability /Recycling / Responsible sourcing / Carbon footprint reduction / European battery market competitiveness / Extended producer responsibility [EPR] Project Experience: Ramboll advises the client on the implications[83].

Addendum C

Statistics'.
Power Consumption.

UK Responsible Bodies:
Department for Energy Security & Net Zero, publish Energy Consumption in the UK (ECUK) 1970 TO 2022
Electricity consumption from all electricity suppliers in the United Kingdom (UK) from 2000 to 2023 are published under the Statista webpage.[84]

BEIS - Business, Energy, and Industrial Strategy (BEIS)- formed after Brexit. In 2023 restructured to:
- **Department for Business and Trade (DBT),**
- **Department for Energy Security and Net Zero (DESNZ)**
- **Department for Science, Innovation and Technology (DSIT)**

National statistics are published under:
Digest of UK Energy Statistics (DUKES) 2022 – published by BEIS.
Digest of UK Energy Statistics (DUKES) 2022: chapters 1-7, annexes A to J and supporting data table. **Reference: Chapter 5: Electricity Flow Chart 2021 (TWh)** mailto:electricitystatistics@beis.gov.uk
ps://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2022

(ECUK[85]): Energy Consumption in the United Kingdom': annual statistical publication, with a particular focus on trends since 2000. Covers 5 themes: Overall energy consumption in the UK / Energy intensity by sector / Primary energy consumption / End uses / Electrical products and stock.

Energy Consumption in the UK, ECUK, Department for Energy Security at net zero.

Energy Units: Normally the consumption is given in TWh, which is an energy unit.
[One TW corresponds to 8,760 TWh per year.] / *[Watt(W), 1 joule/ sec. (j/s)- unit of power]*
Terawatt hour (TWh) **unit of energy to express amount of produced energy, electricity,**
and heat. 1 TWh = 1,000 GWh = 1,000,000 000 kWh; 1 TJ= 0.278 GWh

Background:
The United Kingdom's electricity use declining since peaking at 357 terawatt-hours in 2005. In 2023, UK's electricity consumption fell to its lowest level this century, 266 **TWh.**18 Apr'24

2018 - 332.9 TWh (26 Mar 2020)
2019 - 323.7 TWh, a decrease of 2.8 per cent – *Covid effect*
2020 - 330.07 TWh - *Covid effect*
2021 – 333.0 TWh
2022 - 325.3 TWh, up 5.3 per cent compared to 2021.

UK Power Consumption Information: [333.2 TWh in 2021]

- 2021 electricity consumption - 2nd lowest this century - 294.4 terawatt-hrs.[86]
- Total electricity supplied in 2021 was **333.2 TWh**, with net imports of **24.6 TWh**, 7.4 per cent of electricity supplied. Electricity generation fell to a record low of 308.7 TWh in 2021, 1.2 % less than 2020. From **renewable sources decreased 9.3 % to 122.2 TWh in 2021.**
- ESO's analysis (2022), energy mix UK: Gas- 38.5% Wind- 26.8% Nuclear- 15.5% 3 Feb 2023. *To be read in conjunction with Grid Augmentation.*

Addendum D

File Note Nuclear Strategy Facts

1.Important supportive Note: Nuclear power is an important low-emission source of electricity, providing about 10% of global electricity generation. For those countries where it is accepted, it can complement renewables in cutting power sector emissions while also contributing to electricity security as a dispatchable power source. It is also capable of producing low-emission heat and hydrogen.
References: 'Nuclear power in the UK' - House of Lords Library[87]

2.Power Station Locations:
Presently generating: Hinckley / Dungeness / Sizewell / Wylfa (Anglesey) / Heysham / Hartlepool / Torness (Scotland) / Hunterston (Scotland)
Confirmed new sites: Hinckley / Oldbury / *Bradwell / Sizewell* / Wylfa / Heysham / Sellafield / Hartlepool.

3.UK Nuclear Power: [24 GW target for 2050]
The proportion of electricity generated by nuclear power in the UK has declined since the 1990's, with all nuclear power stations except one set to close by 2030. The Government has stated an ambition of up to 24 GW of new nuclear power stations by 2050, which will

include the under-construction Hinkley Point C and proposed Sizewell C reactors. Beyond this though, the optimal potential contributions of current and proposed technologies are less clear, if required at all to help meet emissions reduction targets.[88]

4.Status of nuclear power in the UK[89]
Nuclear UK Annual figures highlights:
In 2017, UK's av. nuclear load factor 77.4%. See 'special feature'[90]
In 2018, UK's 8 Nuclear power stations - supply 18.7% total electricity[91]
In 2019, nuclear supplied 17% of the country's electricity. This energy comes from 13 nuclear reactors at six plants, though at any time some of these reactors are not operating because of planned or unplanned shutdowns.
In 2020, 16% of the UK's electricity came from nuclear power plants[92], and only one new plant, Hinkley Point C, is currently under construction[93].

5.Small modular reactors (SMRs) are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, which is about one-third of the generating capacity of traditional nuclear power reactors. SMRs, which can produce a large amount of low-carbon electricity, are:
Small – physically a fraction of the size of a conventional nuclear power reactor.
Modular – making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.
Definition: **Reactors –** harnessing nuclear fission to generate heat to produce energy.

6.Storage and Disposal of Radioactive Waste Near-surface disposal facilities at ground level are currently in operation in the **UK at LLW Repository at Drigg in Cumbria,** operated by UK Nuclear Waste Management (a consortium led by AECOM with Studsvik UK, Serco, and Orono on behalf of the Nuclear Decommissioning Authority.

7. Decommissioning of a nuclear installation, such as a power plant or research reactor, is the final step in its lifecycle. It involves activities from shutdown and removal of nuclear material to the environmental restoration of the site. The whole process is complex and typically takes 20 to 30 years to complete[94].

8. Government policy (Comment): The Government has said that new nuclear power is an important part of meeting its carbon reduction target. While the Government emphasises its commitment to renewable energy generation, it argues that ensuring the energy system is reliable means "intermittent renewables need to be complemented by technologies which provide power, or reduce demand, when the wind is not blowing, or the sun does not shine". One of these technologies, says the Government, is nuclear power. "Delivering new and advanced nuclear power" was the third of ten points listed in the Government's Ten Point Plan for a Green Industrial Revolution, published in November 2020, and reiterated in the Government's December 2020 energy white paper. The white paper listed offshore wind, nuclear power, and hydrogen as key to decarbonising the country's energy system.

9. Statistics at end 2025

1. ONR[95], the Office for Nuclear Regulation presently regulate the UK's [96]15 civil nuclear reactors[97], Three[98] have ceased generating, at Hunterston B, Hinkley Point B, and

Dungeness. They have begun defueling, the last phase of operations prior to decommissioning.

2. The government has named UK six nuclear sites currently being decommissioned[99] where there is interest in establishing new nuclear developments.
3. Two[100] UK nuclear plans are to generate for longer to support energy security for the UK.
4. UK's 15 civil nuclear reactors, which consist of 14 Advanced Gas-cooled Reactors (AGR) and one Pressurised Water Reactor (PWR) operated by EDF.

UK 15 No. Reactors	
2 AGRS	Dungeness B
2 AGRS	Hartlepool
2 AGRS	Heysham 1
2 AGRS	Heysham 2
2 AGRS	Hinkley Point B
2 AGRS	Hunterston B
1 PWR	Sizewell B
2 AGRS	Torness

Footnotes

[1] Kempton, Robert, Restructuring of the Environmental Impact Process (EIA) after Brexit for Incompleteness (November 18, 2023). Available at SSRN: https://ssrn.com/abstract=4647130 or http://dx.doi.org/10.2139/ssrn.4647130 /
- Kempton, R. Restructuring of the Environmental Impact Process (EIA) AFTER Brexit for Incompleteness. Preprints 2023, 2023120085. https://doi.org/10.20944/preprints202312.0085.v1

[2] Seven Barrage / West Somerset Lagoon / Swansea Bay Lagoon / Wyre Barrage / Mostyn Docks / Mersey Barrage or Lagoon / North Wales Lagoon / Morecambe Bay and Duddon Estuary, https://www.newcivilengineer.com/latest/how-tidal-range-and-tidal-stream-projects-could-play-a-key-role-in-uk-energy-mix-03-02-2023/

[3] Wave Energy crucial to UK's clean energy ambitions, Mal Mace, 5th March 2024, hJps://www.edie.net/wave-energy-crucial-to-uks-clean-power-ambi@ons-report-finds/

[4] GW= billion watts

[5][5] Agreement, under the UN Conventions on the Law of the Sea on the Conservation and Sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ).

[6] Climate Change Act 2008, UK Public General Acts, 2008, c 27

[7] ibid, Part 1, Carbon Budgeting, regs, 4-10

[8] ibid, Part 2, The Committee on Climate Change, regs (32((33)(34)(35)(36)(37)(38)(39)(40)(41)(42) (43).

[9] ibid, Part 1, Carbon Targeting and budgeting, The target for 2050, s1

[10] PAS 2080:2016, British Standard Institute Publicly Available Specification, Carbon Management in infrastructure, Construction Leadership Council, The Green Construction Board, 4 May 2016.

[11] Ibid, 1 Scope, Table 1, The scope of PAS 2080

[12] Ibid, 1 Scope, lines 1-3.

[13] Ibid, 3.17 greenhouse gases (GHGs), NOTE 2.

[14] ibid, 7 Quantification of GHG emissions, 7.1.4 quantitative methodology.

[15] Ibid, 3.7 carbon dioxide equivalent (CO_2e); [BS ISO 14064-1]: 2006; pas 2050: 2011]

[16] Ibid,3.16 global warming potential (GWP); BS ISO 14084-1: 2006

[17] Net Zero, The UK's contribution to stopping global warming, Committee on Climate Change, May 2019. https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

[18] Environment Act 2021, UK Public General Acts, 2021, c 30, Chapter 2, The Office for Environmental Protection, s 22 - 43

[19] ibid, Reg. 17(1)(2)(3)(4)(a)(b)(5)(a)(b)(c)(d)(e)

[20] GOV.UK Improvement Plan 2023. https://assets.publishing.service.gov.uk/media/64a6d9c1c531eb000c64fffa/environmental-improvement-plan-2023.pdf

[21] A Concept of Energy, Embracing Earth's Environmental Mechanisms, 4 Climate Change, 2025

[22] United Nations Convention on the Law of the Sea

[23] "North Atlantic Current and European Slope Current Circulation in the Rockall Trough Observed Using Moorings and Gliders", Neill J Frazer et al, JGR Oceans – Research Article, 1st published 29 November 2022, https://doi.org/10.1029/2022jc019291

[24] Scotland's Marine Atlas: Information for The National Plan, Strategy / Plan published 16 March 2011, Part of Marine and Fisheries, ISBN 9870755982547, https://www.gov.scot/publications/scotlands-marine-atlas-information-national-marine-plan/

[25] Ibid

[26] Currents and Circulations - Scotland's Marine Atlas
[27] Currents and Circulations, Scotland's Marine Atlas, 16 March 2011,
[28] Reference: Appendix 4, Information Sheet - 'MeyGen' Tidal Power Project
[29] Marine-Scotland assessment, Scottish Government, *Circulation.*
https://marine.gov.scot/sma/assessment/circulation
[30] Hydrography of the Irish Sea SEA6 Technical Report POL Internal Document 174 M.J. Howarth,
[31]hJps://assets.publishing.service.gov.uk/media/5a7a1b7840f0b66a2qfff19/SEA6_Hydrography_POL.pdf
[32] https://en.wikipedia.org/wiki/Irish_Sea
[33] Reference: hJps://irishriverproject.com/wp-content/uploads/2021/11/blue-carbon-in-irish-waters-and-coastal-habitats_marine-ins@tute-report_may-2021.pdf
[34] Scotland's Marine Atlas: Information for the National Marine Plan, Published, **16 March 2011**
Part of Marine and Fisheries, ISBN 9870755982547
[35] Mapping and Assessment of Ecosystems and their Services, European Commission, 2nd Report - Final, February 2014
[36] hJps://doi.org/10.1029/2022JC019291
[37] Renewable Energy 91 (2016) 189e195 ; Experimental verification of a floating ocean-current turbine with a single rotor for use in Kuroshio currents
[38] A Concept of Energy, embracing Earth's Environmental Mechanisms, SSRN, posted 30 Jul 2025.
[39] What is carbon capture, usage, and storage (CCUS) and what role can it play in tackling climate change? 13 March 2023, LSE Home, https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/
[40] General Reference: *"Going Underground, Can, carbon capture and storage help the UK reach net zero. https://www.bgs.ac.uk/news/going-underground/*
[41] IEA – International Energy Agency Publication,
https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage
[42] Sleipner Carbon Capture and Storage Project, (20 years storage)
https://www.netzeroteesside.co.uk/project/#:~:text=These%20proposals%20help%20support%20the,backs%20up%20intermittent%20renewables%20%E2%80%93%20crucial
[43] British Energy Security Strategy, HM Government April 2022, Renewables pages 16-23.
[44] La Rance Tidal Power Station Facts Sheet, Environmental Issues, February 2023; https://tethys.pnnl.gov/project-sites/la-rance-tidal-barrage ; Appendix 3.
[45] House of Commons Library, Research Briefing, 14 October 2025 BBNJ Bill(2024-25)
https://researchbriefings.files.parliament.uk/documents/CDP-2024-0079/CDP-2024-0079.pdf
[46] Agreement, Miscellaneous No. 8(2023) under UNCLOS, for BBNJ, New York, 20 September 2023, not yet in force.
[47] Article 68(1) of the Agreement, under UNCLOS, on Conservation and Sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction.
[48] OFFSHORE RENEWABLES THE UNTAPPED POTENTIAL OF OCEAN ENERGY, https://edinburgh-innovations.ed.ac.uk/case-studies/skills-for-the-future-of-offshore-wind
[49] Agreement, Miscellaneous No. 8(2023) under UNCLOS, for BBNJ, New York, 20 September 2023, not yet in force.
[50] Ibid, PART II
[51] Ibid, PART III, Article 22, management tools: marine protected areas (MPAs).
[52] Ibid, PART V, Capacity-Building, and transfer of marine technology.
[53] Environment Act 2021, UK Public General Acts, 2021 c. 30
[54] Kempton, R. Restructuring of the Environmental Impact Process (EIA) AFTER Brexit for Incompleteness, 4.3 New Identified Environmental Regulations under a restructured process, Tables 1-5, Table 4- New Part: Procedures for climate change requirements, SSRN publication.
[55]
[56] Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction. New York, 20 September 2023. [The Agreement is not in force]. Presented to Parliament by the Secretary of State for Foreign, Commonwealth and Development Affairs by Command of His Majesty, October 2023. Miscellaneous No. 8 (2023)
[57] Restructuring of the Environmental Impact Process (EIA) after Brexit for Incompleteness by Robert Kempton - Environmental Law
[58] Climate Change Act 2008, UK Public General Acts, 2008 c 27
[59] Explanatory Memorandum to Climate Change Act 2008 (2050 Target Amendment) Order 2019, 2019
[60] PAS 2080: 2080 'Carbon Management in Infrastructure', CLC Construction Leadership Council, The Green Construction Board, bsi licence
[61] Institution of Civil Engineers, "How tidal range projects could play a key role in UK energy mix", NCE Journal Rob Hakimian, 3 Feb 2023
[62] https://en.wikipedia.org/wiki/

[63] NYSERDA - New York State Energy Research & Development Authority; https://www.nyserda.ny.gov/
[64] BBC News, Environmental Correspondent, Matt McGrath, 5 July 2022
[65] https://www.energy.gov/

[66] B. R. Hindle, D. T. Johnstone, R.C. Kempton, J. H. Morgan, Institution of Civil Engineers, Proceedings, Part 1, Design and Construction, December 1989, Volume 86, *Salford docks urban renewal: design, construction and management of civil engineering works* 1067-1087.
[67] Ibid, 1081-1087
[68] Editors K.N. White, E.G. Bellinger, A.J. Saul, M. Symes and K Hendry, *Urban Waterside Regeneration, problems, and prospects*, 10.7 Funding, para (1.) 89.
[69] French funded project: "Improvement/Refurbishing of Sewage Treatment Plant Phase-I, II, Rehabilitation of Sewage Treatment Plant Phase - III, and Construction of Sewage Treatment Plant Phase-IV, Islamabad, 2005 - 2007 (the Project)
[70] Fethiye Municipality; 'Project Completion Report' 'Wastewater Collection and Treatment Facilities for Fethiye', February 2004, archived; important statistics: date of commencement 'Lot 1 Contract' 4 June 2002, original date of completion 29 January 2004, actual completion date 12 December 2003,
[71] Reference: Fethiye Advanced Biological Wastewater Treatment Plant, 2nd Stage Units Applica@on Project, Final Environmental and Social Impact Assessment Report
hJps://documents.worldbank.org/curated/en/353601590561579771/text/Environmental-and-Social-Impact-Assessment-for-Fethiye-Advanced-Biological-Waste-Water-Treatment-Plant-Second-Stage-Units-Applica@on-Project.txt
[72] Wadi Arab Project Completion Report, Volumes 1,2,3 and 4, submitted in June 2001 for both Projects to Water Authority of Jordan (WAJ); https://tecogrp.com/wadi-arab-waste-water-treatment-plant/
[73] Project Financed by Kreditanstalt fur Wiederaufbau (KfW), in the framework of the German Jordanian Cooperation
[74] Ref: ICE February magazine, 03 Feb 2023 by Rob Hakimian
[75] https://tethys.pnnl.gov/project-sites/la-rance-tidal-barrage
[76] https://simecatlantis.com/tidal-stream/meygen/
[77] https://www.khanacademy.org/science/ap-biology/cellular-energetics/photosynthesis/a/intro-to-photosynthesis#:~:text=Photosynthesis%20is%20the%20process%20in,is%20released%20as%20a%20byprodu ct.
[78] Carbon Works: https://www.carbonworks.com/energized-carbon
[79] Humic substances are coloured recalcitrant organic compounds naturally formed during long-term decomposi@on and transforma@on of biomass residues. The colour of humic substances varies from yellow to brown to black.
[80] https://www.energy.ox.uk/research/ University of Oxford - One Network. Oxford Institute for Energy Studies [OIES]

[81] https://www.siemens-energy.com/global/en/offerings/storage-solutions/battery-energy-storage.html
[82] https://www.elandcables.com/electrical-cable-and-accessories/cables-by-type/battery-storage-technology-cables
[83] Felicity Frick, Ferdinand Zotz, Dr Anna Berninger, December 8, 2023, https://www.ramboll.com/en-gb/insights/resource-management-and-circular-economy/new-eu-batteries-regulation-what-it-means-for-manufacturers
[84] New procurement models critical for Great Grid Upgrade., Belinda Smart, New Civil Engineer Journal, March 2024
[85] https://assets.publishing.service.gov.uk/media/651422e03d371800146d0c9e/Energy_Consumption_in_the_UK_2023.pdf
[86] https://www.statista.com/statistics/322874/electricity-consumption-from-all-electricity-suppliers-in-the-united kingdom
[87] https://lordslibrary.parliament.uk > In Focus
[88] Research Briefing, published, 13th December 2022; https://post.parliament.uk/research-briefings/post-pn-0687/#:~:text=The%20Government%20has%20stated%20an,and%20proposed%20Sizewell%20C%20reactors.
[89] https://lordslibrary.parliament.uk/nuclear-power-in-the-uk/
[90] Special feature - nuclear electricity in the UK, Table 1: Nuclear power stations in the UK supplying electricity to the public distribution network, 1956 - 2035,
[91] hJps://assets.publishing.service.gov.uk/government/uploads/system/uploads/aJachment_data/file/789655/Nuclear_electricity_in_the_UK.pdf
[92] Almost half of the UK's current nuclear capacity is due to be decommission by 2025

[93] If no other new nuclear power sta@ons are built, the UK's nuclear capacity in 2050 will be a third of what it is today.

[94] https://energy.ec.europa.eu/topics/nuclear-energy/decommissioning-nuclear-facilities_en#:~:text=The%20decommissioning%20of%20a%20nuclear,to%2030%20years%20to%20complete.

[95] https://www.onr.org.uk/our-work/what-we-regulate/operational-power-stations

[96] Ibid, Operational Power Stations

[97] Ibid, Table 3.

[98] Ibid, 2nd paragraph

[99] https://www.newcivilengineer.com/latest/government-names-six-decommissioning-sites-beingconsidered-for-new-nuclear-30-09-2025/, 30 September 2025, Tom Pashby

[100] https://www.edfenergy.com/media-centre/two-uk-nuclear-plants-generate-longer-supporting-energysecurity