Severn Estuary Commission
Comisiwn Aber Afon Hafren

Western Gateway
Porth y Gorllewin

Severn Estuary Commission Report

March 2025

Contents

Glossary

BNG	Biodiversity Net Gain
CBA	Cost Benefit Analysis
CCC	Climate Change Committee
CfD	Contract for Difference
DBFO	Design Build Finance Operate
DBT	Department for Business and Trade
DDM	Dynamic Dispatch Model
DECC	Department of Energy & Climate Change
DEFRA	Department for Environment, Food & Rural Affairs
DESNZ	Department for Energy Security and Net Zero
EDF	Electricité de France
FES	Future Energy Scenario
FLOW	Floating Offshore Wind
GVA	Gross Value Added
GW, GWh, GWh/y	Gigawatt (1 GW = 1,000 MW), Gigawatt-hour, Gigawatt-hours per year
ha	Hectares (1 ha = 10,000 square meters)
HPC	Hinkley Point C
HRA	Habitats Regulations Assessment
IROPI	Imperative Reasons of Overriding Public Interest
LCOE	Levelised Cost of Electricity
MHCLG	Ministry of Housing, Communities & Local Government
MW, MWh, MWh/y	Megawatt (1 MW = 1,000 kW), Megawatt-hour, Megawatt-hours per year
NETS	National Electricity Transmission Network
NESO	National Energy System Operator
NPV	Net Present Value
NPS	National Policy Statement
RAB	Regulated Asset Based
RT	Required Transfer
SAC	Special Area of Conservation
SPA	Special Protection Area
SSEP	Strategic Spatial Energy Plan
SSSI	Sites of Special Scientific Interest
TW, TWh, TWh/y	Terawatt (1 TW = 1,000 GW), Terawatt-hour, Terawatt-hours per year

Chair's Foreword

The UK's rapidly growing demand for electricity, the war in Ukraine and widespread geo-political instability have focussed everyone's minds on the need for local energy production. There is also a general recognition that our climate is changing dangerously. To date, the parallel biodiversity challenge has not been recognised to the same degree.

We are faced with a conundrum – we know that we need a lot more electricity to meet our decarbonisation targets, and we know that it should be local and low-carbon. Equally we know that all projects have an environmental impact. Balancing the local environmental impact of a project against its broader environmental and economic benefit is the key compromise to be made when considering renewable energy. The Severn Estuary Commission was established to consider the feasibility of electricity production from the Estuary. That same conundrum was the essential theme of our deliberations.

There is a lot of history attached to this subject. We are grateful both to those who have provided historical context and technical expertise and to the current experts who have helped us to assess new possibilities. We have also benefitted greatly from the support and cooperation of The Crown Estate, the Severn Estuary Partnership and, of course, the many stakeholders whom we have consulted.

The Commissioners have approached their work with open minds. There has been plenty of frank discussion and constructive tension. I thank all of them for their hard work.

Andrew Garrad CBE FREng

Chair of the Severn Estuary Commission

Commissioners

Sue Bartlett-Reed

Peter Davies CBE

Dr Nigel Costley

Dr Madeleine Havard

Ian Simm

Chris Mills

Introduction

The Western Gateway is the UK's only pan-regional partnership covering two countries. Comprising 28 Local Authorities, one Mayoral Combined Authority in England, and two Corporate Joint Committees in Wales, it represents over 4.8 million people. The Partnership exists to generate and support economic growth; using shared strengths to find new ways to reach net zero, create opportunities for communities, and, in the process, build a sustainable economy.

The Severn Estuary sits at the heart of Western Gateway's geography and has long been recognised for its potential to generate clean, renewable electricity. The combination of climate change, increasing energy demand and the UK's legally binding net-zero commitments compelled the Western Gateway Partnership to re-examine this potential.

An independent commission was therefore launched to consider the feasibility of developing tidal range energy in the Severn Estuary, to capture its significant energy potential and to facilitate economic growth in the Western Gateway Region, while taking proper account of the Estuary's extraordinary environmental importance.

Chaired by Andrew Garrad CBE FREng, the Severn Estuary Commission comprises experts in science, engineering, finance, sustainable development, and environmental disciplines. Using input from specialist consultancies it has considered the following key areas:

- environmental impact,
- socio-economic factors,
- financing models,
- energy production and implications for the grid, and
- engineering viability.

The individual detailed reports are available online.

The Commission has spent a year considering expert analysis and engaging with hundreds of stakeholders in these areas. This report draws that information together to address the core question of the feasibility of generating sustainable electricity from the Severn Estuary. The Commission has used example projects, of a range of sizes and types, as a basis for this analysis, but its role is not to promote a particular project. Instead, it has focused on assessing the feasibility of tidal range energy in the Estuary as a whole.

Example projects were chosen based on previous studies, located in representative areas of the Estuary, and covering feasible tidal project types and sizes:

- Small lagoon (Swansea Bay)
- Medium lagoon (Stepping Stones)
- Large lagoon (West Somerset & Cardiff Bay)
- Small barrage (Shoots)
- Large barrage (Cardiff-Weston)

Map of example projects

Alongside this activity, Western Gateway is working closely with the Welsh Government's Tidal Lagoon Research Challenge, thereby ensuring alignment with ongoing research and development. This collaboration strengthens the evidence base for tidal range energy and helps integrate the findings from both initiatives to support future decision-making.

Executive Summary

After a year's engagement with more than 500 individuals from over 200 local and national organisations, the Severn Estuary Commission has concluded that development of tidal range energy in the Severn Estuary is feasible. Tidal range projects would generate predictable low-carbon energy, independent of weather conditions, help to meet the UK's significant increase in electricity demand, and contribute to the stability of the grid.

According to both the National Energy System Operator (NESO) and the Climate Change Committee (CCC), the UK electricity demand is set to more than double by 2050. Meeting that demand is critical to the UK Government's growth ambitions in fuelling business and industry. As global events have demonstrated, to ensure the energy security of our nations, generation must be domestic. The UK needs immediate investment in low-carbon energy schemes to meet its target of Net Zero by 2050.

Tidal range is a clean, predictable source of energy and, in the Severn Estuary, the UK has one of the highest tidal ranges in the world. A project in the Estuary offers a rare opportunity for the UK to showcase its ability to capture this valuable resource.

NESO's 2024 Future Energy Scenarios state that 3-5 GW of tidal range energy will be needed by 2050. NESO is working on its first Strategic Spatial Energy Plan (SSEP), a nearer term plan, which will be updated regularly. The Commission expects tidal range energy to be covered in future iterations as more detailed information becomes available on the timing and development of projects.

The Severn Estuary is of international environmental importance and heritage significance and must be protected. Climate change is already affecting the Estuary, with rising sea levels and water temperatures changing its ecology. There are significant gaps in environmental data and addressing these gaps is crucial to enable proper consideration of development within the Estuary. The Estuary is also the home of much commercial activity with some major ports on its shores. There is therefore a compromise to be reached between the local impact of a project in the Estuary and the broader environmental and commercial benefits derived from it.

How tidal range energy might be developed in the Estuary depends on the size, location and type of energy project proposed. The Commission has consulted widely with commercial and environmental stakeholders, and it has investigated the socio-economic implications of implementing tidal range energy projects. It has also examined the value that tidal range energy could bring to the grid.

Current legislation would, in all likelihood, preclude the development of a large barrage because of the extent of compensatory habitat required. It is also likely that ports and other commercial activity would be significantly disrupted by such a scheme.

Taking account of commercial issues, legislative challenges, and stakeholder views, the Commission has concluded that, at this stage, the development of a large barrage should not be pursued.

The Commission recommends that the UK and Welsh Governments provide policy support for tidal range energy to ensure private sector investor confidence and public sector engagement in environmental research and monitoring. A Tidal Range Energy National Policy Statement would then be needed to further establish clear policy backing. Alongside this statement NESO should revise its Strategic Spatial Energy Plan to include tidal range potential. The immediate priority is to develop a governance structure, spatial planning approach, and capacity-building strategy, involving key national infrastructure bodies to support long-term tidal range development. This would enable the long-term delivery of tidal range energy in the Severn Estuary as an integral part of the UK's future electricity supply.

This policy support should be underpinned by a locally led Estuary-wide spatial plan to manage the Estuary as a whole. This plan would bring together the different legislative and administrative regimes to produce a single strategic vision. That vision would protect the Estuary's environment whilst balancing the needs of society, electricity generation, commercial shipping, transport and coastal communities. By considering the Estuary as a whole, in a strategic manner, rather than from a private, project-by-project, developer perspective, it would ensure that the most appropriate locations are chosen for development, not only for tidal range energy but for all activities.

In parallel a tidal lagoon should be developed - a Commercial Demonstration Project (CDP). As well as generating a substantial amount of low-carbon electricity, its purpose would be to understand the energy and socio-economic benefits of such a project and to provide a platform for full scale evaluation of its environmental impact. This initial project must be commercially viable and financeable. It should be co-designed by engineers and environmentalists working together and with a comprehensive plan for mitigation and compensation. If it were found to be both commercially and environmentally acceptable then it could be the basis for a series of lagoons either in the Estuary or around the UK coast.

During the development stage public sector involvement will be required to provide the necessary support and investment. Such a project must be sufficiently large to be commercially viable, but also small enough, and in a relatively benign area of the Estuary, to minimise its environmental impact. The information gathered, and the experience obtained, would allow decisions taken about any proposed future developments in the Estuary to rely on better evidence than is available today.

The Commission has concluded that the Regulated Asset Based (RAB) approach to funding and finance, such as adopted for the Thames Tideway Tunnel and as proposed for Sizewell C would be optimum.

The Western Gateway Partnership, collaborating with UK and Welsh Governments, should work to establish a Project Delivery Vehicle for the CDP. Comprising relevant public and private sector interests, this vehicle would lead the development, convene relevant stakeholders, promote collaboration and drive progress. It would also work to secure public funding to support the high-risk development phase for early projects, which seems unlikely to attract private finance. It would then encourage private finance institutions to enter into the construction phase for which there appears to be significant appetite.

The Commission's assessment of a range of example tidal lagoon projects shows that they have the potential to create between 30,000-220,000 job years and £1.6-12 billion GVA during the construction phase. This benefit would increase significantly if it were determined that there was environmental and commercial merit in proceeding with a wider programme. Sequencing of projects over time would allow supply chain, contracting, and financing efficiencies to be achieved.

The Commission has made its recommendations to the Western Gateway Partnership. For a new tidal range energy strategy to be enacted effectively, the recommendations require co-ordinated decisions by UK and Welsh Governments. They should be complemented through further actions by other key stakeholders who have a responsibility for delivering the UK's clean energy strategy by 2050 and for co-ordinating environmental planning.

The Western Gateway Partnership is well positioned to take a leadership role in this effort and to coordinate engagement across key stakeholders. Local and regional authorities, working in collaboration with national decision-makers, should provide the necessary foundation to follow this strategic and coordinated path.

1 Changing Context

The Commission's work builds on an extensive history of tidal range research projects. Despite decades of reports urging tidal range energy development, none of the recommendations has been implemented. Financial concerns, environmental impact, and the need for subsidies have consistently halted progress.

So, what is the different context that justifies another commission? Circumstances have changed significantly since the last strategic review in 2010. Climate change is accelerating, and it now seems that there is only a remote possibility of the world being able to restrict temperature rise to the 1.5^{0}C agreed at the Paris COP in 2015. There is an urgent need to transition to low-carbon energy and to increase electricity supply to meet the greatly increased demand of a net zero UK. According to forecasts by both the National Energy System Operator (NESO) in their 2024 Future Energy Scenarios[1] and by the Climate Change Committee (CCC) in their seventh[2] carbon budget, electricity demand is forecast to be more than double 2023 levels by 2050. The scale of increase is shown in Figure 1.1. The potential demands of Artificial Intelligence and the associated data servers have taken the electricity industry somewhat by surprise. That demand is not included in these studies. It is, however, acknowledged to be large and so will provide significant additional demand on the system.

Bondi Committee (1981) – Assessed a Severn Barrage, estimating it could generate 7% of UK electricity. Recommended further study but was not pursued due to cost and environmental concerns.

Severn Tidal Power Group (1981-1994) – Reassessed the barrage, advocating government-backed funding. Shelved in 1994 due to cost and environmental concerns.

Sustainable Development Commission (2007) – Supported tidal range projects, particularly a Severn Barrage and tidal lagoons, as part of a renewable energy transition.

DECC Feasibility Study (2008-2010) – Evaluated five tidal options. A large barrage could provide 5% of UK electricity. Recommended further financial and environmental study. Government deemed costs and risks too high.

Hendry Review (2016-2017) – Focused on tidal lagoons, particularly Swansea Bay. Recommended government support for a pilot to establish a scalable tidal lagoon industry, citing energy security, economic growth, and reliability. Rejected due to high costs.

[1] NESO (2024), Future Energy Scenarios (FES) 2024: NESO Pathways to Net Zero, https://www.neso.energy/publications/future-energy-scenarios-fes
[2] Climate Change Committee (2025), The Seventh Carbon Budget, https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

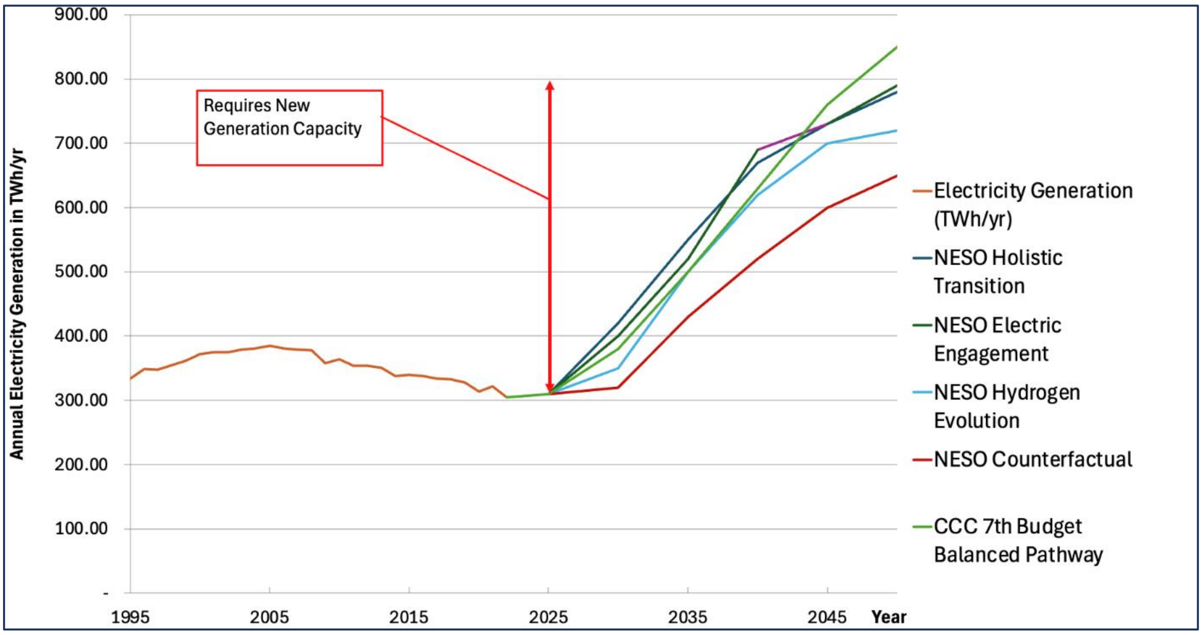


Figure 1.1: NESO 2024 Future Energy Scenarios

It is recognised that tidal range energy can play a role in meeting this increased demand. The various Future Energy Scenarios assume that tidal energy projects could contribute as set out in Table 1.1. A large majority of this contribution will be from tidal range rather than tidal stream. The Severn Estuary possesses the largest tidal range energy resource in the UK. The total contribution from projects in the Estuary could be between 7 TWh and 21 TWh/yr or between 2.3 % and 7% of current electricity demand.

Table 1.1: NESO FES 2024 Marine Energy Contributions[3]

Net zero pathways	Tidal capacity
Holistic Transition	3GW by 2043 including 1 large and 1 small tidal range project
Electric Engagement	4GW by 2042 including 2 medium to large tidal range projects
Hydrogen Evolution	5GW by 2050 including 3 medium to large tidal range projects
Counterfactual (does not achieve net zero by 2050)	2 GW by 2050 including at least one tidal range project.

At present, in cold winters during periods of high atmospheric pressure and associated low wind speeds, over 60% of the UK's electricity generation is still from gas-fired power stations. The reduction of gas usage in winter is a significant challenge and is one of the areas in which tidal range power can contribute. Tidal range provides a predictable source of low carbon generation every day of the year, independent of the weather, thus reducing the requirements for long term storage. It can help to provide frequency support and has the ability to generate power at short notice. Although expensive to

[3] NESO (2024), Future Energy Scenarios (FES) 2024: NESO Pathways to Net Zero, https://www.neso.energy/publications/future-energy-scenarios-fes

build, it has a long asset life and its cost reduces over time in real terms. Its life time unit cost is comparable to other forms of renewables. Projects are likely to be close to loads and connection points, reducing the need for transmission lines and long undersea power cables.

The Government has set out its strong desire to bring energy production within UK control,[4] securing and stabilising the market. As part of its industrial strategy,[5] it is expecting manufacturing and new technologies to drive growth. Equally, the need to decarbonise difficult industries, of which there are many in South Wales and South West England, is a strong driver. The current global political and economic situation makes indigenous low-carbon energy production highly desirable, independent of the energy considerations themselves. These are all good reasons for looking again at the feasibility of developing tidal range energy projects in the Severn Estuary.

It is also acknowledged that the Estuary itself is changing as climate change results in sea level rise and an increase in water temperature. The nature and scale of these changes in the ecology need to be understood when considering the long-term future of the Estuary and the impact of any tidal range energy infrastructure on the special features of that environment.

It is important now to consider how a tidal range project in the Severn Estuary could contribute to the UK and Welsh Governments' wider policy agenda of improving energy security and achieving net zero while facilitating economic growth within environmental, community, and regulatory safeguards.

[4] DESNZ (2024), Clean Power 2030 Action Plan, https://www.gov.uk/government/publications/clean-power-2030-action-plan
[5] DBT (2024), Invest 2035: the UK's modern industrial strategy, https://www.gov.uk/government/consultations/invest-2035-the-uks-modern-industrial-strategy/invest-2035-the-uks-modern-industrial-strategy#executive-summary

2 Technology

2.1 The nature of tides

Coastal areas experience two high and two low tides every 24 hours and 50 minutes. High tides occur 12 hours and 25 minutes apart. The highest tides, spring tides, occur twice each lunar month all year long. The lowest tides, neap tides, occur 7 days after a spring tide.

The Severn Estuary has the third highest tidal range in the world and the highest in the UK, it has a range of 14.85m[6] between the Lowest and Highest Astronomical Tides. Only the Bay of Fundy and Ungava Bay in Canada exceed this range.

2.2 Which technology?

Tidal energy is abstracted from the rise and fall in the tides (tidal range) and from the currents that flow as the tide changes (tidal stream). Electricity generated by the tides is available for between 12 and 16 hours every day of the year.

Wave energy harnesses the power of ocean waves to generate electricity and is quite distinct from tidal energy. The wave energy potential in the South West and South Wales is offshore, in the Atlantic approaches from Cornwall to Pembrokeshire, and is not considered in this report.

2.3 Tidal stream

Tidal stream technology, see Figure 2.1, relies on tidal current generally flowing at high speed between two land masses. The power is a function of the cube of the current speed so, if the speed doubles, the power increases by a factor of eight. Sites with high-speed currents are therefore more likely to be exploited for commercial projects than those with modest speeds.

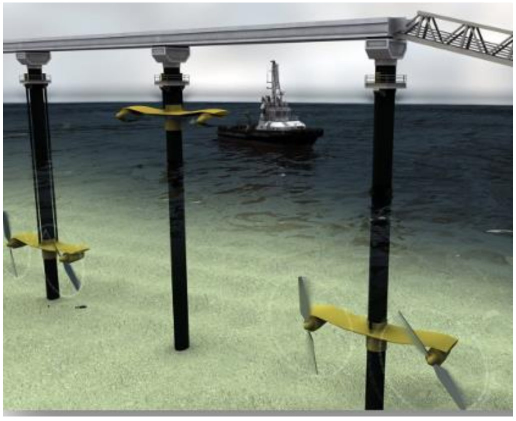


Figure 2.1: Tidal stream devices in a tidal fence

Unlike tidal range, tidal stream already has Government backing through a ring-fenced subsidy mechanism. Over 120MW of projects have been awarded contracts for delivery before 2030. Tidal stream development therefore has a framework for commercial development.

Present estimates of tidal stream resource indicate that there is potential for 11GW of projects around the UK coastline. Most of these sites have much higher flow speeds than those found in the Estuary where more work is required to understand their significance. The Estuary sites are likely to be relatively unremarkable when compared

[6] National Tidal and Sea Level Facility, (accessed Jan 2025), Highest & lowest predicted tides https://ntslf.org/tides/uk-network/predictions-hilo

to the tidal range which is exceptional. Therefore, although there may be interest in Estuary in the future as new, low speed technologies are developed tidal stream technology is not considered any further in this study.

2.4 Tidal range – barrages and lagoons

Tidal range energy can be generated using two types of construction, either a barrage crossing the Estuary or lagoons constructed along one shoreline. Both impound water as the tide comes in and then release it through a classical "bulb turbine", see Figure 2.2, which generates power. Some projects generate both as the tide comes in and as it goes out. As the water level in the impounding basin is changed, there is some loss of inter-tidal habitat within the impounded area.

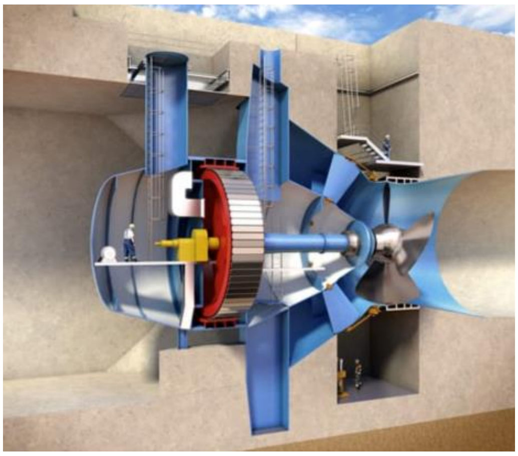


Figure 2.2: Bulb turbine cut away as proposed by GE-Andritz

It is possible to construct a lagoon that does not connect with the land. It has the advantage that no inter-tidal habitat is lost, but it is significantly more expensive. The volume of materials required for an offshore lagoon is more than double that of a land-connected lagoon for the same energy output. On this basis, offshore lagoons are not considered any further here.

2.5 What is required to construct a tidal range project?

There are two operating tidal barrage projects in the world. La Rance, in Brittany, is rated at 240 MW and was commissioned in 1966. It is owned by EdF who state that it now generates their cheapest energy. The other is in South Korea, at Sihwa Lake, near Ansan. It is rated at 250 MW, is owned by Korea Water Resources Corp and started operation in 2011.

All tidal range projects involve the construction of a marine wall. The marine wall extends above the high-water mark and can be constructed either by using a rock protected sand/gravel embankment or by using caissons. A caisson is a large rectangular concrete structure that can be constructed remotely and towed into position.

The marine wall incorporates one or more "power houses". They are rectangular concrete structures that house the turbines and control equipment including sluice gates to control operation and associated water levels. The turbines contain a generator housed within the bulb. The electricity generated is transmitted by buried cables to a sub-station where it is connected to the grid. Special care is required in the construction of the reinforced concrete structures due to the saline environment. Cathodic protection can be used to reduce the risk of corrosion of the steel reinforcement in the structures.

The zone most at risk is where frequent wetting and drying occurs as the tide rises and falls.

Since the aim is to generate low-carbon electricity, the carbon used in construction is important. Modern concrete technology continues to innovate and there are now low carbon sources of concrete available. Orsted[7] estimates that the lifetime carbon emissions from a coal power station are 900 g/kWh and are 6 g/kWh from an offshore wind farm. Other estimates for offshore wind are between 7 and 30 g/kWh. The Crown Estate has commissioned work to assess whole life carbon emissions from tidal range energy projects. For a project with a rock and sand sea wall with concrete caissons being used only for the powerhouse, and assuming zero emissions from construction plant, the whole life emissions may be as low as 4 g/kWh. If a tidal range project was built using plain concrete caissons for the sea wall, a figure of 12 g/kWh may be more appropriate. It is therefore estimated that the carbon intensity of a tidal range project, when calculated over its operational life, is between 4 and 12 g/kWh, which is similar to the expected range for new offshore wind projects.

The marine wall itself is designed and constructed to minimise seepage and to take account of future sea level rise over its anticipated operating life. The wall acts as the impounding structure allowing water within the impounded basin to be stored at a different level to the sea. Figure 2.3 shows a typical arrangement of a tidal range power plant. The example shown is a barrage. A lagoon would be similar but without the large navigation lock.

Figure 2.3: Typical tidal range barrage power project, with navigation lock[8]

The engineering for the civil, electrical and mechanical elements has been used for many decades on water supply reservoirs and pumping stations, hydro-electric power plants, ports and harbours.

7 Orsted (accessed Jan 2025), What is the carbon footprint of offshore wind?, https://orsted.com/en/what-we-do/insights/the-fact-file/what-is-the-carbon-footprint-of-offshore-wind

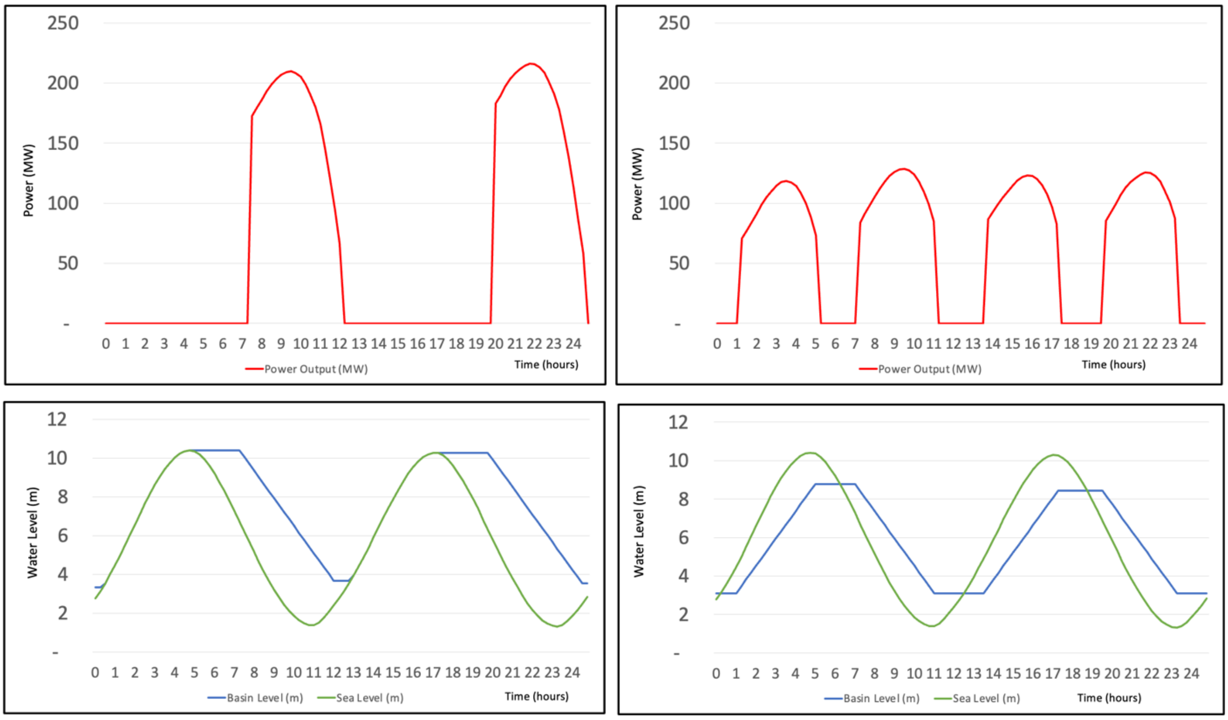
8 Copyright WSP.

2.6 How does it operate?

When the tide is going out it is known as an ebb tide, when it is coming in it is a flood tide. There are two basic forms of operation as shown in Figure 2.4.

Ebb only – the flood tide passes through sluices to fill the impounding basin and, after the tide turns and a suitable head has developed, water passes from the basin through the turbines to the sea. This form of operation results in two phases of generation, each lasting six hours, every day.

Ebb and Flood – water passes through the turbines during both flood and ebb tides resulting in four phases of generation every day, each lasting approximately four hours. The peak power output is lower than for ebb only generation and more turbines are required to produce the same energy output.



(a) Ebb Only b) Ebb and Flood

Figure 2.4: Water level variations and power outputs during a 24-hour period

Both of these modes of generation can be supplemented by pumping and sluicing to increase generation heads and increase water exchange between the basin and the sea respectively.

2.7 Cost considerations

The various projects that have, historically, been proposed in the Severn Estuary are shown in Figure 2.5.

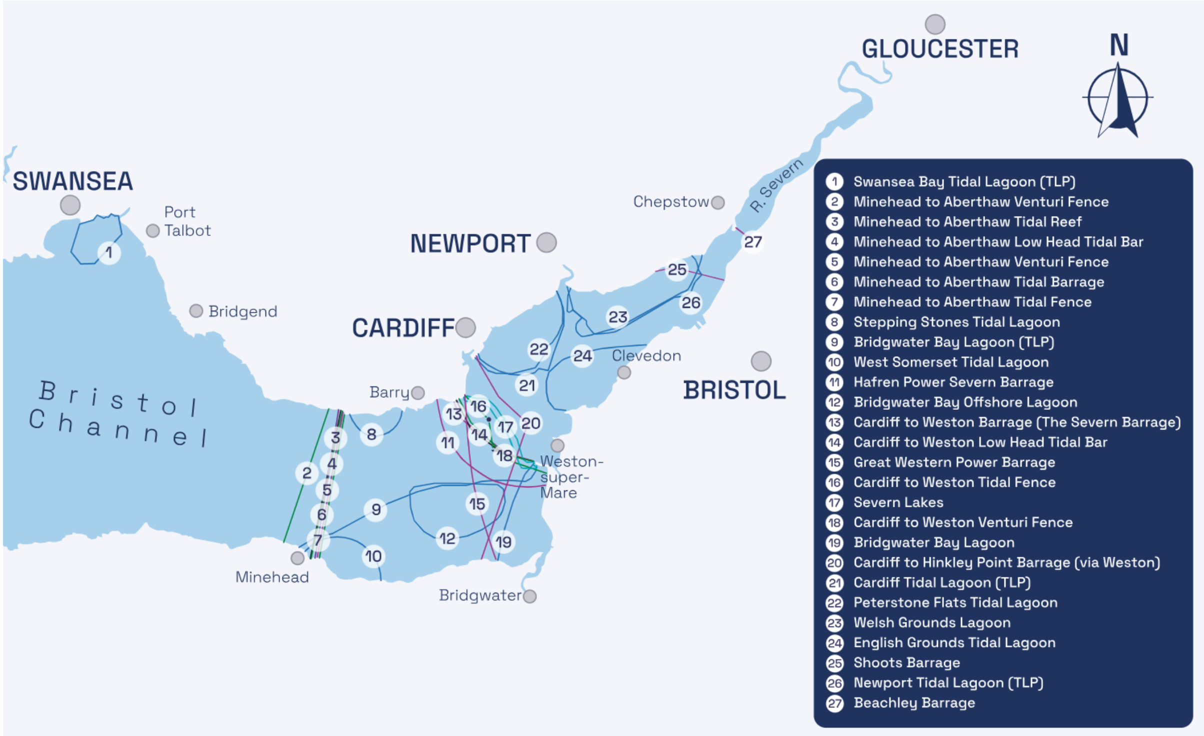


Figure 2.5: Previous projects proposed in the Severn Estuary

The Commission chose six of these projects as examples to illustrate the various aspects of the study. It is stressed that the Commission is not recommending these projects, they are merely examples that have had the benefit of some previous investigation. The example projects are listed in Table 2.1 with reference to Figure 2.5.

Table 2.1: Example projects used in the study

No	Project	Construction Cost £bn (2023 prices)	Installed capacity. (GW)	Annual Output (GWh/y)
13	Large Barrage (Cardiff Weston)	33.4	8.64	16,700
25	Small Barrage (Shoots Barrage)	6.8	1.05	2,800
21	Large Lagoon 1 (Cardiff)	12.3	2.0	5,500
10	Large Lagoon 2 (West Somerset)	10.9	2.5	6,500
8	Medium Lagoon (Stepping Stones)	2.3	0.6	1,200
1	Small Lagoon (Swansea Bay)	1.8	0.32	520

The costs of the two barrage examples are based on the independent and conservative estimates produced for the Severn Tidal Power Feasibility Study. The lagoon examples use the data published by their proposers. All cost estimates have been inflated to a

2023/4 baseline. Until definitive designs are produced, cost estimates should be treated as indicative only.

Approximately 70% of the construction cost is for the civil works, the remaining 30% is for mechanical and electrical work, including grid connection. In addition, there are client costs for project management and contractor supervision. There are other costs incurred in the development phase: conceptual design, consenting, obtaining contractor bids and arranging finance. Depending on the site there may also be significant costs resulting from environmental habitat compensation. For the six example projects, development costs would be expected to be between £30m and over £200m, spent over a 5-to-8-year period. Annual operating costs are relatively low compared to other power projects at approximately 1% of the total construction cost. They will include a sinking fund to cover the replacement of components when they reach the end of their life and, ultimately, decommissioning.

2.8 Conclusions

Obstacles to the construction of tidal range projects in the Estuary are neither technical nor engineering in nature. A barrage or a lagoon could be built today using conventional engineering practice. While barrages have been built before, a lagoon would be the first of its kind—but it relies on the same proven technology.

3 Environment

3.1 Ecology and importance of the Severn Estuary

The Severn Estuary is environmentally and ecologically important, both nationally and internationally. The Estuary is highly protected. It is recognised as a wetland area of international importance and is a designated Ramsar site. It is also a Special Protection Area (SPA) and Special Area of Conservation (SAC) under the Habitats Regulations (2017). Many parts of the Estuary have been designated as Sites of Special Scientific Interest. There are also a number of National Nature Reserves. The area of study is shown in Figure 3.1.

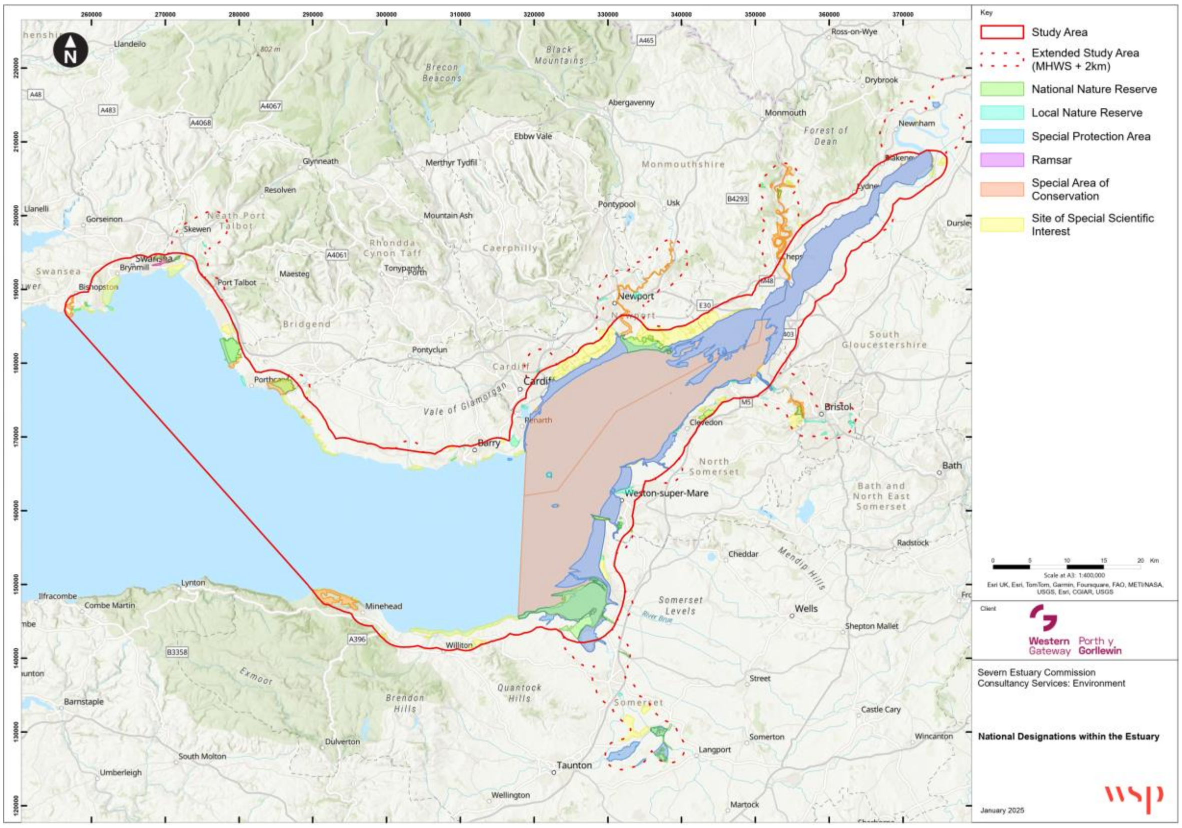


Figure 3.1: The Study Area (red boundary) and protected areas

The Severn Estuary is particularly important for birds and fish. Each winter the saltmarshes and mudflats of the Estuary host a wide assemblage of passage and over-wintering birds, of which six species are of international importance and 11 species of national importance. The fish community, within the Estuary and further west to the Bristol Channel, is diverse and rich, with over 100 different species living, feeding and moving through the area, and seven migratory species of international importance.

3.2 Environmental baseline

Climate change is affecting the Estuary as a whole. The water temperature is rising. There are changes in salinity and increased run-off from extreme rainfall events and associated storms, which leads to higher coastal erosion risks and sea level rise.

According to the IPCC in 2021,[9] the sea level is expected to rise by between 0.5m and 0.9m by 2100. These changes will impact the Estuary's hydrodynamics, species and habitats. For example, there will be increased coastal squeeze,[10] challenges for cold-water fish such as salmon, and potentially alterations to the migratory habits of birds. These changes could affect the ecology of the Estuary and might even result in the loss of some species and the gain of others. Existing environmental legislation does not allow for consideration of these long term spatial and temporal climatic changes in the natural system.

There is a large amount of valuable information contained in the earlier studies on the feasibility of tidal range energy from the Severn Estuary. This information has been drawn upon during the Commission's work. The most recent large-scale study was undertaken in 2010.[11] The data is therefore relatively old but nevertheless useful.

It is regrettable that few of the recommendations of previous studies for future work have been acted upon. There are therefore still many data gaps. Addressing these gaps is critical for a full understanding of any development's impacts, designing effective mitigation, and, where necessary, implementing compensation. There is a need to ensure that data collection is open and transparent, that the data is made generally available, and all parties agree on methodology, including modelling.

3.3 The effects on the environment from tidal range energy projects

The impacts of a tidal range energy structures will depend on whether they are lagoons or barrages, their scale, mode of operation and their location in the Estuary. Possible impacts include loss of habitats, including saltmarsh and mudflats, loss of cultural heritage; changes in flood risk, preventing the passage of fish and the killing or damage to fish passing through turbines. During construction, and possibly operation, there could also be disturbance and dispersal of toxic chemicals that are currently contained within the sediment.

Detailed hydrodynamic modelling is required to understand the full range of environmental changes resulting from the introduction of tidal range projects. That modelling will simulate changes in water levels, currents, erosion, deposition and siltation.

A barrage which crosses the Estuary would have a much wider environmental impact than a lagoon. It would fundamentally change the environment and ecology up- and down-stream of it. It would create a significant obstacle to fish passage and reduce the extent and availability of saltmarsh and mudflats, which are critically important to overwintering birds.

[9] IPCC (2021), Sixth Assessment Report, Chapter 9: Ocean, Cryosphere and Sea Level Change, https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-9/
[10] Coastal squeeze is the term used to describe the effect on the shoreline from sea level rise.
[11] DECC (2013), Severn tidal power: feasibility study conclusions, https://www.gov.uk/government/collections/severn-tidal-power-feasibility-study-conclusions

Lagoons are smaller impoundments, occupying a relatively small proportion of the Estuary. Their environmental impact will therefore be lesser and more localised. They would not block the passage of migratory fish, unless located in the vicinity of a river mouth. If more than one lagoon were to be built, then the cumulative impact would obviously be greater, and a detailed assessment would be required.

Outputs from previous studies have been used to evaluate the likely environmental effects. To complement those studies a multi-criteria assessment was undertaken, using available data, to assess the Estuary as a whole in order to identify variations in environmental sensitivities. Figure 3.2 shows the protected habitats in the study area. Unsurprisingly, the analysis showed that the existing protected areas were the most sensitive and that environmental sensitivity reduced to the west, except for the area between Nash Point and Swansea Bay.

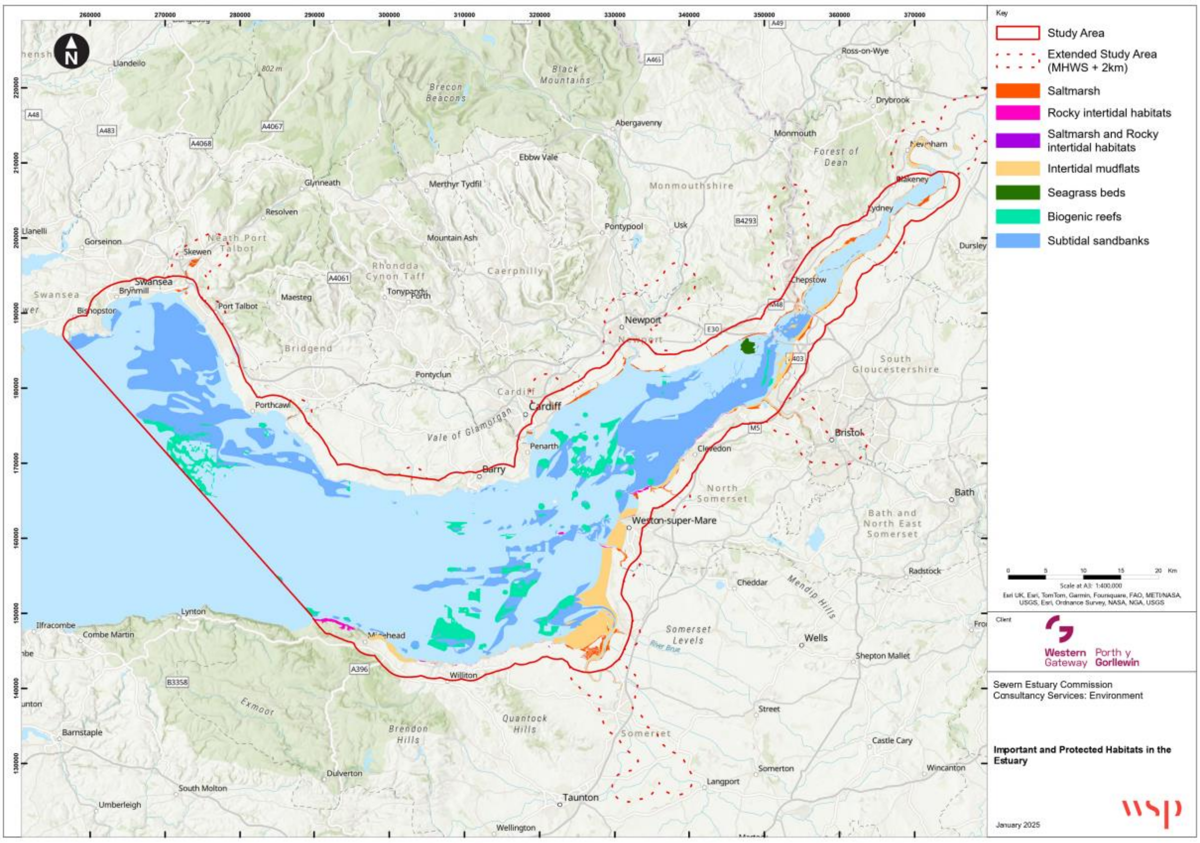


Figure 3.2: Important and Protected Inter-tidal habitats

Estimates of potential inter-tidal habitat loss were produced for the six example projects. These estimates were derived through analysis of the inter-tidal habitat types and locations provided by previous studies. The extent of habitat loss was assessed for the example projects and was shown to be much more significant for tidal barrages (between 3,000 and 14,000 ha) than for lagoons (up to 450 ha). This result is as expected given that a barrage impounds a significantly greater length of shoreline per unit of energy generated.

The large marine walls used in both tidal lagoons and barrages could provide flood protection to local and upstream communities from future sea level rise and storm surges. In some cases, tidal barrages, in particular, may also result in the need to upgrade existing flood defence infrastructure, for example, to enlarge tide-locked drainage outfalls.

3.4 Legislation and consenting

The Estuary is extensively protected.[12] Balancing the need to mitigate against future climate change with the need to comply with environmental legislation is problematic. The importance of the Severn Estuary's contribution to nature, and its protection in law means that any development that is likely to impact its environment and ecology will be subject to the Habitat Regulations (2017). In many cases, the paucity of current data about the condition of the sites designated under the Regulations could, without further monitoring, make assessment of compliance with the legislation challenging.

The Habitat Regulations do provide for an Exemption or Derogation which allows plans or projects to be approved provided three tests are met:

1. There are no feasible alternatives to the plan or projects which are less damaging;
2. There are "Imperative Reasons of Overriding Public Interest" (IROPI) for the plan or project to proceed;
3. Compensatory measures are secured to ensure that the overall coherence of the network of UK sites is maintained.

The IROPI and "reasonable alternatives" tests would likely rest on (i) the national need to increase the UK's low-carbon generation capacity in order to meet 2050 targets, and (ii) the assertion that tidal range energy projects are beneficial in achieving that goal.

A barrage would almost certainly fail to meet the requirements of the current legislation. A lagoon or lagoons could possibly meet them depending on size and location. The provision of mitigation and/or compensation would be difficult to provide at a large scale. There is a need to continue research on project related habitat compensation nationally in an effort to identify regional and UK-wide solutions. An estimate of the scale of compensation has been derived and remains an issue. Given the potential scale required it is probable that like-for-like compensation will not be feasible locally or nationally, in which case a more strategic approach may be needed.

A strategic approach would facilitate earlier identification and hence delivery of new habitats, giving them longer to mature before any tidal range project becomes operational. As well as the Habitat Regulations, there is the added complexity of the recently introduced Biodiversity Net Gain[13] (BNG) regulations and its equivalent requirement in Wales, Net Benefits for Biodiversity.[14] BNG currently does not apply to

[12] Habitats Regulation Sites, Ramsar designation and various Sites of Special Scientific Interest (SSSI).
[13] DEFRA (2023), Biodiversity net gain, https://www.gov.uk/government/collections/biodiversity-net-gain
[14] Welsh Government (2023), Planning Policy Wales: net benefit for biodiversity and ecosystems' resilience, https://www.gov.wales/planning-policy-wales-net-benefit-biodiversity-and-ecosystems-resilience

projects, such as a tidal range developments, seeking Development Consent Orders[15] but is likely to do so in the future.

There is already a management plan for the Severn Estuary designated sites (Ramsar, SAC, SPA), developed and managed under the auspices of ASERA.[16] In addition, a technical group of local authorities and other organisations co-ordinates the Severn Estuary Shoreline Management Plan.[17] The Severn Estuary Partnership,[18] a non-statutory initiative, works with all those involved in the management and use of the Estuary. However, the Commission believes that a broader, more strategic approach that considers the planning and management of all activities in the Severn Estuary is required. This approach would provide a more effective solution to maintaining the integrity of the Estuary whilst enabling appropriate development to take place in the right location.

3.5 Stakeholders' input and public perception.

The Commissioners held a number of environmental stakeholder consultations and a workshop, attended by key environmental stakeholders, at which a range of views was presented. There was clear feedback from stakeholders voicing opposition to the development of a large tidal barrage. There was more support for tidal lagoons with their reduced environmental impact. Most stakeholders were open to piloting a lagoon project on the basis that knowledge and experience could be gained in a controlled manner, and it could be used to determine how best to mitigate/compensate for any adverse effects. Other feedback from the workshop is summarised below. There is a need to:

- Address the lack of current knowledge of the Estuary;
- Standardise data specification and collection and require data to be made generally available;
- Develop a strategic approach to planning and management of the Estuary;
- Involve stakeholders at all stages of development and delivery of any plan or project.

The Commission had identified many similar issues and welcomed this stakeholder input. It considers that the design of any tidal range project in the Severn Estuary should be undertaken with an inter-disciplinary team drawn from both engineering and environmental fields. A co-production approach should be adopted from the outset so that the optimal environmental outcomes can be integrated into any proposed engineering design.

[15] MHCLG (2024), Planning Act 2008: Content of a Development Consent Order required for Nationally Significant Infrastructure Projects, https://www.gov.uk/guidance/planning-act-2008-content-of-a-development-consent-order-required-for-nationally-significant-infrastructure-projects
[16] https://asera.org.uk/
[17] SECG, The Shoreline Management Plan https://severnestuarycoastalgroup.org.uk/shoreline-management-plan/
[18] https://severnestuarypartnership.org.uk/

The Commissioners have not held consultations with the general public but have noted that the Swansea Bay Tidal Lagoon proposal had substantial public support for a project in their local vicinity. In addition to its power generation role, it was seen as having benefits for flood risk management. The recent public consultation over the tidal range energy project on the Mersey attracted significant public interest[19] with 84% of the 3,000+ respondents voicing their support.

3.6 Carbon intensity

The Estuary's role in absorbing and storing carbon is significant. In addition to their importance in biodiversity terms, the saltmarsh and mudflats, in particular, are important sequestrating habitats.

3.7 Decommissioning

Decommissioning, at the end of the life of a lagoon or barrage, would take place in 120 years or more. It is therefore difficult to assess the environmental impacts since the prevailing conditions are unknown. However, it is likely that a marine wall would, by then, have provided a habitat to some species, and there would be concern about removing a structure that was both supporting those species and providing a flood defence function.

3.8 Conclusions

- A more strategic approach to the planning and management of all activities in the Estuary is needed;
- Any tidal range energy development would impact on the environment. Designated sites and protected species are both likely to be affected. The impacts would vary dependent on location, scale, design and operation, and there are still many uncertainties, including how fish might be impacted;
- Given the potential scale of development, it is likely that a strategic approach to compensation would be needed at a national level;
- Further research, data collection and modelling would be a prerequisite for any project development. Agreed methodologies should be used, and all data should be open and available;
- Tidal lagoons offer a preferred option to barrages. Cumulative effects of such developments must be considered, and an integrated environmental and engineering co-production approach to design and site selection be adopted.

[19] New Civil Engineer (2025), Mersey Tidal energy scheme receives very strong public support in first consultation, https://www.newcivilengineer.com/latest/mersey-tidal-energy-scheme-receives-very-strong-public-support-in-first-consultation-29-01-2025/

4 Electrical System Integration

4.1 Connection process

Connection to the grid is, of course, a vital step. The Severn Estuary sites are surrounded by transmission assets on both the Welsh and the English sides and hence there are multiple potential connection points. However, as well as a substation to which a connection can be made, transmission reinforcements may also be required. The nature of the reinforcements will depend on the power of the project to be connected and also on the other generation, storage, demand and degree of interconnection of the grid in the region.

Even the "small" projects (~0.5 GW) under consideration represent significant extra generation and, since the grid in the Estuary area is quite congested, careful evaluation will be required. Projects over 1.8 GW would require more than a single connection to meet the loss of power infeed limit. To optimise integration, for the larger projects the connections may be made to different substations or connection locations.

The six example projects considered in this study would each require a connection agreement with the National Energy System Operator (NESO) in order to connect into Great Britain's National Electricity Transmission Network (NETS).[20] All connections must comply with the various codes and lengthy and detailed liaison with National Grid plc will be needed to cover connection points and time frames.

Accepted applications receive an offer from NESO and, if signed by both parties, they enter into a contractual agreement and they join the connections queue. Since the connection reforms introduced in January 2025,[21] the queue[22] is now pro-actively managed by NESO to accelerate projects that are complying with their contractual rate of progress. Under connection reform, a project can receive an indicative offer, and subsequently a more comprehensive offer when the project is sufficiently mature. The current TEC Register[23] shows less that 1GW of tidal power with none located in the Severn Estuary. Currently NESO, Ofgem and DESNZ are focussed on prioritising projects for connection which can deliver for Clean Power 2030 or soon after for 2035, so largely outside the time line for projects in the Estuary.

4.2 Connection infrastructure

National Grid Electricity Transmission produces its own business plans, which have to be agreed by Ofgem, in order to allow for future grid investments to be made. For

[20] NETS is the high-voltage network that transports electricity across the country. NESO is the publicly owned body responsible for the future planning and day to day management of the network. The network itself is constructed, owned and maintained by National Grid plc.
[21] NESO (2025), Connections Reform https://www.neso.energy/industry-information/connections/connections-reform
[22] As of July 2024, there were over 550GW of projects contracted to connect to the transmission system, compared to nearly 90GW of connected generation already on the system.
[23] NESO (2025), TEC Register - 14 March 2025 https://www.neso.energy/data-portal/transmission-entry-capacity-tec-register/tec_register_14_february_2025

example, the latest version[24] for the South West regional grid infrastructure is provided below.

> *"The South West England high voltage transmission network principally consists of a 400 kV ring fed by circuits from South Wales, West London and the South Midlands. The region is in transition from a net importer to net exporter of power due to the connection of the Hinkley Point C Nuclear generator (3.2 GW) expected 2029-31. The surrounding network has recently been reinforced to support the Hinkley Point C connection, with further enhancements planned to ensure continued reliability and capacity."*

National Grid also makes regular projections of the future requirements of the high voltage network which are affected by both demand and generation:

- There is a significant shift in the energy landscape for the region with large volumes of clean generation looking to connect in South West England and South Wales.
- Further requirements include industrial developments for example, Hinkley Point C, Tata Group's Agratas battery manufacturing "Giga-Factory" facility and new data centres.

The equivalent statement for Wales[25] states that the network in South Wales expects a similar increase in demand resulting from the decarbonisation goals of industry, new data centres and hydrogen production. Demands on the transmission and distribution networks are increasing and National Grid Transmission and National Grid Distribution are currently assessing various options to determine the long-term reinforcement needs of the South Wales network.

Significant reinforcement of the high voltage network in the region may be required with several new connections proposed including the Celtic Sea's Floating Offshore Wind and the possible 3.6 GW Xlink intercontinental interconnectors from Morocco, which is planned to "land" in Devon.

NESO's 2024 Ten Year Statement[26] gives a ten-year view of the demands on the grid system, on a region-by-region basis, detailing constraint points and projected grid infrastructure requirements. The two regions of interest to the Severn Estuary are South Wales and South West England and the transmission boundaries are SW1 and B13.

NESO's analysis of the South Wales and the South West grid capacity are shown in Figures 4.1 and 4.2 respectively. These figures show the capacity of the grid and the Required Transfer (RT). Loosely, RT is a measure of the use that is made of that capacity.

[24] National Grid (2025), South West: Future Network Blueprint, https://www.riiot3.nationalgrid.com/document/30131/download
[25] National Grid (2025), Wales: Future Network Blueprint, https://riiot3.nationalgrid.com/document/30136/download
[26] NESO (2024) Electricity Ten Year Statement, https://www.neso.energy/document/352001/download

It has two different forms – Economy and Security. When either of the RT levels approaches the capacity then grid re-enforcement is needed.

Figure 4.1 illustrates the South Wales capacity and demand for the HE pathway. The South Wales grid has excess capacity at present and will continue to do so for the next ten years. Much of today's excess capacity will be used up by the 3GW of floating offshore wind, if it connects as planned, in the middle of the next decade. There is also spare capacity to at least 2042. The electrification of the Port Talbot steel works[27] presents a substantial rise in the need for low-carbon electricity. It would be an attractive load for a tidal range energy project in the Estuary, and a private wire to connect the project could add commercial value. However, the timing of the electrification of the steel works and the construction of a tidal range project may not be compatible. Tidal range energy could also be a source of energy for green hydrogen production.

Figure 4.2 illustrates the South West capacity and demand according to the HE pathway. The South West England grid has sufficient capacity up to 2030, but further reinforcements may be required post-2030, again following the connection of possible offshore wind projects in the South West.

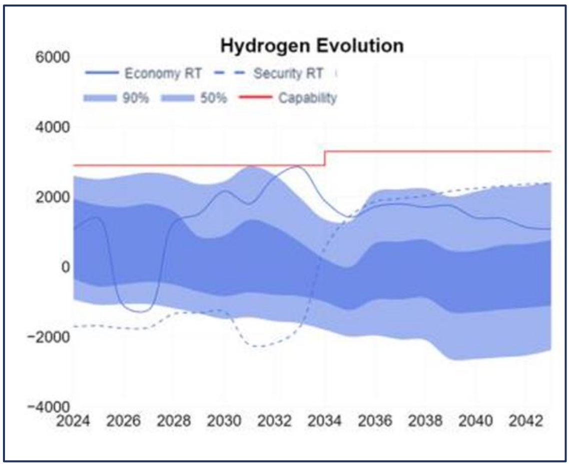


Figure 4.1: South Wales Grid Capacity (MW) to 2042

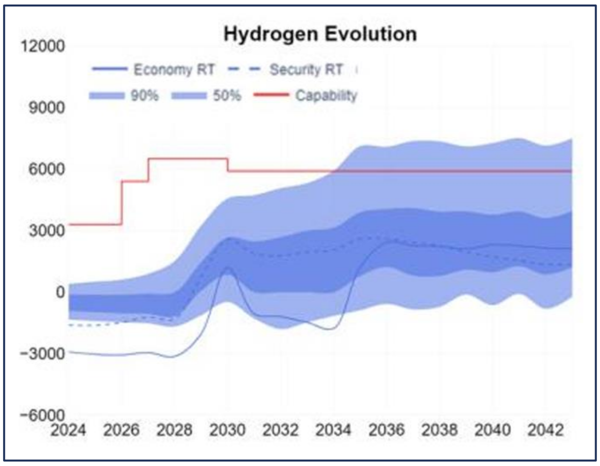


Figure 4.2: South West England Grid Capacity(MW) to 2042[28]

4.3 NESO Future Energy Scenarios

NESO's Future Energy Scenarios[29] (FES 24) set out multiple credible pathways to decarbonise the energy system by 2050. The Commission has used the "Hydrogen Evolution" pathway as the reference for its analysis. This pathway is the most ambitious

[27] Tata Steel (2023), Tata Steel and the UK Government jointly agree on investment proposal https://www.tatasteeluk.com/corporate/news/tata-steel-and-uk-government-jointly-agree-investment-proposal

[28] NESO (2024), Electricity Ten Year Statement, https://www.neso.energy/publications/electricity-ten-year-statement-etys

[29] NESO (2025), Future Energy Scenarios, https://www.neso.energy/publications/future-energy-scenarios-fes

in terms of tidal range deployment and is also being used by NESO in their own work addressing the potential impacts of tidal range on the GB energy system operability. It was therefore chosen, in consultation with NESO, in order to be consistent.

4.4 Cost of grid connection infrastructure

The cost of connection to the electricity transmission network is accounted for, in broad terms, in the cost estimates used for the six example projects described in the August 2023[30] Report prepared by WSP for Western Gateway provided as an appendix on line. The need for wider reinforcements, to remove constraints on the network, as it expands from servicing the current electricity generation capacity of 90GW to over 300GW by 2050 will influence connection dates. Wider reinforcements are paid for through TNUoS charges.[31] Estimates are included within the annual operating costs of the six example projects. These estimates may be conservative since it is possible that a tidal project in the Estuary might benefit from negative TNUoS as does Hinkley C.

4.5 Other grid connection considerations for tidal range

Generators and Suppliers of electrical energy are incentivised to match supply and demand but final balancing of the power system, so that supply meets demand at all times of the day, is NESO's responsibility. It involves continuously monitoring the generators on the system and managing excess supply and demand. There is also the challenge of understanding where constraints on the grid occur, and curtailing energy generation to ensure the transmission network operates within its limits. These actions usually involve curtailing energy generation behind a constraint and procuring energy from another provider elsewhere on the system. These are called "constraint costs" and are forecast to reach between £2-3bn per annum in the early 2030s. The location of generation projects on the transmission network is of increasing importance. Most constraints currently arise for North to South flows on transmission boundaries in Scotland and Northern England. From the Commission's review of the projected grid capacity in South Wales and the South West to 2042, it seems that tidal range energy projects are unlikely to increase net constraint costs and could be expected to have a downward influence on them.

To keep the grid stable and enable it to perform its function of moving power from generation sources to demand, both voltage and frequency must be managed. Historically, the majority of electricity generation on the system used synchronous generators e.g. in coal, hydro, gas and nuclear plant. The inertia of these spinning turbine generators helps to reduce frequency fluctuations. These machines act as flywheels. The increasing use of power electronics to connect infeeds and generation has reduced the system inertia. The "inverter-based resources" (IBRs) including battery storage, wind and solar do not provide inherent inertia. These technologies can however provide

[30] WSP (2023), Sustainable Energy in the Severn Estuary, https://www.severncommission.co.uk/wp-content/uploads/2024/03/Severn-Estuary-Evidence-Base-and-Framework.pdf
[31] NESO (2024), Transmission Network Use of System (TNUoS) Charges, https://www.neso.energy/industry-information/charging/tnuos-charges

'synthetic inertia'. Synthetic inertia has been proven to be useful for recovering from faults, but it cannot prevent them from occurring in the first place.

Additional sources of inertia and frequency control require a source of stored energy, for example by flywheels or short duration but fast response batteries. If suitably controlled, for the periods when they are running, typically 16 hours per day, directly connected tidal range synchronous generators can contribute to the grid's system inertia, voltage control and system strength (short circuit level).

A tidal range energy project operates every day and is highly predictable and forecastable, it therefore has reduced operational reserve requirements compared to other forms of renewable generation. If appropriately controlled, tidal range energy can provide storage and controllability which sets it apart from the other renewables which are weather dependent. The variability of other renewables is now adequately addressed through intra-day trading and storage. Storage is presently being added to the system but so is more wind and solar. Since mismatches in generation and load, measured in hours, which tidal range energy can address through its inherent storage, can result in large changes in price, this characteristic is of some value to the grid and potentially of high value to the owner of the asset.

Tidal range energy is a variable, renewable resource that is not affected by so-called "*Dunkelflaute*"[32] – periods of low wind and little sun. It can therefore play a significant role in displacing the 5% remaining gas-powered generation from the power system in the Clean Power Action Plan, 2030.[33]

In principle tidal range power could help with peak shaving[34] since, if some energy is stored rather than released immediately, it can be available at short notice. There will, however, be times of maximum demand, such as the so-called "winter tea-time peak" when, due to the tidal cycle which is 12 hours and 50 minutes rather than exactly 12 hours, on occasion, no tidal range energy will be available. The predictable, but shifting time of the tides, and potential storage capability of tidal range generation, present both challenges and opportunities for grid operation. Finally, tidal range energy projects in the Estuary are located relatively close to centres of demand, compared to offshore wind, and thus do not require such long lengths of transmission line to connect them to the grid.

4.6 Wholesale energy cost considerations

The changing climate policy, electricity generation, carbon prices, gas prices, electrification, interconnection and transmission network expansion together present a very complicated landscape. Predicting wholesale electricity prices for the decade 2040

[32] *Dunkelflaute* is a German term that means "dark lull". It refers to a weather event where there is little wind and sunlight for a prolonged period.
[33] DESNZ (2024), Clean Power 2030 Action Plan, https://www.gov.uk/government/publications/clean-power-2030-action-plan
[34] "Peak shaving" is the use of an additional power source in synchronisation with the main power supply to deliver enough power to meet the peak demand that cannot be met by the main power supply.

to 2050 and beyond is challenging. By way of example, the Hydrogen Evolution pathway,[35] anticipates that, in 2050, the mix of electricity generation assets and their respective energy outputs will be as set out in Table 4.1. The mix in 2024 is also shown for comparison. It is clear that the extent of change is significant. The potential contribution from tidal range projects in the Estuary has been added to the table. Given the energy mix in 2050, with a very significant increase in wind energy content, tidal range energy, with its predictable energy output, is expected to reduce the day-ahead wholesale electricity price.

Table 4.1: Anticipated Energy Outputs in TWh from the GB Electricity Generation Mix in 2050 together with contribution from possible tidal projects in the Estuary[36]

Technology	Annual Energy Output 2024 (TWh)	Annual Energy Output 2050 (TWh)
Interconnectors (export)	-15.9	14.9
Biomass	28.4	0.0
CCS Biomass	0.0	30.6
Fossil Fuel	54.3	0.0
CCS Gas	0.0	41.6
Nuclear	44.0	76.8
Hydrogen	0.0	24.4
Offshore Wind	61.5	369.9
Onshore Wind	38.3	79.7
Solar	17.3	76.5
Waste	14.6	4.3
Hydro	3.5	4.0
Marine	0.1	7.9
Storage	0.8	6.6
Large barrage	-	*16.7*
Large Lagoon	-	*5.5*
Medium lagoon	-	*1.2*

[35] NESO (2024), Future Energy Scenarios, https://www.neso.energy/publications/future-energy-scenarios-fes
[36] Ibid.

4.7 Market cost benefit analysis

Modelling undertaken for the Commission showed that the larger generation capacity scenarios (above 4.5GW) were found to significantly reduce the wholesale power price over the study period. The scenarios with less capacity only had a modest impact compared to the counterfactual. Reduction of wholesale costs would marginally increase the costs of existing renewables through the CfD although the benefits of reduced wholesale costs are significantly larger.

The smaller tidal power projects (below 4.5MW) located in the Severn Estuary do not increase constraints costs compared to the counterfactual[37] in the study period. However, the larger target case scenarios suggest that capacities above 4.5GW could increase constraint costs payments. There is the potential for future network development to reduce the cost impact of the larger capacity scenarios.

The modelling indicates that tidal generation assets would likely have a positive impact on system stability by providing increased system 'inertia' and reducing the need for the NESO to procure frequency response services. This benefit has not been quantified but is expected to be much smaller in magnitude compared to wholesale prices and constraint costs. The system benefits increase with the scale of the tidal project considered.

Adding a co-located 4-hour duration battery of 6.8GW peak capacity to create a hybrid generation asset for the largest tidal power scenario (the 8.6GW tidal barrage) was also considered. This reduced the negative impact on constraints costs, because of it be able to offer a higher degree of flexibility.

The modelling results were combined into a single Cost Benefit Analysis (CBA), aggregating each element of the quantified results into a single figure Net Present Value (NPV) figure that covers the period of assets coming online to 2050.

The different scenarios have different commissioning dates, so the CBA was undertaken over different time periods, but the results are broadly positive (i.e. less cost to the consumer) across the range of CBA time periods, with the major influence being the reduction in the day-ahead wholesale price.

[37] The counterfactual is the GB energy system with the tidal component replaced with a representative generation mix.

4.8 Conclusions

The following conclusions are drawn about the connection of tidal range energy projects in the Estuary to the grid.

- It is feasible for Severn Estuary tidal range energy projects to contribute zero carbon generation to the grid or make equivalent private wire arrangements;
- Grid capacity exists for an early, small to medium sized tidal range project providing NESO accept a connection case post 2030;
- The timetable to begin generation is 2035 for a small to medium project and 2040 for a large project. For these times. tidal range projects have either a neutral or positive effect on curtailment costs;
- Tidal range energy is variable, but highly predictable. When suitably controlled, it incorporates some inherent storage which adds some support to the grid and, more markedly, value to the owner of the asset;
- A large tidal project, alongside other proposed renewable developments connecting in the in South West /South Wales, may result in further grid reinforcement being required in 2040 or beyond;
- Tidal range energy is likely to cause downward pressure on wholesale electricity prices;
- Tidal range projects with directly connected synchronous generators can support grid system stability providing inertia, voltage control and frequency support;
- Projects in the Estuary are likely to be located near centres of demand thereby reducing transmission line lengths and cost. There may be opportunities for private wire connection to major loads.

5 Socio-economics

5.1 The regional economy

The Severn Estuary region has a population of 5.5 million and is characterised by cities and sparsely populated rural areas. The workforce is relatively well-educated, a significant proportion hold degree-level qualifications. However, there are notable disparities in employment and income levels, with pockets of deprivation in urban centres and the Welsh Valleys.

Economically, the region is robust, with a total GVA of £144 billion in 2024, making it larger than both the Greater Manchester and the West Midlands Combined Authorities. Future growth projections for the region are positive. High-value services, such as information and communication, and professional, scientific, and technical activities, are expected to drive this growth. The region has significant experience of delivering major civil engineering projects and has shown that it can scale up quickly as demonstrated by the construction of Hinkley Point C (HPC) nuclear power station in Somerset.

5.2 Potential economic impacts

The development and construction phases of tidal range projects are expected to generate significant employment opportunities. The projects vary in scale, with the smaller projects supporting approximately 30,000 – 40,000 job years, while the Cardiff-Weston Barrage, a “mega project”, could support almost 600,000 job years. These figures include direct, indirect and induced jobs. Figure 5.1 shows the construction employment for each of the six example projects. Jobs expected for each year of the operational phase vary from 190 for a small lagoon to 3,500 for a large barrage.

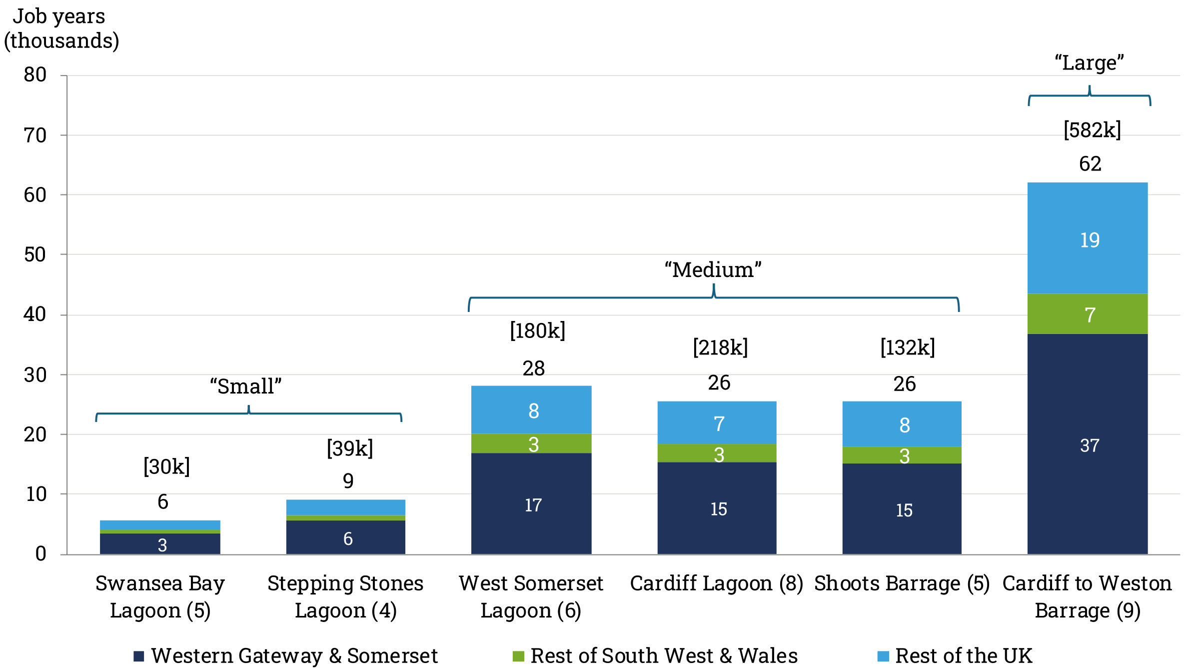


Figure 5.1: Development and Construction Average Annual Job Years in the UK by Impact Area and Project, Mid-Point Scenario

Figures in rounded brackets ( ) indicate number of construction years. Figures in square brackets [ ] indicate cumulative job years throughout development and construction phase.

Supply chain impacts

Tidal range projects, and other renewable energy projects, present significant supply chain opportunities for the Severn Estuary area, the wider region and the UK as a whole.

Securing UK and local content, in order to maximise economic benefits of investment, will largely rely on contractual requirements and incentives. The experience from HPC demonstrates that, with concerted efforts to build local capability, high levels of local, regional, and UK content can be achieved. HPC has led to significant growth in local businesses and substantial contracts were awarded to companies in the region together with significant inward investment.

Turbine manufacture and assembly present specific challenges, in both volume and timescale, since globally there are few manufacturers of turbines suitable for tidal range application. In fact, outside China there are only three. The UK has lost some of the manufacturing capability identified for the development of the Swansea Bay project for which local content estimates were made at the time. The industrial capacity required to deliver large-scale mechanical/electrical contracts provides an attractive opportunity. There are some well-qualified facilities in the UK that could be encouraged to expand around the Severn Estuary.

A summary of the GVA analyses is presented in Table 5.1.

Table 5.1: Summary of UK level Jobs and GVA for different example projects

Type	Large Barrage	Small Barrage	Large Lagoon	Medium Lagoon	Small Lagoon
Cumulative Construction Phase GVA (£m)	36,000	8,000	10,000-12,000	2,100	1,600
Annual Operational GVA(£m/yr)	320	65	100-120	20	15
Construction Jobs Years, '000:	580	130	180-220	40	30
Operational Jobs	3,500	700	1,100-1,300	240	190

A multi-project approach

A multi-project approach, for example a series of lagoons, as opposed to a single large project, would spread capital expenditure over a longer period. That approach could help develop the supply chain and offer longer-term employment opportunities. Such projects would not necessarily be within the region but could be elsewhere in the UK and allow the country to take an international lead in tidal range project implementation.

The speculative nature of the many historical and abandoned projects has led to a reluctance to invest in workforce development and supply chain readiness. However, if this obstacle can be overcome, with appropriate policy statements and other indications to give confidence, the potential for a range of infrastructure projects across the Severn Estuary region presents an opportunity to train a workforce that can move from scheme to scheme both in the UK and possibly internationally. Effective coordination and sequencing of projects would ensure a steady pipeline of work and a skilled workforce ready to tackle new challenges.

Sector development

The longer-term export opportunities arising from investment in tidal range energy within the Severn Estuary, and the wider UK, are expected to be concentrated in expertise and knowledge, and exporting these skills and services globally.

Port related impacts

The ports within the Severn Estuary are significant economic infrastructure assets performing a regional and national role. They support a combined 40,000 jobs and are responsible for £3bn per annum of GDP. They underpin a number of sectors and provide a large number of jobs in the Severn Estuary area and the wider Wales and South West economies.

For the six example projects, the greatest risk to ports is associated with the Cardiff Weston Barrage which previous studies also showed had an adverse economic impact. The lowest risk example project was, unsurprisingly, considered to be the Swansea Bay lagoon. Any tidal range energy project that progresses will need to ensure that its design minimises any disruption to shipping and navigation.

A large barrage would require significant investment in navigation infrastructure, including new locks, modifications to existing port infrastructure, and increased dredging of navigation channels close to the port entrances. There would be other adverse effects including the increased time to transit an additional set of navigation locks. Both ABP and the Port of Bristol oppose a tidal barrage downstream of their ports.

Lagoons do not impede navigation channels or routes but, in some locations, and dependent upon scale, there will be some change in sedimentation and currents.

A snapshot of marine traffic in the Severn Estuary in 2023 is shown in the "heat map" in Figure 5.2.[38] It demonstrates that, of the six example projects, the large barrage and the Cardiff Lagoon would have the highest impact on current shipping patterns.

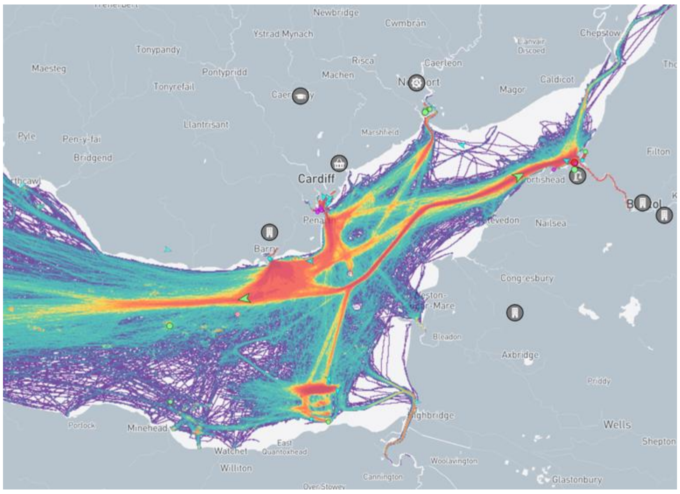


Figure 5.2: Heat map of shipping movements in the Severn Estuary

In evidence to the Commission, the Bristol Port Company offered their own experience of the suspended silt load in the Estuary to illustrate likely damaging effects on tidal range energy projects. This experience included the extent of dredging and wear on pump impellors and seals in Avonmouth and Portbury. However, given their different scale, location and mode of operation, the Commission considers that care is needed in transposing such effects to potential tidal range energy structures.

5.3 Wider economic impacts

Tourism and leisure impacts

There is scope for tidal lagoons to act as catalysts for wider tourism and leisure-based regeneration. Between 10 jobs for a small project in a remote location, to more than 100 for a large lagoon in a more populated location could be provided.

Opportunities from low carbon energy

The development of a tidal range project, as a part of a wider cluster in and around the Severn Estuary area, would balance the current dominance and concentration of low-carbon power generation in the East of England arising from offshore wind.

The Severn Estuary and Bristol Channel have plans for new floating offshore wind (FLOW) farms in the Celtic Sea which include new substations in Devon, Carmarthenshire and to the East of Swansea. There are also plans for investment in the

[38] Marine Traffic (2023), Heat map of shipping movements in the Severn Estuary for 2023 (purple - low to dark red – high), https://www.marinetraffic.com/en/ais/home/centerx:-3.0/centery:51.4/zoom:10

associated port infrastructure which would benefit tidal range energy. If both tidal range and FLOW projects proceed, then careful planning will be needed to ensure complementarity rather than competition.

5.4 Social and community effects

Delivering large scale infrastructure projects

Tidal range energy projects contribute to skills development, thus increasing future employment prospects. However, they can also lead to the temporary or permanent migration of workers into the local area, increasing demand for housing and services. Effective strategies are essential to ensure any migration of workers into the area creates an economic uplift.

Flood protection

The flooding implications of the six example projects were investigated. Using the existing evidence base, primarily from the 2010 Severn Tidal Power Feasibility Study, advantages were identified within the impounded areas. They mainly related to protection of communities and assets from future sea level rise and increased storm surges, resulting from climate change. Ingress of water during extreme sea levels into the impounded area are prevented and, for some operating modes, upstream water levels will be lower than they are today. Potential issues were also identified. For example, modifications to tide locked drainage outfalls may be needed. Provided that any negative impacts are mitigated within the project scope, the net outcome of a tidal range project is a benefit for flood and coastal protection.

The Commissioners therefore conclude that tidal energy projects can contribute to future flood defence and coastal protection. Further work would be required to quantify the scale and nature of such benefits when a tidal power project is proposed in the future.

5.5 Conclusions

- Tidal range energy schemes in the Severn Estuary offer significant socio-economic opportunities, particularly during development and construction, even for smaller projects. The UK supply chain would need substantial scaling-up to meet demand. Strategic and tactical actions are required to seize these opportunities, both nationally and internationally, while also building confidence in the sector.
- The smaller projects would create approximately 30,000 – 40,000 job years during construction, while a big barrage would create almost 600,000 job years.
- A large barrage scheme would significantly disrupt port operations within the Estuary and faces strong opposition. In contrast, lagoons are less contentious and present a more viable alternative. A series of lagoon projects could also provide longer-term economic benefits, more broadly across the region and nationally, compared to a single barrage.
- These lagoon projects would not necessarily be within the Severn Estuary and could be developed anywhere in the UK. In other locations barrages may well be

acceptable, for example in the Mersey. The technology for lagoons and barrages is essentially the same and hence there is an opportunity to establish the UK as a hub for tidal range activity as a whole, not just for lagoons.
- To maximise the potential benefits, effective coordination, early planning, and investment are essential to ensure the readiness of the workforce and supply chain.
- A tidal range project is likely to be beneficial for flood protection.

6 Funding and Finance

6.1 Project characteristics

The following characteristics of tidal range projects are key issues for private sector financiers:

- **Large scale and long construction timeframe.** The tidal range technical solutions considered in this report range from c. £2bn, generally deemed "large" by private finance providers to c. £33bn, generally deemed "very large." Compared to conventional projects like gas-fired power plants and on- and off-shore wind farms, tidal range projects have a much longer construction period, ranging from five to nine years. Interest on debt finance is typically capitalised over this timeframe and thus represents a high percentage of total project costs compared to shorter-duration projects, so the sourcing and cost of finance is a critical component of a project's overall economics.
- **Long operating life.** Tidal range projects are expected to be operational for at least 120 years. There may be a need to service or replace electrical and mechanical equipment/turbines every 40 to 50 years, but otherwise, operational costs are low.
- **Few precedents.** Globally, there are only two operational tidal range projects. Given the limited number of precedents and the scale of the capital expenditure required to build them, it is unlikely that the price of construction can be finalised/contracted in advance, representing a major potential risk for financiers.
- **Specific development challenges.** The development phase is challenging given the wide range of environmental issues and the concerns of public sector and special interest group stakeholders. It is unlikely that private sector capital can be found to finance the development phase of a tidal range project in the Severn Estuary.
- **Moderate decommissioning issues.** Decommissioning will be relatively limited in scope. Given the expected impact on the environment of removal of the marine wall, the likely requirement is to remove the turbines and leave the wall in place.

6.2 Assessment of funding model options

If they are to attract financing from the private sector to cover their construction and other costs, infrastructure projects typically require a regulatory regime that removes some of the uncertainty around their revenue, for example guaranteed connectivity to the consumer and/or restrictions on price variability. The design of this regulatory regime, or funding model, is a key consideration.

The suitability of four possible funding models has been assessed in the context of the characteristics of tidal range projects.

- **Design Build Finance Operate (DBFO)** is a long-term contract between a private party and a government entity for designing, building, financing, and operating a public asset and related services. It was used extensively in Private Finance Initiative (PFI) projects earlier this century. It is used for short contract lengths (25-30 years) and does not allow for cash-flow back to investors during construction. Given the historical problems with PFI projects, Government currently prohibits DBFO structures.

- The **Cap & Floor** mechanism is a regulatory framework which sets a floor price to ensure that an asset can cover its operating expenses and debt service, with a cap to limit excessive profits for asset owners. Although this structure provides some financial predictability for investors, partially reducing investment risk, cash-flow to investors during construction is also not possible. There is no precedent for its use for large or long-term assets.
- The **Contract for Difference (CfD)** is a mechanism for providing price certainty by guaranteeing a 'strike price' for electricity generated, which has been used successfully for renewable energy projects, particularly offshore wind. It was also used for Hinkley Point C nuclear power station. However, a 2017 NAO report and subsequent analysis in 2020 by the Nuclear Industry Association, commented that the strike price included a significant premium over the cost of finance for a typical regulated asset. The CfD model is not currently seen as appropriate for assets with a long operating life, particularly as it does not permit investor cash-flow during construction.
- **Regulated Asset Base (RAB)** funding is a form of economic regulation commonly employed in the UK for monopoly assets, such as water, gas, and electricity networks. A "RAB Co" receives a licence from a regulator, granting it the right to charge a regulated price to users in exchange for providing services that utilise the specified infrastructure. Cash-flow to investors during construction is permitted, allowing investors, consumers and Government to share construction and other risks. Projects with RAB funding can attract 50+ year investment, and RAB can offer better long-term value than other schemes by reducing overall financing costs. However, it requires consumers to start paying for the asset before construction is completed and introduces greater regulatory complexity compared to other schemes. There are elements of the CfD funding structure that can be incorporated advantageously into a RAB funded project.

6.3 Historical context & current initiatives

The UK has a rich history of funding structures that have enabled major infrastructure projects to be largely or entirely financed by the private sector. There has been some particularly useful experience trying to finance the tidal range energy project in Swansea Bay. Since this attempt was abandoned, recent initiatives in related sectors, particularly water and nuclear power, provide important lessons, suggesting that a new attempt to develop and finance tidal range energy in the Severn Estuary could be successful.

- The **Swansea Bay Tidal Lagoon** project was promoted by Tidal Lagoon Power Ltd from 2011 and received a Development Consent Order in 2015. The Hendry Review, in 2017, recommended that Government support the scheme, adopting a choice of a 35 or a 60-year CfD contract. Ultimately, in June 2018, Government decided not to progress the project. A key factor was the high CfD strike price compared, using conventional metrics, to wind, solar, and nuclear projects. Relative to alternative tidal range opportunities in the Severn Estuary, the Swansea Bay project is small with a high cost of energy for the consumer. It was always intended as a "path-finder" - a pre-cursor to a series of commercial projects.

- Recent experience of large-scale infrastructure schemes is particularly relevant. For **Hinkley Point C** (a 3.2 GW nuclear plant in construction), which reached financial close in 2016, a CfD approach was adopted. At the time, the strike price of £92.50/MWh, based on 2012 prices, index-linked for 35 years was considered to be very high. As described above, construction risk is borne by investors, resulting in a high cost of finance, which accounted for approximately 62% of the CfD strike price.[39]
- Between 2010 and 2018, **NuGen and Horizon**, two proposals to build nuclear power plants, sought to improve the viability of the CfD structure, but were ultimately unable to raise financing at a price considered to be good value for money. These proposals were abandoned.

Separately, there has been increased focus on the RAB funding structure, notably, for example:

- **Thames Tideway Tunnel**[40] (built and entering commissioning) is a £4.5 billion, 25km 'super sewer'. It was RAB funded and constructed within its initial budget.
- **Sizewell C,** a 3.2GW nuclear power station, is currently under development and seeking to use a RAB funding structure.

In light of this experience the Commission has concluded that the RAB funding approach should be adopted for tidal range projects in the Severn Estuary.

6.4 RAB model – profile of consumer charges

Figure 6.1 shows the expected profile of regulated charges (in real terms, 2023 prices) under the RAB model as well as typical, or actually agreed, CfD strike prices for projects using other technologies. The two tidal range solutions shown represent the most cost-effective barrage and the most cost-effective lagoon projects. The breadth of the banding reflects both high/low assumptions for the cost of capital at a particular site, and also the key conclusion that the choice of site has a significant impact on the cost for consumers of energy from the selected project and, most likely, the project's financial viability.

[39] National Audit Office (2017), Report – Value for money, Hinkley Point C, https://www.nao.org.uk/reports/hinkley-point-c/
[40] Thames Water (accessed Jan 2025), Thames Tideway Tunnel, https://www.thameswater.co.uk/about-us/projects/thames-tideway-tunnel

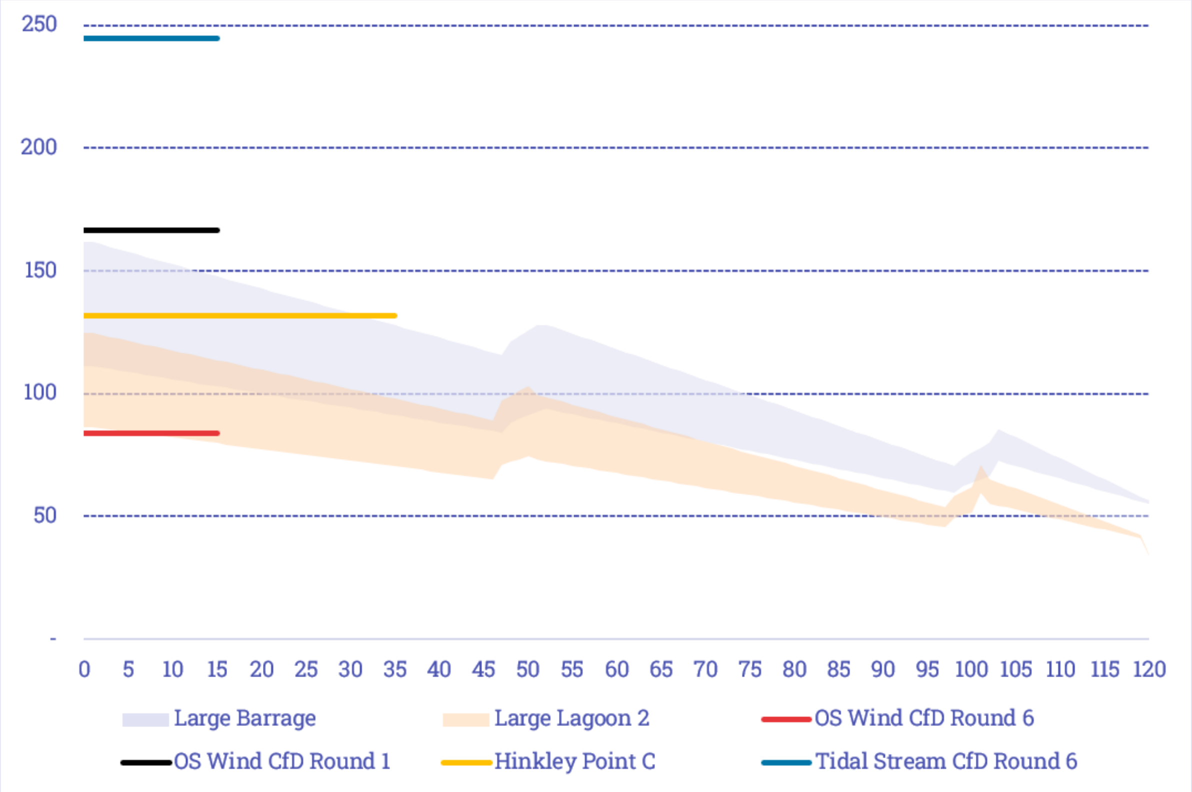


Figure 6.1: Expected profile of regulated charges (in real terms, 2023 prices) under the RAB model for tidal range and CfD strike prices for other technologies.

Several of the six example projects considered by the Commission lie within the shaded ranges. The outliers are the small barrage and Swansea Bay Lagoon, which are both more expensive in terms of higher cost per unit of electricity generated.

This analysis shows that RAB-funded tidal range projects may be more competitive, from the outset, than power generation projects based on other technologies, without taking account other system-wide benefits that would be taken into account in a Dynamic Despatch Model or similar.[41] Notably, the cost of energy from RAB funded projects falls over time.

6.5 Conclusions

The Commission has concluded that the RAB model offers the most appropriate framework for balancing investor needs, consumer protection, and project viability. Although Cap & Floor and CfD regimes have both been successful in some segments of the energy market, neither offers sufficient flexibility in sharing risk between investors, Government and consumers to be viable for large, long-life tidal range assets.

[41] DESNZ uses a Dynamic Dispatch Model (DDM) approach when evaluating power generation projects. DDM enables a more comprehensive analysis of how different policies affect generation mix, costs, prices, security of supply, and carbon emissions.

This conclusion reflects current best practice for the funding of major infrastructure projects, for example the Thames Tideway Tunnel, which is now operational, and, potentially, in Sizewell C,[42] which is currently under development. Tidal range projects share several characteristics with these assets.

Building a smaller, but commercial, tidal range project first could serve to boost investor confidence, prior to developing additional tidal range projects on a staged basis, both in the Severn Estuary and, potentially, elsewhere in the UK. The successful completion and proven performance, both commercially and environmentally, of such an initial project would, if combined with a suitable funding model, likely serve to lower perceived construction risks and potentially attract lower-cost private sector finance.

An initial project should be large enough to be commercially viable but not so large that it deters private sector capital providers; a medium sized lagoon project could fulfil this requirement.

Round-table discussions concluded that there is considerable interest among private capital providers in financing the construction phase of a project with RAB-based funding. There was, however, limited investor appetite for financing the development phase and it was suggested that development funding for the first project would likely need to come from the public sector. There was unanimous agreement that a clear policy statement in support of tidal range energy was a necessary requirement for any serous investor interest.

Preparation of the RAB model

The Commission recommends that further work is carried out to define the next steps needed to implement the RAB model, that will facilitate the raising of private sector financing for tidal range projects in the Severn Estuary. This main recommendation should be supported by the following actions:

- Develop a comprehensive risk allocation framework specific to tidal range projects, clearly defining responsibilities for each stakeholder group.
- Define and agree a bespoke project evaluation methodology, such as a modified Dynamic Despatch Model approach, that appropriately values the long-term, predictable nature of tidal range energy generation.
- Conduct a detailed value for money assessment of tidal range projects in the Severn Estuary, quantifying the potential for risk transfer under a RAB funding structure compared to public funding alternatives. Ensure utilisation of a robust environmental and social impact assessment methodology.
- Undertake further market engagement activity to test investors' appetite.

[42] The Government estimated that, for Sizewell C, consumers were expected to save over £30bn over the project's lifetime compared with other financing methods.

- Develop a comprehensive stakeholder engagement plan, including environmental groups, investors, government bodies, local authorities and communities.

7 Key Findings

7.1 The need for tidal range energy to meet Net Zero

The UK's demand for electricity is anticipated by both the National Energy System Operator and the independent Climate Change Committee, to more than double by 2050. The potential contribution of tidal range energy to a decarbonised electricity supply is well documented.[43] The output from tidal range projects is variable but highly predictable - a unique characteristic that distinguishes it from other renewable energy sources to the benefit of both the operators of the project, the grid and offtakers. Tidal range energy has full life carbon costs similar to other renewables.

The changing context of electricity supply and demand means that there is now a clear public interest case for the development of tidal range energy as part of the long-term energy mix. NESO'S 2024 Future Energy Scenarios assumes that a contribution of between 3 GW and 5GW of tidal range energy will be required by 2050.

At over 14m, the Severn Estuary has one of the world's highest tidal ranges offering the potential to contribute up to 7% of present electricity needs. It is the largest tidal range energy resource in the UK.

7.2 Construction and engineering

Tidal range energy in the Severn Estuary can be harnessed using conventional turbine technology and could be implemented today through the construction of barrages and/or lagoons.

While there are innovations in turbine design underway, there are commercially and technically proven turbine types available, and there is no case to delay implementation awaiting their arrival.

Unlike wind and solar, tidal range costs are largely fixed due to the need for large sea walls, which limit savings from industrial scaling. Any cost reductions will depend on efficiency, contracting strategies and risk reduction rather than mass production.

The ease of access to the grid and the location of major energy users close to the Estuary allow reduced transmission costs compared to remote offshore wind farms.

It is the size and the associated costs and impacts of such a project, rather than the basic technology, which present the dominant commercial risks.

[43] Sustainable Development Commission (2007), Turning the Tide, Tidal Power in the UK, https://www.sd-commission.org.uk/publications.php@id=607.html

7.3 Current state, importance, and protection of the environment and ecology of the Severn Estuary

The Severn Estuary is environmentally and ecologically important both nationally and internationally. The Estuary is highly protected and recognised as a wetland area of international importance.

Over the last few decades, a series of well-funded studies on the Estuary's energy potential have yielded consistent recommendations emphasising the need for more research and systematic gathering of environmental data.

It is regrettable that few of the recommendations have been acted upon. There are still many data gaps. Concern over these data gaps has featured strongly in the responses from environmental stakeholders. It has also been stressed that there is a lack of knowledge of the current conservation status of designated sites. Addressing these gaps, and ensuring information is up to date, is critical for a full understanding of any development's impacts, designing effective mitigation, and implementing compensation where necessary.

There is some evidence that the Estuary and its ecology are already being impacted by climate change. Based on international and national climate change data and predictions, it will change further, with rising sea levels, warming waters, and shifting weather patterns. These changes will impact the Estuary's species and habitats, for example there will be challenges for cold-water fish such as salmon, and potentially the migratory habits of birds. These changes could alter the ecology of the Estuary and might even result in the loss of some species and the gain of others.

7.4 Environmental impacts of tidal range energy development

The environmental changes that would occur as a result of a tidal range energy project will depend on the type of construction i.e. lagoon or barrage, as well as size, and location in the Estuary.

Possible impacts include loss of habitats, including saltmarsh and mudflats, loss of cultural heritage, increased or decreased flood risk, preventing the passage of fish, and the killing of or damage to fish passing through turbines. During construction, and possibly during operation, there could also be disturbance and dispersal of toxic chemicals that are currently contained in the sediment.

A barrage which crosses the Estuary would have a much wider environmental impact than a lagoon. It would fundamentally change the environment and ecology up-and down-stream. It would create a significant obstacle to fish passage and reduce the extent and availability of saltmarsh and mudflats, which are critically important to overwintering birds.

The environmental impacts of lagoons will be less and more localised because they are smaller structures only occupying a relatively small part of the Estuary. They would not block the passage of migratory fish unless located in the vicinity of a river mouth. How they might impact local habitats, and species would depend on their siting and operation. They would inevitably change the environment within the water body they contained, and there are concerns that they could entrap fish. If more than one lagoon were to be built, then the cumulative impact would obviously be greater.

7.5 Managing environmental impacts

The current UK environmental and planning laws, including the Habitat Regulations (2017) require competent authorities[44] to assess projects and reject those that harm site integrity unless exemptions apply. Projects can only proceed under exemption if there are no feasible alternatives, there are Imperative Reasons of Overriding Public Interest (IROPI), and compensatory measures maintain the UK site network.[45]

Under current legislation, habitat and species compensation at scale for large projects may be impossible, consequently a barrage would likely fail these legal tests. Depending on size and location, lagoons might comply, but all developments would require mitigation or compensation. In many cases, the paucity of current data describing the condition of designated sites could, without further monitoring, make assessment of compliance with the legislation challenging.

The Commission acknowledges that the UK Government is currently considering revisions in legislation relating to nationally significant projects.[46]

7.6 Cross-border governance

There are differences in the UK and Welsh Government policy that apply to the Severn Estuary, and, although there is cooperation between bodies, there is no statutory cross-border governance in place for its management, nor is there a single overall planning system. Significant challenges remain in working in a large geographic region spanning a number of different administrative boundaries, including two Governments, 28 local authorities, a Combined Authority, and two Corporate Joint Committees.

Lack of a cross-border governance structure and a statutory spatial planning system for the Estuary, and potential differences in licensing and consenting regimes makes it difficult to ensure that suitable development takes place in the right location and reduces investor confidence.

[44] A competent authority is a public body, statutory undertaker, minister or department of government, or anyone holding public office. https://www.gov.uk/government/publications/changes-to-the-habitats-regulations-2017/changes-to-the-habitats-regulations-2017

[45] The UK National Site Network is a protected area system of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), ensuring habitats and species are maintained or restored under Habitats Regulations (amended 2019). https://www.gov.uk/government/publications/changes-to-the-habitats-regulations-2017/changes-to-the-habitats-regulations-2017

[46] MHCLG (2025), Planning Reform Working Paper: Planning Committees, https://www.gov.uk/government/publications/planning-reform-working-paper-planning-committees/planning-reform-working-paper-planning-committees

7.7 Economic potential

A national pipeline of tidal range projects could provide sustained economic benefits at both regional and national levels, positioning the UK as a leader in tidal range energy.

Tidal range energy projects in the Severn Estuary present significant socio-economic opportunities, particularly during the development and construction phases, even for the so-called "smaller" projects. The benefit is highly dependent on project size: a small lagoon would add £1.6 bn to the UK's GVA and a big barrage would add £36 bn. The corresponding number of job years during construction is estimated to be 30,000 to 580,000. The figures for the 120-year operation period, will be 190 and 3,500 jobs respectively.

However, the UK supply chain requires substantial scaling-up to deliver these projects, as the current capacity has declined since previous reviews. There is a need for strategic and tactical actions to realise these opportunities, alongside building confidence and certainty to unlock the necessary commercial investment.

A large barrage scheme poses substantial risks to major port operations within the Estuary, despite its potential economic benefits. An approach involving multiple smaller lagoon projects, is viewed by stakeholders and the Commission as a more realistic and sustainable approach. This scenario allows for gradual scaling of the workforce and supply chain, offering a robust investment case and long-term job opportunities.

7.8 Grid connection

Tidal range energy is variable, but highly predictable and, since it incorporates some inherent storage and uses synchronous generators it can support grid system stability. Tidal range energy will cause downward pressure on wholesale prices.

Grid capacity exists for an early, small to medium sized tidal range project providing NESO accept a connection case post 2030. The timetable for connection is 2035 for a small to medium project and 2040 for a large project. For these connection times tidal range projects will have either a neutral or positive effect on curtailment costs. Tidal range projects are likely to place downward pressure on wholesale prices.

7.9 Funding tidal range projects

The Commission has concluded that the RAB model offers the most appropriate framework for balancing investor needs, consumer protection, and project viability. Although Cap & Floor and CfD regimes have both been successful in some segments of the energy market, neither offers sufficient flexibility in sharing risk between investors, Governments and consumers to be viable for large, long-life tidal range assets.

This conclusion reflects the current best practice for the funding of major infrastructure projects, for example the Thames Tideway Tunnel project, which is now operational, and, potentially, Sizewell C, which is currently under development. Tidal range projects share several characteristics with these assets.

Building a smaller tidal range project first could serve to boost investor confidence, prior to developing additional tidal range projects on a staged basis, both in the Severn Estuary and, potentially, elsewhere in the UK. The successful completion and proven performance of such an initial project would, if combined with a suitable funding model, likely serve to lower perceived construction risks and potentially attract lower-cost private sector finance.

An initial project should be large enough to be commercially viable but not so large that it deters private sector capital providers; a medium-sized lagoon could fulfil this requirement.

The round-table discussions concluded that there is considerable interest among private capital providers in financing the construction phase of a project with RAB-based funding. There was, however, a limited investor appetite for financing the development phase and it was suggested that development funding for the first project would likely need to come from Government sources. There was unanimous agreement that a clear policy statement in support of tidal range energy was a necessary requirement for any serous investor interest.

When funded through the RAB model, tidal range projects, despite high initial costs, can provide low-carbon electricity at unit costs comparable to other forms of low carbon energy. The cost to the consumer decreases in real terms over the life of the project. The Government, in its assessment of the application of RAB funding to Sizewell C, calculated consumers would benefit by over £30bn over the project's lifetime. The example of La Rance tidal barrage, which has now been in operation for 60 years, provides clear evidence of the low cost of tidal range being one of the lowest cost forms of energy on the EdF system.

7.10 Lack of tidal range policy

The lack of clear policy support from the UK Government makes it extremely difficult to secure investor, industry, and developer support for tidal range projects. The Hendry Review in (2017) recommended that the Swansea Bay Lagoon project be built. The UK Government rejected this recommendation which undermined the confidence of potential developers and the supply chain. Consultation with developer stakeholders indicated that the latest guidance,[47] has not improved the situation.

Financial and industrial sectors have consistently highlighted this lack of Governmental support as a major barrier to development. Environmental stakeholders have also stressed that, without Government support, there are insufficient resources to address data gaps and research challenges needed for project consent.

[47] DESNZ (2023), Criteria for a well-developed tidal range proposal, https://www.gov.uk/government/publications/tidal-range-projects-criteria-and-how-to-submit-a-proposal/criteria-for-a-well-developed-tidal-range-proposal

Summary

The Severn Estuary has a nationally significant tidal range energy resource that can deliver electricity at costs comparable to other renewables. Given its important environmental characteristics, great care should be taken in harnessing its valuable potential.

A large barrage is not viable under current regulatory limits. It would have significantly greater environmental impacts than a lagoon, requiring extensive habitat compensation, and would severely disrupt port navigation. In addition, the global supply chain currently lacks the capacity to produce the required turbines without a highly coordinated international effort.

Tidal lagoons are a more feasible option as they do not cross the Estuary. They limit disruption to commercial shipping and offer a lower overall environmental impact, while they still significantly contribute to electricity supply and the local and national economy.

Although outside its remit, the Commission notes that flood protection could be a significant function of a tidal range structure. Rising sea levels and increased storm surges due to climate change are expected to heighten the risk of coastal and estuarine flooding, particularly in vulnerable areas of the Severn Estuary. Both tidal lagoons and barrages provide defence to upstream communities and infrastructure from sea level rise and storm surge. In this study, the primary justification for a tidal range structure is electricity generation with flood protection as a secondary benefit. Currently, flood risk and coastal erosion is a major concern for some parts of the Estuary. The Commission proposes that due weight is given to the potential protection benefits of any tidal energy project when assessing future projects.

The Commission concludes that tidal range energy in the Severn Estuary has an important role to play in the UK's future decarbonised energy system.

8 Recommendations

The Commission recommends the following actions to address these findings:

1. **Governments to recognise the role of tidal range energy in the UK's future electricity supply and support its development as an industry**

UK and Welsh Governments should work together to provide clear policy support for tidal range energy and put in place structures to enable its long-term delivery as an integral part of the UK's future electricity supply. A clear and consistent policy framework is essential to provide investor confidence and facilitate public sector investment in environmental research and monitoring.

A Tidal Range Energy National Policy Statement would reinforce government commitment, strengthen regulatory certainty, and enable long-term development. For any tidal range project in the Severn Estuary to proceed, UK and Welsh Government policies on tidal range energy must be aligned, taking into account wider policies on decarbonisation, environmental protection, and green growth.

The National Energy System Operator (NESO) should review its Strategic Spatial Energy Plan to include a pathway for tidal range energy as part of the UK's net zero and energy security goals.

The immediate priority is to establish a robust policy approach supported by a delivery structure for governance, spatial planning, and capacity building. This should involve key national infrastructure bodies to realise the contribution of tidal range energy across the UK.

2. **Develop a Commercial Demonstration Project to demonstrate potential and evaluate environmental effects**

A Commercial Demonstration Project (CDP) should be developed as the first step in assessing, and possibly further harnessing, the Severn Estuary's tidal range energy potential.

It should serve as a test case for tidal range feasibility and a focal point for action now, while ensuring that environmental and commercial considerations are fully evaluated before assessing any future projects. Due to socio-economic and environmental concerns, the Commission does not support further consideration of a barrage at this stage. The CDP should therefore be a commercial lagoon.

The CDP should be commercially viable and capable of attracting private construction finance but will require public sector support for the development phase.

- Development should not be delayed by waiting for innovation, priority should be given to proven technologies. Engineers and environmental experts should adopt the co-design approach and collaborate, from the start, to ensure that technical feasibility and environmental sustainability are considered together.

- A parallel research initiative should address ecological data gaps, including climate change effects on the Estuary, to ensure decisions are based on robust evidence.
- The CDP should integrate a dedicated plan to evaluate mitigation and compensation measures, providing empirical data on their effectiveness.

This approach ensures that tidal range development is strategic, evidence-based, and adaptable, setting the stage for future deployment across the UK in line with the long-term energy and climate commitments.

The Commission recommends a series of actions to be taken by UK and Welsh Governments in support of the CDP and associated measures.

3. Create a regional plan to enable the better management of the Severn Estuary

A new regional plan should be developed to manage all activities in the Severn Estuary, not just energy projects. This plan should include a statutory Estuary-wide spatial plan covering both land and marine areas, with a strong cross-border governance structure to ensure consistent interpretation of UK and Welsh legislation. It should support an integrated approach to environmental research, planning, and management, providing a framework that considers energy, environmental, and socio-economic impacts of major infrastructure projects, including but not limited to a tidal lagoon.

A proactive and transparent stakeholder engagement strategy is essential to secure both public and industry support. Given its well established networks and experience in coordinating and informing stakeholders across the region, the role of the Severn Estuary Partnership in facilitating informed public engagement should be supported further so that it can continue to play a key role in the future governance of the Estuary.

4. Develop funding and financing framework to unlock private investment

HM Treasury should expand the application of a funding and financing framework based on the Regulated Asset Base model to cover tidal range energy projects, thereby unlocking potential for public and private finance.

5. Take a public sector led initial development approach – a Project Delivery Vehicle

The Western Gateway Partnership, collaborating with UK and Welsh Governments, should work to establish a Project Delivery Vehicle for the CDP. Comprising relevant public and private sector interests, this vehicle would lead the development, convene relevant stakeholders, promote collaboration and drive progress. This entity should secure public funding to cover high-risk pre-construction/ development phases, conduct feasibility studies and site assessments, and establish risk-sharing mechanisms to attract private investment. By undertaking early-stage development and obtaining regulatory approvals, it can de-risk projects and create a clear pathway for private sector involvement in construction. A long-term strategy should ensure a smooth transition from publicly supported development to a sustainable, investment-ready tidal range energy market.

6. Invest in research and monitoring to address current gaps in the environmental data and evidence

In parallel to the CDP, relevant authorities, such as the Environment Agency, Natural England and Natural Resources Wales, should be resourced to develop and implement a comprehensive environmental research and monitoring plan to address current data gaps in our knowledge about the Estuary's ecological, hydrological, and sedimentary systems.

Should a tidal range energy project be progressed, in addition to the required mitigation and compensation, an additional environmental research plan to evaluate the effectiveness of these measures, as well as key questions about its environmental impact, such as on fish, birds and intertidal habitat, should be developed and implemented in order to determine the feasibility of further tidal range developments.

7. Take a strategic approach to mitigation and compensation delivery

The Project Delivery Vehicle, with the support of UK and Welsh Governments, should work with other interested bodies to assess the feasibility of delivering mitigation and compensation for tidal range development in the Severn Estuary at the necessary scale. Compensation should be delivered in a UK-wide strategic manner, ensuring that measures are effective, proportionate, and aligned with broader environmental and policy goals.

Environmental challenges must be addressed strategically, including managing research to fill data gaps and exploring how mitigation and compensation can be delivered in a UK-wide perspective. This task would address the challenge of achieving "like-for-like" compensation and ensure a more pragmatic and targeted approach.

9 Call to Action

The Commission has made its recommendations to the Western Gateway Partnership. For a new tidal range energy strategy to be enacted effectively, the recommendations require co-ordinated decisions by UK and Welsh Governments. They should be complemented through further actions by other key stakeholders who have a responsibility for delivering the UK's clean energy strategy by 2050 and for co-ordinating environmental planning.

The Western Gateway Partnership is well positioned to take a leadership role in this effort and to coordinate engagement across key stakeholders. Local and regional authorities, working in collaboration with national decision-makers, should provide the necessary foundation to follow this strategic and coordinated path.

Severn Estuary Commission
Comisiwn Aber Afon Hafren

Western Gateway
Porth y Gorllewin

Visit our website at:
www.severncommission.co.uk