Solway Energy Gateway

Executive Summary

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Foreword

The Northwest Regional Development Agency, Scottish Enterprise and the Nuclear Decommissioning Authority welcome the publication of this initial stage of investigation into the technical, financial and environmental feasibility of generating renewable energy from the available tidal resource within the Solway Firth. As project sponsors we recognise that the ongoing development, innovation and deployment of marine energy will serve to further strengthen the findings of this study.

The United Kingdom faces a significant challenge to tackle Climate Change and satisfy the need for Renewable and Low Carbon Energy generation. This project assesses the viability of energy extraction from the Solway Firth and highlights how local communities on both sides of the Firth can benefit directly from the highly significant local resource.

The report builds on recent research by the Joule Centre, Universities of Liverpool and Lancaster and previous studies by Babtie, Shaw and Morton in the 1960s which highlighted the potential for tidal energy extraction from the Solway.

In producing this initial feasibility study the Funding Partners wish to acknowledge the work by Halcrow Group Ltd, Mott MacDonald Ltd and RSK Environmental Ltd and thank all members of the project team for their efforts. The work has also benefited from the input of the Solway Energy Gateway team, the Solway Firth Partnership, Cumbria Vision and Envirolink. Recognition should also be made of the contribution by Cross Border stakeholders in their support for the project

Introduction

The Solway Firth is the third largest estuary in the UK and the second most powerful tidal estuary after the Severn. It has the potential to accommodate a range of renewable energy generation capacity, from under 100MW to around 6GW, which could support the UK in rapidly moving towards its 2020 targets for carbon reduction. A developed scheme would also provide significant regional investment in the North West of England and the South West of Scotland, particularly in Cumbria and Dumfries and Galloway. This energy can be extracted through a range of technologies and in several locations but there are significant technical, environmental and financial constraints to implementation.

This summary document briefly presents the output from the feasibility study to identify options for energy generation within the Solway Firth. The focus of the work is to inform decision making on the necessary activities to plan and implement an energy generation project in the Solway Firth. It presents the potential impacts, both positive and negative, that a scheme would incur and provides conclusions and recommendation on how the options could be moved forward if a decision were made to proceed.

The aim of this study is to identify available options for energy generation within the Solway Firth and assess current feasibility in technical, environmental and socio-economic terms.

The Solway Firth is a funnel shaped shallow embayment estuary that extends from Dubmill Point to Southerness Point. It features extensive sandbanks, mudflats and saltmarsh, which characterise the large intertidal area of the estuary. The inner estuary is shallow, drying before full low tide, and the outer estuary reaches depths of around 30m; with widths varying from under 2km to over 30km respectively.

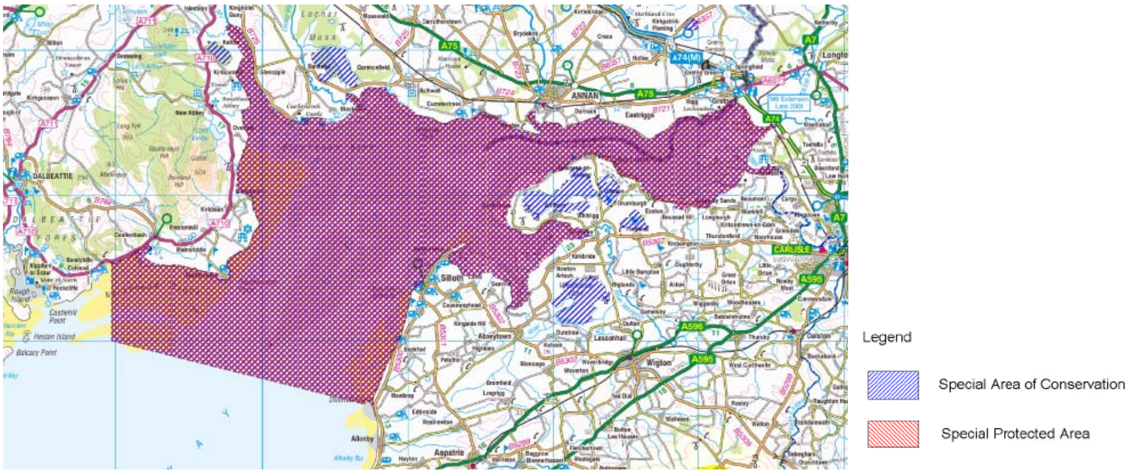
The Firth has a number of characteristics that make it attractive for renewable energy generation which include:

- Tidal ranges of between 5 and 8 metres

- Tidal stream velocities up to 2 m/s
- Wind speeds at an average of 10 m/s throughout the year

It is a region of diverse social demographic that straddles the English and Scottish border. The region has a requirement for socio-economic development and is likely become increasingly impacted by any future climate change effects. However, the Solway Firth is also an area of environmental significance and this is best described by the range of designations that exist both within and around it.

Extent of the International Conservation Designations in the study area



Methodology

The technical study followed a gated process for identifying, de-selection, development and discussion of a range of options, as illustrated below:

Study Flow Chart

Review of available data

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Identification of available option long-list

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De-selection of options against key criteria to develop option short-list

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Development of selected options to enable fair assessment

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Technical, environmental and financial assessment of options

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Discussion of feasibility

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Development of project route map for implementation

Option Identification

A project team workshop ensured that the process of arriving at feasible options was thorough and balanced, without excluding any obvious considerations.   The long-list included:

- Algal biomass
- Tidal technologies – tidal range and tidal stream
- Wave energy
- Wind energy
- Heat sources
- Novel concepts to enhance conventional versions of the above

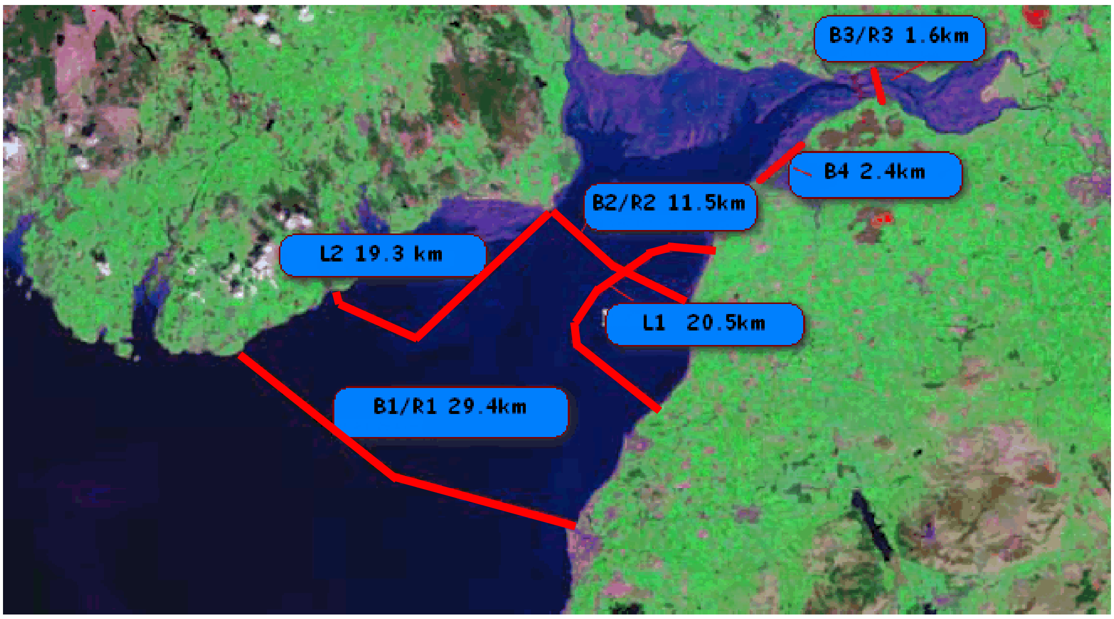
Subsequent assessment of the options was completed utilising data related to the physical characteristics of the estuary, the nature of the available resource and the technology development status. The assessment and de-selection was completed using agreed high level criteria based around:

- Selecting solutions that could be feasibly developed to meet targeted timeframes
- Making the best use of the energy potential within the Solway Firth

Results

The initial assessment and de-selection process identified nine main options that are shown below and comprise:

- Four barrage options (B1, B2, B3, B4)
- Two lagoon options (L1, L2)
- Three tidal reef options (R1, R2, R3)



These options were further developed in terms of their outline size, technology requirements and activities necessary in their construction. This also included estimating the available energy and determining the extent of affected environmentally sensitive areas. A financial model was then developed based on whole life costs and expected energy markets and support mechanisms.

Summary of option details

Project	Basin Area	Constructed Length	Affected Intertidal Area	Installed Capacity	Annual Energy Production	Indicative Connection Cost	Total CAPEX	Cost per MW installed	Cost of Energy at 8% rate of return
Identifier	(km^2)	(km)	(km^2)	(MW)	(GWh)	(£m)	(£m)	£m/MW	£/MWh
B1	**814**	**28.4**	**137**	**5,891**	**11,500**	**2,000**	**16,000**	**3**	**184**
B2	**288**	**11.5**	**72**	**2,703**	**3,800**	**250**	**6,100**	**2.3**	**175**
B3	**40**	**1.9**	**12**	**316**	**320**	**37**	**1,200**	**3.8**	**389**
B4	**12**	**2.6**	**4**	**113**	**120**	**23**	**640**	**5.7**	**553**
L1	**94**	**20.5**	**14**	**692**	**900**	**102**	**4,000**	**5.7**	**519**
L2	**56**	**19.3**	**8**	**435**	**600**	**55**	**3,300**	**7.5**	**639**
R1	**814**	**28.4**	**137**	**1,318**	**3,800**	**102**	**12,100**	**9.1**	**406**
R2	**288**	**11.5**	**72**	**535**	**2,070**	**55**	**7,000**	**13.0**	**358**
R3	**40**	**1.9**	**12**	**88**	**170**	**23**	**1,000**	**11.2**	**598**

Note: The values calculated for energy production and capital costs are not based on detailed site information. The values are intended to enable comparison between options and the level of uncertainty inherent in them will be reduced only by further work.

Identifier	Location	Description
B1	Workington to Abbey Head	Largest barrage scheme with greatest energy output and environmental impact. Scale of construction and capital costs are limiting factors
B2	Southerness Point to Beckfoot	Intermediate barrage, still with substantial environmental impact but offers some compromise
B3	Bowness to Annan	Smaller barrage located at narrow section of inner estuary with reduced capital cost and energy output. The location has shallow bathymetry and dynamic sediment regime.
B4	Moricambe Bay	Barrage located out of main estuary to reduce environmental impact. Small impounded area reduces available energy.
L1	Rascarrel to Southerness	Larger lagoon on North side offering localised environmental impact but higher cost of generation than barrage options
L2	Maryport to Beckfoot	Southern lagoon with lowest energy output of the two options but similar potential environmental benefits
R1	Workington to Abbey Head	Largest reef scheme that enables large scale of generation with lower impact than barrage option
R2	Southerness Point to Beckfoot	Mid range reef solution in terms of energy and environmental impact but improved cost of energy due to lower scale
R3	Bowness to Annan	Smallest reef where energy generation is limited by reduced tidal range in the shallow estuary. Potential to offer minimal environmental impact.

Some of the key observations from these results are:

- An increase in enclosed basin area results in greater installed capacity and a larger area of affected intertidal habitat.
- Lagoons incur a higher construction cost per MW installed than barrages as a greater length of structure is required for a given enclosed area.
- Reefs offer a lower CAPEX cost to construct for a given size structure but a lower energy generation capacity increases the cost of installed power.

Discussion

Each of the available options must be considered as large scale; with significant associated impacts. These are split into technical, environmental and financial issues that are discussed briefly below:

Technical

- There are a variety of risks associated with projects of this scale that are amplified by the unique nature of their application in the dynamic environment of the Solway Firth estuary.
- Despite the considerable tidal range and available potential energy, the shallow depth of the inner estuary and low velocity of flow in the outer estuary combine to make tidal stream technology unviable at present. Tidal stream technology generally requires velocities greater than 2.5m/s and a water depth over 20m to support achieving commercial viability. Further technology development is required to overcome this.
- The outer Solway is the deepest area of the estuary with less variation in its bathymetry. This makes the placement of larger turbines, with higher power ratings, possible. However, the scale of such development will result in higher capital costs and impacts on electrical grid infrastructure.
- The existing grid infrastructure of the region will require significant improvement to accommodate the larger schemes under consideration. The complexity of achieving these upgrades at a UK grid level must be taken into account.
- The inner Solway has a very dynamic sediment regime and is shallow in nature which limits turbine size and energy generation capacity; although the narrow channel reduces the scale of construction required. The energy available is further limited because the estuary dries out prior to completion of a full tidal cycle.
- The tidal reef concept could be based on proven technology but its application in the Solway is at a significantly greater scale and in a new operating environment. Also, using current technology the lower operating head inhibits output as a greater turbine diameter is required to pass the necessary flow.

Financial

- Using predictions of the energy price outlook, (an upper and lower 2020 price of £70/MWh and £148/MWh), and assuming support through the renewable obligation order and the climate change levy, only the larger barrage schemes appear commercially viable.
- The high level of risk associated with planning, construction and operation inherent in these developments increase costs and reduce investor confidence.
- The assessment is based on an 8% rate of return as a base case, but variation of this shows a significant change in the financial model output. Lower rates of return increase significantly the financial viability of all options, however, the difficulty is in unifying the high risks of development with agreement on a low return on investment. This is unlikely without some form of intervention.
- Revenue and cost estimates can be refined through further detailed investigations and surveys; which would support the reduction in uncertainty and risk.
- Taking a socio-economic benefit viewpoint a typical scheme would generate around 800 jobs during construction (variable dependent on project scale).
- In addition a large scale project could have tourism potential equivalent to up to 200,000 visitors per annum with associated revenue generation in the region

Environmental

- Environmental impact is unavoidable due to the sensitivity of the area.
- The EU Habitat and Birds Directive will require extensive, appropriate assessment of the impact of any of the schemes due to existence of protected habitats and species. The challenges of delivering any compensatory habitat proposals will include significant financial and logistical considerations.
- The scale of the schemes and variations in technology allow some mitigation of environmental impact through:
  - Two-way operation of all technologies will reduce the affected intertidal area
  - The use of tidal reefs to further minimise change from the natural tidal cycle
  - Lagoons have lower direct impact but more complex changes to flow patterns
- A baseline scenario must be defined to allow comparison of the effects of climate change alone with the predicted effects of any chosen scheme within the Estuary.
- Ongoing stakeholder engagement is essential to set the decision making framework and agree scope of future studies.

Current Feasibility

A traffic light system has been used to indicate the level of feasibility of each option under three key headings. It is a comparative scale, and green should be taken as meaning the best available level of feasibility rather than an indication of absolute feasibility. The purpose of the diagram is two-fold:

- It provides a simple way of comparing the available options under the three key areas of consideration to identify preferred options.
- It can be used as a tool to identify areas of work required to increase overall feasibility. Decisions can then be made on how realistic it will be to move each option towards green and identify the simplest routes to improvement.

Indication of feasibility

Option	Technical	Financial	Environmental
B1	Green	Amber	Red
B2	Green	Green	Red
B3	Amber	Amber	Amber
B4	Amber	Red	Green
L1	Amber	Red	Green
L2	Amber	Red	Green
R1	Red	Red	Red
R2	Red	Amber	Amber
R3	Red	Red	Green

Cost of Energy

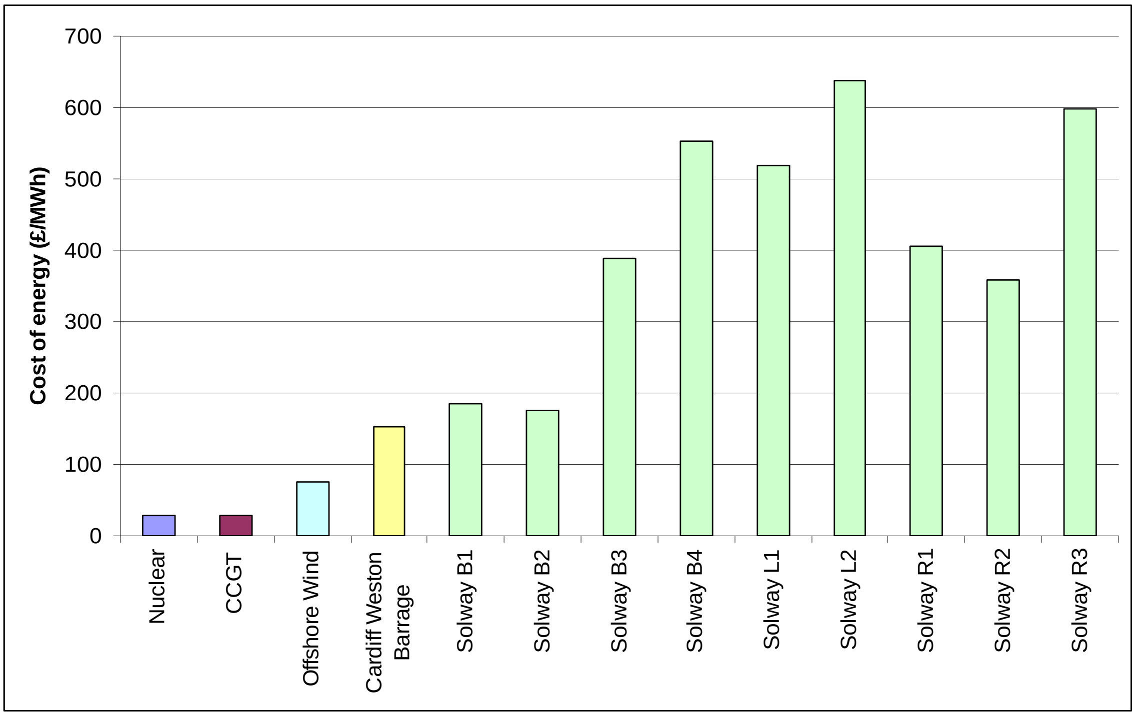
Decisions to take forward any of the options identified will depend on how they compare in the context of the National portfolio of options. Energy utilities and the UK as a whole are working towards developing security of supply through a diverse energy mix that has sufficient renewable content. This decision is influenced by two factors:

- The need to justify investment with a business case that indicates acceptable rates of return. At present this favours more conventional options such as fossil fuels or more proven renewable technologies such as onshore wind.
- The social, environmental and increasing financial pressure to increase uptake of low carbon generation technologies. There are overarching UK targets that require 35% of electricity generation from renewable sources; this reduces the need to compete

with conventional options but does not remove the need for the Solway Firth options to be comparable to other renewable technologies.

The indicative costs of energy for various options are compared below (based on 8% return for barrages and 10% for other options).

Market Comparison of Cost of Energy



Two conclusions can be drawn from this situation:

- At present the Solway Firth options appear more expensive than more conventional alternatives but the best performing options can be considered comparable with the Cardiff-Weston Severn tidal barrage proposal.
- This comparison, however, does not reflect:
    - Tidal energy is a predictable renewable energy source and investment in its development will likely reduce predicted costs
    - The need to develop a diverse energy mix to ensure security of supply
    - The costs of some alternatives may increase; offshore wind in deeper waters, uncertainty over nuclear disposal costs or depleting fossil fuel reserves

The Way Forward

The Solway Firth is one of several key estuarine environments around the UK that enables access to a range of useable renewable energy sources. Previously, many studies have been carried out to determine the potential for extracting the Solway's tidal energy. This study has further investigated the underlying issues that affect the feasibility of development to determine a short list of options and begin the process of comparing their relative viability.

It is clear that tidal energy is an attractive resource, and reserves of the order of several GW are theoretically available in the Solway estuary, but any development to capture this cannot be achieved without significant environmental impacts.

Overall feasibility of any option must be assessed jointly against technical, financial and environmental factors. Unfortunately, there are fundamental conflicts in the requirements of each of these. A large scheme produces a high energy output but with increased costs and environmental impact; in the case of a small scheme there is reduced capital cost and environmental impact but the energy output and revenue generation is inhibited. This conflict can be overcome to varying degrees through the application of different technologies, optimisation of operating regimes and by maximising the available benefits of the specific physical characteristics. Further and more focussed investigations offer the opportunity to identify potential compromise solutions.

A scheme could be implemented in the Solway estuary to contribute significantly to targets for carbon reduction and renewable energy generation. The unique development will also result in significant investment and job creation in the region, as well as providing opportunities for niche skill and knowledge development. There are options available that could satisfy a 2020 deadline, however, the timescale for implementation depends heavily upon developing a scheme that satisfies a planning process that is complicated by cross border legislative differences. Achieving consent depends on adequately addressing all the technical, financial and environmental constraints.

Recommendations

Significant additional work will be required to support any further development of the options and this work should focus on:

- Further studies to increase certainty of cost and energy predictions.
- Ongoing stakeholder engagement including the support development of any necessary mitigation proposals.
- Survey activity to enable clearer understanding of the dynamic nature of the estuary and determine the baseline for comparison against proposals.

Completion of these activities will develop a detailed understanding of both the current situation and the expected impact of the feasible options.

Achieving consent for any scheme will require extensive and open engagement with local and national stakeholders and support delivery through the regulatory processes.

Further Information

The Solway Energy Gateway website (www.solwayenergygateway.co.uk) contains information about this study and the progress of other relevant activities.

Further information and contact details are also available on the partner websites:

Envirolink Northwest	-	www.envirolinknorthwest.co.uk
Northwest Regional Development Agency	-	www.nwda.co.uk
Nuclear Decommissioning Authority	-	www.nda.gov.uk
Scottish Enterprise	-	www.scottish-enterprise.com

Project Team

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