The Severn Tidal Barrage Project: a legal paradox? A case study looking at the possible conflict between climate change policy and environmental legislation in the UK.

[1]Tilak Ginige, [2]Ann Thornton, [1]Fraser Ball, [1]Natalie Sparks.

[1]School of Conservation Sciences, Bournemouth University, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB, United Kingdom

[2]Lindsay Carrington Ecological Services Ltd, The Old Squash Court, Rempstone Hall, Rempstone, Corfe Castle, Wareham, Dorset, BH20 5JQ, United Kingdom.

Abstract

The proposed construction of a tidal barrage to generate electricity in the Severn Estuary between England and Wales could provide an economically attractive and environmentally acceptable way of supplying up to 7% of England and Wales's electricity consumption with low-cost, low-carbon electricity by 2020. Thus helping the UK government to meet its obligation under its current Climate Change Policy and specifically those contained within the Renewable Energy Strategy (2009) of achieving 15% of energy supply from renewables by 2015.

This development will however have a huge impact upon 63,000 overwintering birds; destroy protected areas of wetland; and alter the estuarine ecosystem beyond repair.

If projects like this were permitted, the UK would have to take compensatory measures to ensure the overall coherence of Natura 2000 was protected (Art. 6(3) & 6 (4) of the EC Habitats Directive 92/43/EEC). Will these compensatory measures be effective considering that we do not fully appreciate the role and function of ecosystem services provided by areas such as those around the River Severn? Perhaps more importantly are we prepared to gamble that their loss will be less damaging to us than the impact from future climate change?

This then obliges us to question the weight given to conservation of species and habitats in an era of economic transformation and climate change obligation. We need to ask ourselves if we truly are at a point in our evolution where we will be making decisions of whether or not to sacrifice one good for another greater good (Alder, J. and Wilkinson, D., (1999).

Given the overwhelming legal protection afforded to this area one of the issues that needs to be explored is how such a proposal was even considered? Have we approached the moment when Article 6(4) of the Habitats Directive '**Imperative Reasons of Overriding Public Importance**' (IROP) will include combating climate change? If such a project is allowed to go ahead in this area, does the prevention of climate change represent the 'trump card'? Does this present an open door to developers wishing to capitalise upon opportunities presented by the government's binding targets? Provided that it can be shown that the project or development contributes towards these targets, will all other environmental considerations be ignored?

Thus placing us in a paradoxical situation where the environment will be irrevocably changed in order to prevent the environment being irrevocably changed.

Keywords:
Climate Change Policy, Renewable Energy Strategy, Habitats Directive (Dir.92/43/EEC), Paradox, Balancing interests.

Introduction

It has been estimated that the offshore renewable energy industry could generate the same amount of electricity a year by 2050 as one billion barrels of oil (Clarke, 2010). If the UK were to harness just 29 per cent of its wind, wave and tidal resources it would be able to match the electricity generated by North Sea oil and gas production. Such a move would be a huge boost in cutting emissions, saving a cumulative total of 1.1 billion tonnes of carbon dioxide over the next 40 years (The Offshore Valuation Group (OVG) 2010). The OVG estimated that it would cost £443bn to harness 29 per cent of the offshore resources, but at the same time that the scheme would generate £62bn in annual exports. This figure could rise to £164bn if the government invested around £993bn – or 76 per cent of available resources.

In the UK, using tidal power or tidal range in the form of barrages or lagoons could make the largest contribution for future renewable energy. (OVG 2010) A tidal barrage works in a similar way to hydroelectric power schemes, in that it is a way of converting the kinetic energy of water into electric power (Frontier Economics, 2008). This technology would extract the energy associated with the difference between high and low tides, but out of all the renewable energy technologies it is by far the most expensive (Clarke, 2010) (OVG) 2010).

Severn Estuary

The Severn Estuary located at the south-west coast of the UK between Wales and England at the mouth of the Severn, Wye and Avon rivers has the second highest tidal range in the world after the Bay of Fundy, Canada with a mean tidal range of 4.68m at Milford Haven and 8.52m at Avonmouth (Sustainable Development Commission October 2007). The tidal range has resulted in around 200km^2 of inter-tidal zone in the Severn Estuary that supports a wide variety of fauna. A high tidal range, as exhibited in the Severn Estuary, is caused by the combination of estuary shape and the velocity at which the tide wave propagates causing tidal resonance. As a result, the high spring tides at Avonmouth can exceed 14m (Xia, J.Q., 2010), making it an ideal site for constructing a tidal power project.

Tidal Barrage Scheme

The idea of a barrage across the Severn estuary is not new and was first mooted during the latter half of the 19th century for the purposes of harbour creation, flood defence and as a rail transport link. Its use for energy generation was brought to the forefront of government thinking during the fuel crisis of the 1970s (Pethick et al. 2009). The Severn Barrage Committee (SBC) was set up as a result. Additional fuel issues during the 1980s, including the Chernobyl nuclear disaster and disturbances following pit closures, led the SBC to endorse a barrage scheme. As a result in 1989 a report was produced for the then Conservative government. It concluded that the Severn barrage could provide significant economic, social and environmental benefits (HMSO (1989) Energy Paper 57). However, following the privatisation of the electricity industry, the Severn barrage project was effectively 'shelved'.

In 1999 Energy Minister Ian Battle controversially refused to approve a reappraisal of the proposed barrage despite pressure from the Severn Tidal Power Group (STPG) - (a consortium of McAlpine, Balfour Beatty, Alsthom, Rolls Royce, Taylor Woodrow and Carillion). However, a year later a recommendation by the Royal Commission on Environmental Pollution provided the impetus for a re-assessment of tidal energy production as a way of reducing CO^2 emissions (22nd Report: RECP, 2000).

The Kyoto protocol (United Nations, 1997) and sustainable development implications led the new Labour government to instigate a discussion on the feasibility of a Severn tidal barrage. In 2002 the STPG produced 'The Severn Barrage – Definition Study for a New Appraisal of the Project' (Taylor, 2002). This study concluded that a reappraisal of the Severn barrage was justified on several grounds: reductions in the capital building costs of the scheme; Kyoto targets for greenhouse gas emission reductions; flooding risk in the Severn basin due to

climate change which would be mitigated, in part, by the barrage.

However, by 2004, the barrage proposal was again dismissed by Industry Minister Lord Sainsbury due to the likely 'significant effects' on the ecosystem of the area. This was despite calls from other peers suggesting that the barrage could provide additional transport links to the region in the form of a rail crossing. Lord Sainsbury also added. "We would be required under our international obligations to recreate inter-tidal habitats in order to compensate for that [ecosystem] loss." (ENDS Report No. 348, 2004) The STPG consortium proposed that predictions of habitat loss from climate change should form the baseline of any environmental assessment - although these may be extremely difficult to make in practice.

In 2007, the Sustainable Development Commission (SDC) produced 'Turning the Tide', a study into the potential of tidal energy production in the UK (SDC, 2007). It incorporated recommendations for a sustainable Severn Estuary Barrage. The Government's five sustainability principles (Cullingworth, B. and Nadin, V. (2006)) would form the basis upon which a decision could be made as to the feasibility of such a large-scale development. From a sustainable development perspective, this document contained a number of pertinent points regarding the environmental issues and legislation covering the Severn basin area. The Commission highlighted the 'significant adverse effect on the integrity of the protected sites' although it acknowledged that these effects would be different dependant upon the location and scale of the chosen development.

The report also notes views expressed concerning the suitability of both the Habitats and Birds Directive in coping with the implications of climate change ((SDC), 2007 pp. 130). Furthermore, the SDC heard views suggesting that 'one-off derogation' would be appropriate for matters of climate change mitigation ((SDC), 2007 pp. 131). The Commission certainly remained convinced that such derogation would send entirely the wrong signal to other Member States. In addition, it could create difficulties in the scale of development that would be deemed appropriate for such derogation. The Commission also acknowledged that increased housing and other development around the Barrage could reduce the effectiveness of any climate change benefits.

The SDC concluded that "any proposal for a Severn barrage must fully comply with the Directives and adhere rigorously to the process they set out". It stated emphatically that they "would be firmly against any moves to revise or derogate from the Directives to facilitate proposals for a Severn barrage". Despite these reservations and contrary to the findings of the 1980s feasibility study, the now defunct SDC (ENDS Report 426, July 2010, pp. 5-6)

advocated a 10 mile barrage between Cardiff Bay and Weston-super-Mare (ENDS report 393, 2007).

Following the publication of 'Turning the Tide', the Department for Energy and Climate Change (DECC) called for proposals for tidal energy schemes for the Severn Estuary in 2008. As a result of the consultation that formed part of Phase 1 of the Feasibility Study, a long-list of 10 projects was formed (DECC, 2009), these included barrages, tidal lagoon and tidal fence schemes. In January 2009, a short-list of five was developed based upon the findings of the feasibility study together with best available technology. The five short-listed schemes (fig 1) currently under consideration are:

- **Shoots Barrage** – near the Severn road crossings, estimated to cost £3.2bn to construct and generate 2.7TWh/year, which would account for just under 1 percent of UK electricity
- **Beachley Barrage** – slightly smaller and further upstream than Shoots Barrage, and upstream of the Wye, estimated to cost £2.3bn and generate 1.6TWh/year
- **Welsh Grounds Lagoon** – an impoundment on the Welsh shore of the Estuary between Newport and the Severn road crossings, estimated to cost £4bn and generate 2.3TWh/year
- **Bridgwater Bay Lagoon** – an impoundment on the English shore of the Estuary between Hinkley Point and Weston Super Mare, estimated to cost £3.8bn and generate 2.6TWh/year
- **Cardiff-Weston Barrage** (commonly known as 'The Severn Barrage') – located between Brean Down and Lavernock Point, estimated to cost £20.9bn and generate 16.8Twh/year , which would account for 5 percent of UK electricity.

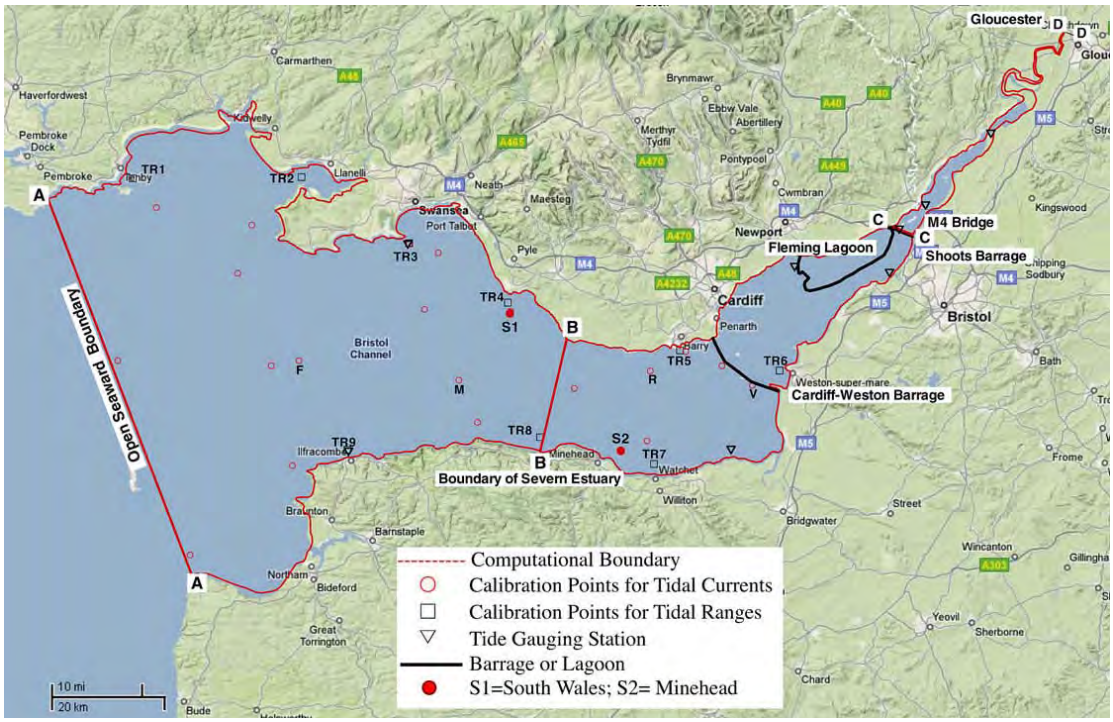

Fig 1 Map of the Bristol Channel and Severn Estuary showing the location of th e Cardiff–Weston (or Severn) and Shoots barrages and the Flem ing lagoon (Xia, J.Q., 2010).

An inquiry conducted in April 2010, by the All Party Parliamentary Group on Angling concluded that the largest scheme, the 'Severn Barrage (Cardiff – Weston)' would damage the estuary and recommended a shorter barrage upstream (Salter and Walker, 2010). Not surprisingly the Department for Energy and Climate Change denied suggestions that this scheme had been abandoned and stated that it will continue to appraise the project along with the other four (DECC, 2009).

The Severn Barrage is considered to be the best, although the cost would be the highest of all the schemes, it is thought that the barrage would generate more power than the other proposals and in turn would help contribute to the renewable energy targets.

As the largest and potentially most damaging of all the schemes, the 'Severn Barrage' has courted most controversy. In February 2010, the RSPB highlighted the potential for increased flooding risk from the barrage. It is widely acknowledged that the Severn Barrage will result in significant impact upon the habitat and wildlife of the basin. This, according to the ENDS report (409, Feb 2009) could extend inland and impact upon salt marsh habitat and the ecosystems of the Somerset Levels.

The Severn Tidal Barrage

The construction of the barrage would contain 216 turbines, each predicted to generate 8,640MW in total. The array of sluices would let the tide in then close to force the water back out through the turbines after the tide has gone out. The purpose for building a head on the water is to create pressure which increases the efficiency of the turbines. Shipping would be accommodated through a series of locks which would handle the larger container vessels. The barrage would take around eight years, requiring around 35,000 employees at peak building time. The lifespan of the barrage is predicted to be 120 years (About three times that of a nuclear reactor), but this could be increased to 200 years with a comprehensive maintenance program (Anderson, S. H., 2007).

In the Severn estuary high sediment load is maintained in the water column is maintained by the current passing though the deep channels, which are narrow with shallow areas, bordered by ground which floods in high tides. The mud suspended within the estuary mostly comes from erosion from the rivers and streams that feed into the estuary, such as the River Wye. (Parsons Brinckerhoff Ltd (2008)). The area also contains large amounts of inter-tidal mudflats, sand flats, salt marsh, rocky inter-tidal areas and sand dunes. These sub tidal habitats are well known for their importance to all the wildlife in the area. However little is known about the wildlife on the estuary floor, due to the dynamic movement of the tides within the estuary. This in turn may alter distributions and concentrations of contaminants in estuary water and sediments. (Pethick, et al., 2009). The changes in suspended sediments may also affect primary productivity and may contribute to eutrophication (Mettam, C. 1978). The government itself acknowledges that the vibrations and noise from the barrage would damage and confuse migratory and estuarine fish species such as the protected Allis and Twaite shad (DECC, 2009).

Climate Change & Renewable Energy Implications

Under the Kyoto Protocol, a number of countries agreed to reduce their greenhouse gas (GHG) emissions. In order to fulfil its Kyoto obligations, in June 2009, the European Commission published the Climate Change and Energy Package of legislation (also known as the "20-20-20 package" (COM (2010) 265 Final (May 2010)) to implement the new EU energy policy adopted in March 2007. The proposals contain measures to reduce GHG emissions in the EU by 20% by 2020, and ensure that 20% of the EU's overall energy needs are met by renewable energy by 2020.

As part of the 20-20-20 package, the Commission published Directive 2009/28/EC OJ L140/16 which would:

- A common EU framework for the promotion of renewable energy.
- 20% of the EU's final energy consumption to come from renewable sources by 2020.
- 10% of each member state's transport energy consumption to come from renewable sources by 2020.
- That the UK achieves a 15% share of its energy from renewable sources by 2020, as its contribution to the EU's overall 2020 target.

This directive took into account the fact that UK's renewable energy share is very low, at 1.3%, in the baseline year of 2005, and only about 2.25% in 2008 (DECC 2009. *The UK Renewable Energy Strategy*). In addition to its international targets, the UK Government has agreed to commit itself to national targets which were made legally binding under the Climate Change Act 2008. Thus making the government legally bound to ensure that the UK reduces its overall GHG emissions by 80% (below 1990 levels) by 2050 (s1(1) Climate Change Act 2008).

To sum up the EU renewable energy targets have committed the UK Government to producing 20% of its total energy from renewable resources by 2020, which corresponds to about 35% of the UK's electricity demand (DTI, 2003; Kirby and Shaw, 2005). At present only about 5% of the UK's electricity comes from renewable energy resources, so the UK Government is currently exploring the scope for increasing its generation of renewable energy from tidal sources, with tides having the advantage over wind and waves in that they are predictable (Falconer et al., 2009)

Economics and Ecosystem Services

The UK Government's 20% targets are higher than EU targets of achieving 15% of total energy consumption from renewable sources by 2020. These targets equate to 93,000GWh and 187,000GWh respectively of electricity generation from renewable sources (Frontier Economics 2008).

A variety of renewable energy sources could be utilised to contribute towards these targets, including the use of on-shore and off-shore wind, tidal, nuclear and hydro projects. The Government needs to consider the cost effectiveness of each method of generation as well as the capacity levels available from each source.

A feasibility study produced by DECC 2008 puts forward the case for the Severn Tidal Power scheme, within which 5 options were short-listed.

A financial analysis of these 5 schemes highlights the cost effectiveness of each proposal after looking at the costs of construction, costs of habitat compensation and maintenance costs. These costs have then been set against the savings produced through avoiding CO_2 emissions and the costs saved by not generating electricity using Combined Cycle Gas Turbines.

Cardiff	Weston Barrage	Shoots Barrage	Beachley Barrage	Fleming Lagoon	Bridgewater Bay Lagoon
Cost £bn	43.4	6.3	4.8	10.4	7.6
Benefit £bn	16.3	2.7	1.6	0.7	3.0
NPV (best estimate) £bn	**-27.1 -3.5**		**-3.2**	**-9.7**	**-4.5**
Value of CO_2 emissions avoided (undiscounted)	£1.5bn £235m		£132m	£196m	£224m

(Source: DECC Severn Tidal Power Feasibility Study(2008)

On the basis of these figures, it is clear to see that none of the options provide a positive Net Present Value (NPV). It is important to note that a positive NPV means that the investment is worthwhile, while the highest NPV among different options means higher net value of the specific investment decision (Mott MacDonald Limited, April 2007).

Therefore the savings produced in terms of CO_2 emissions do not compensate for the large construction, compensatory and maintenance costs incurred. Shoots Barrage would provide the greatest saving of CO_2 emissions in relation to cost therefore appears to be the most attractive option. However the Shoots Barrage would only produce a 0.8% of Annual electricity generation (based on 2020 figures) compared to the 4.8% generation projected for the Cardiff Weston Barrage.

The Cardiff Weston Barrage is estimated to be able to produce 17,000GWh of electricity per annum representing a major contribution to the Government targets. However the costs of generating electricity from this source are deemed to be expensive. Projections have

estimated the cost of producing electricity from a large barrage to be in the region of £60-154/MWh compared against £41-62/MWh from offshore wind (Frontier Economics 2008). Indeed the cost of electricity generation from a large barrage is more expensive than other options with the exception of solar energy (260/MWh) (Frontier Economic 2008) and even nuclear energy provides a cheaper option at £38/MWh (DECC 2008).

Although the NPV calculations have factored in the costs of compensation for destruction of habitat at £65,000/hectare, there are many other economic considerations to account for. Additional environmental costs may exist relating to the loss of species and damage to habitat. The economic cost to local industry (fishing and port activity) needs to be accounted for. Lost employment, although balanced by the creation of jobs from such energy schemes, must also be factored in.

Any NPV should also reflect an additional, emerging, consideration namely the value of the 'services' provided by the Severn Estuary coastal and marine ecosystems. These provide ecological functions that directly or indirectly translate to a variety of tangible benefits to human society. For example they support the production of food, climate regulation, flood protection, pollution sinks and recreational and aesthetic benefits (DEFRA, 2007 *An Introductory Guide to Valuing Ecosystem Services*; Remoundou, 2009) .

Ecosystem services can be defined in a variety of ways, including "the benefits human populations derive, directly or indirectly, from ecosystem functions" (Costanza, R., et al, 1997); "the benefits people obtain from ecosystems" (MEA 2003); "the direct and indirect contributions of ecosystems to human well-being" (TEEB, 2008), and the "services provided by the natural environment that benefit people" (Defra, 2007). The common link between the various definitions of ecosystem services is the emphasis placed upon the beneficial role played by ecosystems in enhancing or maintaining aspects of human well being and thereby human society.

By appreciating the value of these 'services', an assessment can be made as to the economic implications of changes to ecosystem balance. Such changes can arise from dynamic environmental conditions, modification in management practices, and development activity. A valuation of these ecosystem services could provide a convenient method to monitor the impacts of ecosystem change which can also be used identify triggers for intervention in ecosystem management (Watson, R., 2010).

There is considerable debate over how ecosystem services should be defined and classified

which reflects differing interpretations of how social benefits are linked with ecosystem functionality (Beaumont and others 2008; Constanza 2008). Several approaches to the measurement and classification of ecosystem services have been proposed (Eftec,2006; Frid, 2008). Each of these classification systems uses similar, but distinctive categories, which results in a lack of consistency and comparability between assessments. It has been suggested by Fisher and others (2009) that a single ecosystem service classification system will not be applicable in all circumstances and therefore a classification system should be tailored to meet the specific needs of a given assessment. In contrast, there have been recent calls to develop a single internationally standardized list of ecosystem services that can serve different purposes (Haynes -Young, R., and Potchin, M., 2008), but as yet, no such universal approach exists. The most well-known and widely applied classification of ecosystems services was developed by the Millennium Ecosystem Assessment (MEA) (2003) which although useful for educational purposes, is not suited for economic valuation. The MEA firmly established the concept of ecosystem services as an approach for linking ecosystem function to human welfare within the marine environment (UNEP, 2006). It categorises ecosystem services as provisioning, regulating, cultural, or supporting (MEA, 2003). The MEA ecosystem service classification has been complimented as being an intuitive and highly useful as an educational and policy tool (TEEB, 2008). However, it has been widely criticised as not 'fit for purpose' (Boyd, J., Banzhaf, S. (2007) as it exhibits logical inconsistencies within and between categories, it mixes processes (means) and benefits (ends), it is therefore particularly prone to double counting (Haines-Young & Potschin, 2007). It is therefore unable to produce economically robust valuation of ecosystem services (Fisher and others 2009). However, the classification system developed through 'The Economics of Ecosystems & Biodiversity' (TEEB 2009) is based on a distinction between ecological processes and the benefits experienced by humans. This model, it is suggested, is far more consistent with the framework developed by Fisher and others (2009), which similarly focuses on valuing the benefits to human wellbeing, and avoids the risk of double counting by separating such benefits from underlying ecosystem processes. The classification has three components:

- Core ecosystem processes: these describe the basic ecosystem processes supporting ecosystem functions.
- Beneficial ecosystem processes: these are the specific ecosystem processes that directly underpin benefits to people.
- Beneficial ecosystem services: these are the products of ecosystem processes that directly impact human wellbeing.

One such example is that of the saltmarsh habitat that, if lost from around the UK, could result in an additional £17 – 32bn per annum on flood defence (Beaumont et al. 2008).

Therefore based upon the SDC's estimate that the Severn barrage would result in an 'unquantified but substantial loss of existing 539ha saltmarsh resource' it could be argued that this would represent a £205 – £383million increase in flood defence costs.

It is also worth noting that Public Service Agreement 28 (Watson 2010) on the Natural Environment contains within its vision a commitment '….where the value of the services provided by the natural environment are supposed to be reflected in decision-making' (Watson, 2010). Public Service Agreements (PSAs) are essentiality detailed aims and objectives or key priority outcomes that the Government wants to achieve in the current spending period (2008 – 2011). As such there is a danger that they will be disregarded in favour of climate change mitigation (Local Government Improvement and Development, 2009). Furthermore evaluation of 'ecosystem services' in purely monetary terms provides, at best, a wide range of values. At worst the services are impossible to value, for instance cultural or religious benefits, thereby reducing the service to 'value-less' and thus ignored (Ruhl, J.B., Kraft S. E., and. Lant, C. L., 2007).

Proponents of the Severn barrage cite La Rance as a model and highlight the slight impact this latter development made upon the environment. However, the economic implications of the likely more severe environmental impact caused by the Severn barrage is less investigated. By using a more appropriate scheme in Holland for comparison, Morris (2008) highlights the very real possibility of additional flood defence costs incurred as a result of the increased sedimentation of the Severn basin. This is supported by models showing erosion caused by increased wave/wind energy on the standing body of water held by the barrage. His study indicates significantly greater economic costs associated with the rise in flood risk caused by the very barrage that is supposed to reduce flooding. This risk is, of course, further exacerbated by the expected sea level rise as a result of climate change.

The Sustainable Development Commission, however, concluded that 'environmental concerns and the unknown costs of habitat creation should not hold back the development of a barrage across the river [Severn]. This is despite the limited carbon savings it would achieve for its £15bn cost. Indeed, as Friends of the Earth (FoE 2007) point out, £15bn spent upon other renewable energy technology, such as offshore wind farms, could generate 6TWh of electricity more than the barrage and save almost three times as much CO_2 (ENDS report No. 393, 2007).

The economic argument for the introduction of one or more of these schemes is not proven. The wide-ranging estimates used to calculate these forecasts create large margins of error.

However, even the best-case scenarios produce forecasts showing large negative NPVs. This does not make the Severn Tidal Barrage schemes appear cost effective or desirable. Even if the Government's desire to achieve renewable energy targets override the initial economic arguments, when these forecasts are combined with information showing cheaper alternative methods for renewable energy generation, there seems to be little compelling evidence for progressing the Severn schemes.

Environmental implications

As the largest and potentially most damaging of all the schemes, the 'Severn Barrage' has courted most controversy. In February 2010, the RSPB highlighted the potential for increased flooding risk from the barrage. It is also widely acknowledged that the Severn Barrage will result in significant impact upon the habitat and wildlife of the basin. This, according to the ENDS report (409, Feb 2009), could extend inland and impact upon saltmarsh habitat and the ecosystems of the Somerset Levels.

If any of the above mentioned schemes were to go ahead for imperative reasons of overriding public interest (Art.6(4) Habitats Directive 92/43/EEC OJ L206), then compensatory habitats would need to be provided (Art.6(4) Habitats Directive). This could result in managed realignment schemes on an 'unprecedented scale' (SDC, 2007). In 2007, the Severn Estuary and the area surrounding it was put forward by DEFRA as a candidate Special Area of Conservation (Habitats Directive) (DEFRA 2009). The area is a Site of Community Importance (SCI) under the Habitats Directive for intertidal and subtidal habitats and migratory fish species and a Special Protection Area (SPA) designation under the Birds Directive. These designations place a requirement upon the UK government to take compensatory measures to ensure the overall coherence of Natura 2000 is protected (Art 6(3) & 6(4) Habitats Directive 92/43/EEC).

According to the RSPB (2010) the Severn Barrage will result in a loss of intertidal feeding habitat with devastating consequences for the breeding and overwintering bird populations. They support the view held by Morris (2008) that La Rance in France is unsuitable for comparison due to its rocky substrate and agree that environmental data be taken from the Dutch storm surge barrier sited at Oosterschelde. The sediment budget has been changed with less water flow washing sediment out to sea. This has resulted in increased siltation up stream with potential consequences for myriad bird and migratory fish species (van Zanten and Adriaanse, 2008).

Applicable Legislation.

Environmental protection has not always been the goal per se of the European Union and an explicit legislative mandate with respect to environmental policy only appeared after the Single European Act in 1986 (Ginige, T (2002) Mining Waste Part I & II The Aznalcóllar Tailings Pond failure, European Environmental Law review – 76-88 & 102 – 113). It has been suggested by some academic that the Treaty of Lisbon, which was agreed in 2009 reinforces the significance of the environment in the European agenda and the continued influence of EU policy-making on environmental law. The new Article 3 (3) of the Treaty of European Union emphasises the protection of the environment as a key part of sustainable development set in the context of balanced economic growth and price stability intended on ensuring full employment and social progress. (McEldowney, S & J (2009). This is a very naive interpretation and it is suggested that an alternative reading of Art 3 (3) of the Treaty of European Union is that it is indicative of the current trend in the EU of reducing the high level environmental protection by emphasising the importance by given to economical and societal issues.

There is no specific legislation that expressly regulates the activities of renewable energy projects like those proposed in the Severn Estuary either at European Union or at UK level. There are, however, international, European and UK laws governing environmental and nature conservation. Applicable legislation, including the OSPAR, Ramsar, EC Habitats and Birds Directives, EC Water Framework Directive, EC Environmental Liability Directive, Aarhus Convention and the relevant Public Participation Directive 2003/35/EC and the Access to Information Directive 2003/4/EC, Marine and Coastal Access Act 2009, is discussed below.

OSPAR Convention

UK is a signatory to the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)**,** which was signed in Paris in 1992. It has been ratified by the contracting parties – Belgium, Denmark, the Commission of the European Communities the European Community United Kingdom of Great Britain and Northern Ireland, (...). and came into force on 25 March 1998. It is suggested that based on Art.1 of the Convention, the Severn Estuary and the seas adjacent to it, falls within its remit. (DECC, 2008 Severn Tidal Power – Scoping Topic Paper, Marine and Estuarine Water Quality Dec 2008 by Parsons Brinckerhoff Ltd in association with Black &Veatch Ltd) As such UK has a duty to: take all possible steps to prevent and eliminate pollution and (.....) protect the marine

area from adverse effects of human activity (Art.2); all possible steps to prevent and eliminate pollution from land-based sources (....)(Art.3).

Marine & Coastal Access Act 2009 (MCAA)

It is a fascinating bit of draftmanship combining key considerations of protection of the marine environment, human health, prevention of interference with legitimate uses of the sea, (s69 MCAA 2009) and a strong emphasis on renewable energy(s12) and marine economic zones (s116 MCAA 2009). It will require a delicate balance being made between environmental protection and the need to develop a network of renewables to decarbonise the electricity sector in the fight against climate change, if it is to benefit the natural environment and the renewables industry.

Ramsar Convention

The Ramsar Convention came into force in 1975. The treaty imposes a general duty on contracting parties to promote the conservation of wetlands and waterfowl. “Wetland” is defined in a very wide sense and includes areas of marsh, (....) with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which does not exceed six meters. UK ratified the Convention in 1976. In doing so agreed to: designate and monitor wetlands in its territory including those on the list of most important wetlands -this includes the Severn Estuary and its surrounding areas (CCW & Natural England (2009) Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice from CCW and Natural England, June 2009); draw up a national wetland policy as the key means for delivering “wise use”; create a database and the promotion of the exchange of information between citizens and administrative authorities and between the parties to the convention.

It is argued that the convention by interpreting wetland in such a wide manner and establishing protection duties in very general terms runs the risk of being unenforceable (Bell, S & McGillivray, D (1997). In the UK all terrestrial areas included within listed Ramsar sites in England are currently Sites of Special Scientific Interest (SSSI’s) and are legally protected under the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way (CROW) Act 2000 and the Natural Environment and Rural Communities (NERC) Act 2006 (DEFRA 2006, Ramsar sites in England - a Policy Statement). One would rightly assume that with good nature conservation and protection laws in place and sufficient funding (395 million pounds have been spent since 2000), the natural environment would be protected to a very favourable level. It seems that the reality could not be further from the truth. According to the recent National Audit Office Report (National Audit Office, 2008) about a

third of the sites did not have conservation objectives and the quality of the record keeping was variable. The inherent defects of the Ramsar designation coupled with Natural England's track record to date does not bode well for the protect fauna and flora in the Severn Estuary.

Natura 2000

The centrepiece of the European Union's ambitious Biodiversity Strategy is the Natura 2000 network of European protected sites. The legislation that means to deliver this ecological network is the Habitat Directive92/43/EEC OJL206/7 on the conservation of natural habitats and of wild fauna and flora). Once a SAC is placed on the EC Commission list, the Member State must:

- establish priorities for the maintenance or restoration –Art.4(4).
- management plans which correspond to the ecological requirements of the site –Art.6(1).
- avoid the deterioration of the natural habitats and disturbance of the species –Art.6(2).
- conduct an appropriate assessment of the implication for the site of any project not directly connected with or necessary to the sites management, but which is likely to have significant effect on it –Art.6(3).
- undertake surveillance of the habitats –Art.9&11.

The environmental assessment in Art.6(3) is a cause for concern as it is site specific and its focus is on conservation, rather than the significant effect of the project. (Ginige TA (2002). Furthermore under the EC Habitats Directive of 1992 it is suggested that there will be a negative assessment of the project under Art. 6(3), owing to the fact that the scheme will probably cause the disappearance of between about one-third (at neap tide) and two-thirds (at spring tide) of the existing intertidal areas, even before consideration of species specific impacts (FoE,2007).

Another cause for concern is the possibility that per Art.6(4) of the Habitats Directive that a member state may permit a project with damaging implications for a site to be carried out for imperative reasons of overriding public interest so long as compensatory measures are taken to ensure that the overall coherence of Natura 2000 is protected(e.g. habitat restoration) (Scott, J (1989) pg.112).

The European Court of Justice has confirmed in Castro Verde case (Commission v. Portugal (Case C-239/04, 26.10.06)), Art. 6(4), as a derogation from Art.6(3) and the general protection conferred by the Directive, must be interpreted strictly. Article 6(4) reads:" If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of

overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted.

Article 6(4) of the Habitats Directive makes it clear that the obligation to consider alternative solutions is upon the Member State. Further more Regulation 62(1) of the Conservation of Habitats and Species Regulations 2010, SI 2010/490, reads:

> "If they are satisfied that, there being no alternative solutions, the plan or project must be carried out for imperative reasons of overriding public interest (which subject to paragraph 2 (concerned with priority habitats and species) may be of a social or economic nature), the competent authority may agree…to the plan or project notwithstanding a negative assessment of the implications of the site".

As highlighted by the Castro Verde case, "Solutions", and the "reasons"/"public interest" should form the main part of the IROPI test and in the opinion of Advocate General Kokott (Commission v. Portugal (Case C-239/04, 26.10.06 at 53)

> "The absence of alternatives cannot be ascertained when only a few alternatives have been examined, but only after all the alternatives have been ruled out. The requirements applicable to the exclusion of alternatives increase the more suitable those alternatives are for achieving the aims of the project without giving rise – beyond reasonable doubt – to manifest and disproportionate adverse effects. The choice requires a balance to be struck between the adverse effect on the integrity of the SPA and the relevant reasons of overriding public interest. The necessity of striking a balance results in particular from the concept of "override", but also from the word "imperative". Reasons of public interest can imperatively override the protection of a site only when greater importance attaches to them. This too has its equivalent in the test of proportionality, since under that principle the disadvantages caused must not be disproportionate to the aims pursued."

Alternative solutions specific to the Severn Tidal Barrage are all manner of technology capable of producing reliable, low carbon electricity over the long term for the UK. This would include examination of tidal resources throughout the UK, including both tidal range and tidal stream resources (Royal Academy of Engineering , 2008). It will also require the examination of the suitability of other renewable low carbon energy resources. There is an obligation upon Member States under the Directive to examine alternative sites for the project (Krämer L., 2009). The competent authorities have to examine the possibility of resorting to

alternative solutions which better respect the integrity of the site in question … They could involve alternative locations, different scales or designs of development, or alternative processes. The "zero-option" should be considered too". (European Commission in the form of Managing Natura 2000 Sites, published in 2000 at Section 5.3.1). Further more they must consider if alternative solutions exist or not, and that this consideration "will also include other alternative solutions that may be suggested by other stakeholders and should not limit consideration of alternative solutions to those suggested by a project's proponents and that alternative solutions could be located even in different regions or countries …." (EC Commission Assessments of plans and projects significantly affecting Natura 2000 sites November 2001).

Assuming the UK Government can satisfy the "no alternative solutions" and IROPI tests, the final hurdle under Art.6(4) is that it would have to *"take all compensatory measures necessary to ensure the overall coherence of Natura 2000 is protected".* Thus when a competent authority is considering whether habitat or species losses can be made up by compensation, it must look at two different aspects per Art. 3(1) of the EC Habitats Directive, i.e. *"on the one hand the targeted species and habitats in terms of quantity and quality, and on the other hand the role of the site in ensuring the adequate geographical distribution in relation to the range"* and be mindful that these criteria are met. (European Commission. 2007 .Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC January 2007**)**

Furthermore all possible mitigation must be addressed before thinking about compensation. One must not make error of dressing up compensation as mitigation in an attempt to show that the integrity of the site is not affected, as attempted by Associated British Ports who sought unsuccessfully with regard to the Dibden Bay Container Terminal. Here the appropriate assessment was fundamentally flawed in this respect. (Dibden Bay Container Terminal Inspector's Report, at para.36.166)

Finally a Member State cannot propose a project under Art.6 (4) which cannot provide a package of compensation which falls short of being equivalent to that which is lost (European Commission 2007 at 1.51). It is questionable as to how this might be achieved for the Severn Estuary when considering amongst other things, the fact that duration of DECC's 2008 review was too short in comparison with what is considered an appropriated timescale for such evaluation (Sally A. Keith, et al 2009).

Art.16 of the Habitat Directive states that if no satisfactory alternative exists and the derogation is not detrimental to the maintenance of the populations of the species concerned at a favourable conservation status in their natural range, Member States may derogate from the provisions of Articles 12, 13, 14 and 15 (a) and (b) the article that specify the methodology required for the species protection. Thus, instead of having a Directive with a high level of protection for the environment, what we have ended with is one that represents a dramatic reassertion of member states sovereignty over their natural resources (Scott, J., 1989). Furthermore there were numerous flaws in the UK transposed, EC Habitat Directive 1992 legislation i.e. Conservation (Natural Habitats, etc) Regulations 1994, (SI 1994/2716). These flaws included the failure to apply the law fully offshore, the presence of excessively wide defences permitting harmful acts if they were the incidental results of lawful operations, inadequate measures for surveillance and monitoring and the absence of procedures to assess the impact of development plans on designated sites as stated by the European Court of Justice (ECJ) in the recent case of Commission v UK 2005 ((C-6/04) [2005] ECR I-9017, [2005] All ER (D) 231 (Oct)).This in turn has led to the revised and consolidated Conservation of Habitats and Species Regulations 2010, SI 2010/490, which took effect as of 1 April 2010, which should now provide a single source for the law in England and Wales ,conserving the plants, animals and habitats awarded protection at European level notwithstanding Art 6(4) of the Habitats Directive 92/43/EEC.

EC Environmental Liability Directive

The Environmental Liability Directive 2004/35/CE (ELD) is an EU wide legislation with the objective of "establishing a common framework for the prevention and remedying of environmental damage at a reasonable cost to society…" The Environmental Liability Directive of April 2004 came into force in the UK on 1 March 2009 via the Environmental Damage (Prevention and Remediation) Regulations 2009. It will apply to "environmental damage" as defined in Art.2 of the ELD which applies to protected species and natural habitats under the Birds and Habitats Directives. Therefore, if the government reduces intertidal range after a properly carried out exercise under Arts 6(3) and (4) of the Habitats Directive92/43/EEC, that reduction would not amount to "environmental damage" within the ELD. However, it should be noted that this protection extends only to *"previously identified adverse effects."* If for argument sake all prior investigations do not reveal any adverse effect, which then emerges during the building of the barrage, then the government may in principle be liable if the damage was caused either by an Annex III activity (it is suggested that water impoundments might well be included) or, if caused by a non – Annex III activity, where the operator was at fault or negligent- Art.3(1)ELD.

Water Framework Directive

The legislation regarding water quality standards are well developed and can be found at national, European International levels, all covering different aspects(Bell,S 2009). The Water Framework Directive 2000/60/EC (WFD) is comprehensive and provides a framework that classification of water bodies: the setting of objectives and the monitoring of achievement as well as identifying what means are required to maintain energy improvement in water quality requiring that all inland and coastal waters achieve "good status" by 2015 (McEldowney, S., & J., 2009) and it includes "transitional water bodies" or estuaries. The physical and hydrological characteristics of the Severn Estuary support a wide variety of the species; giving consideration of depth variations, the structure and condition of intertidal zones, flow, currents and wave exposure all of which including the water quality status will be affected by a tidal barrage. The Environment Agency(EnA) has made it clear that the Cardiff-Weston barrage would make it impossible for the UK to be in compliance with the WFD by 2015. (Environment Agency, 2010)

The possibility exists that a Severn tidal power scheme may change the components that define the status of the transitional and coastal water bodies in the river basin, and may alter some freshwaters too. Perhaps the question we need to ask, is whether the river system, its sediments and components may be altered drastically further up river by a barrage system? To answer that question we may need to study the effects that the Petitcodiac causeway in south-eastern New Brunswick, Canada had on the Peticodiac river instead of La Rance in France(Sentinells Petitcodiac Riverkeeper. 2010).

Aarhus Convention

The dialogue between the government and the public i.e. what in the UK is known as public participation which "has been pointed out as being limited by consultant institutions and their commissioning bodies pre-framing issues, publics and consultations themselves. This has led to consultations labelled moribund, tokenistic and even deceptive"(Gerlach, J. 2008). This lack of dialogue between the government and individual citizens with regard to the Severn Tidal Barrage is another of the many indication of the glaring problems that exist with regard to the application of the Aarhus Convention in the UK (UKELA 2008). This is not surprising given that, historically, excessive secrecy has been the hallmark of UK's approach to sharing of environmental knowledge with its citizens (McEldowney, S., & McEldowney, J., 2009). The rights afforded by the Aarhus Convention i.e. access to information; public participation in decision-making; and access to justice were further strengthen by the

following EC directives -EIA Directive 85/337/EEC as amended by 97/11/EC and Public Participation Directive 2003/35/EC; IPPC Directive 96/61/EC and as amended by the Access to Information Directive 2003/4/EC.

These rights should be regarded as minimum requirements that operate as a minimum standard rather than an optimum level to be attained; a floor, not a ceiling. Articles 3(5) and (6) state that the Aarhus Convention provisions:

> shall not affect the right of a Party to maintain or introduce measures providing for broader access to information, more extensive public participation and wider access to justice than required by [the Convention] ... and shall not require any derogation from existing rights.

The government considers that since the introduction of new Environmental Information Regulations 2004 (SI 2004/3391) (the Environmental Information Regs. 2004), that the UK is Aarhus compliant. It is suggested that we apply the letter and spirit of the law.

The proposed Severn Tidal Barrage ought to provide the government with the prime opportunity to engage the public meaningfully and to instigate this debate according to a reconfigured geography of more deliberative, inclusive consultation. Without precedent and with the socio-ecological stakes so high, the government cannot afford not to consult the public on the issue"(Gerlach, J. 2008).

Conclusion

The centrepiece of the European Union's ambitious Biodiversity Strategy is the Natura 2000 network of protected sites, under the EC Habitats Directive 92/43/EEC. The environmental assessment in Art. 6(3) is a cause for concern as it is site-specific and its focus is on conservation rather than the significant effect of the project. Another cause for concern is the possibility per Art. 6(4) that a Member State may permit a project with damaging implications to be carried out for reasons of overriding public interest so long as compensatory measures are taken to ensure that the overall coherence of Natura 2000 is protected (e.g. habitat restoration).

The fundamental issue, therefore, remains unresolved. Are we now at the stage where 'imperative reasons of overriding public interest' covers all climate change mitigation development?

Although this paper has focussed upon a significant proposed development in the form of the Severn Tidal Barrage, it applies equally to any development designed to combat the, as yet unknown, effects of climate change. Is this not akin to marching into an area of pristine Brazilian rainforest, chopping down trees and putting wind turbines in their place? The protection afforded to the Severn River basin is on a similarly national, European and international level. Is the legacy of this development to be the irrevocable loss of this ecosystem?

Essentially, if this project can go ahead with the acknowledged significant environmental impacts, then it could represent the future benchmark for other developments. The door will be opened for development anywhere in England and Wales that mitigates climate change, to be allowed to proceed no matter what statutory protection is in place.

In addition, the balancing of conflicting interests inherent within this scheme need to be supported by a scientific study of the environmental impact, an economic study of the NPV and a social study into the pros and cons of this barrage. All three elements need to be sufficiently robust to truly enable the balancing of conflicting interest to take place. Restraint from the current 'eyes wide shut' headlong rush into climate change mitigation is needed to fully appreciate the consequences of the development. As Aronson (et al. 2006) suggest

> 'Ecologists and economists working together with NGOs, community leaders and governments, may help forge a way forward with a new paradigm: ecology as if people mattered; economics as if nature mattered.'

The implementation of the new EC laws incorporating the Aarhus Convention Principles will require the development of new relational capacities both between social agents, in the form of learning how to collaborate and understand others roles and capacities differently, and between social-ecological systems (Pahl-Wostl, et al. 2008). New institutional arrangements will also be required to facilitate the more sustainable relationships, based on new framings of the issues at stake and agents involved. This will necessitate the development of new identities, as well as institutions and individual capacities that are more socially and environmentally robust with the common goal of sustainable nature conservation. Without this debate, there can be no balancing of conflicting interests and, thus, no sustainable development.

Alder and Wilkinson (1999) take the view that:

> ‘Decision makers sometimes have to sacrifice one good for another greater good. The broader our area of environmental concern the more difficult becomes the balancing act’ (Alder, J. and Wilkinson, D. 1999).

However, the current situation would suggest that climate change mitigation represents the ‘trump card’. Thus the paradox remains: the damaging impact to the environment caused by development designed to mitigate the damaging impact to the environment. Only by addressing this paradox can development for climate change mitigation be undertaken with ‘eyes wide open’ and consequences accepted and balanced.

References

Anderson, S. H., 2007. *Barrages And Impoundments: A Preliminary Study of the Potential for Sustainable Net Energy Capture Obtainable by Storage for Tidally Amplified Release (‘Ecostar’ Scoping Model.)* Available from:< http://www.marinet.org.uk/refts/7ecostar1.pdf>[Accessed 20 July 2010].

Alder, J., and Wilkinson, D., 1999. *Environmental Law & Ethics*. London: Macmillan Press.

Aronson, J., Milton S.J., Blignaut J.N., Clewell A. F., 2006. Nature Conservation As If People Mattered Journal For Nature Conservation 14 (2006) 260—263

Beaumont, N. J., Austen, M. C., Mangi, S. C. and Townsend, M., 2008. Economic valuation for the conservation of marine biodiversity. *Marine Pollution Bulletin* 56, 386 – 396.

Bell, S and McGillivray, D., (1997). *Environmental Law,* London, Blackstone Press.

Bell, S., and McGillivray, D., 2009. *Environmental Law*. Seventh Edition. Oxford :Oxford University Press.

Boyd, J., Banzhaf, S., 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics. Volume 63, Issue 2-3, August 2007, Pages 616-626*

Clarke, N. (2010, May). *Independent Newspaper.* Retrieved July 20, 2010, from http://www.independent.co.uk/news/business/news/britains-offshore-renewable-energy-worth-a-billion-barrels-of-oil-and-145000-new-jobs-1977531.html

Commission of the European Communities, Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage , COM (2010) 265 Final (May 2010) (hereinafter Analysis of options to move beyond 20%)

Costanza, R., 2008. Ecosystem Services: Multiple classification systems are needed. *Biological Conservation*141:350-352

Cullingworth, B. and Nadin, V. (2006) *Town and Country Planning in the UK,* Routledge, 14th Edition, pages 200-205.

DEFRA 2006, Ramsar sites in England - a Policy Statement. London:HMSO

DEFRA, 2007 *An Introductory Guide to Valuing Ecosystem Services.* London: HMSO

DECC, 2008 SEVERN TIDAL POWER – SCOPING TOPIC PAPER, Marine and Estuarine Water Quality Dec 2008 by Parsons Brinckerhoff Ltd in association with Black &Veatch Ltd)

Department of Energy and Climate Change, 2009. *Severn Tidal Power Phase 1 Consultation.* London: DECC.

DECC, 2009. *The UK Renewable Energy Strategy*, Cm 7686.London: HMSO

DTI, 2003 Our Energy Future—Creating a Low Carbon Economy. TSO, London, p. 138.

DTI, 2003 Government Gives Green Light to Renewables Future. Press Release, DTI, Dec 1st, 2003, available from http:// 213.38.88.221/gnn/national.nsf/TI/E42654EB406D834F80256DEF00569E89? opendocument.

Dibden Bay Container Terminal Inspector's Report, at para.36.166 as stated in Owen, R., European Nature Conservation Sites and the Appropriate Assessment of Plans and Projects in *Journal of Planning & Environment Law* 2007, December, Sweet & Maxwell

Environmental Data Services, 2004. *Severn Barrage kicked further into touch.* ENDS report, 348, pp. 33, January 2004.

Environmental Data Services, 2007. *Government advisers call for Severn barrage*. ENDS Report, 393, pp. 12 – 13

Environmental Data Services, 2009. *Severn Barrage study unleashes tide of paper.* ENDS report 409, pp. 40 - 41, February 2009.

Environmental Data Services, 2010. *Environmental bodies fall to government's quango cuts.* ENDS Report 426, pp. 5-6, July 2010.

European Commission in the form of Managing Natura 2000 Sites, published in 2000 at Section 5.3.1.

European Commission. 2007 .Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC January 2007.

Falconer, R.A., Lin, B.L., Ahmadian R., and Xia, J.Q., (2009). The Severn Barrage: hydro-environmental impact assessment studies, *Proceedings of 33rd IAHR Congress*, Vancouver, Canada, pp. 2075–2082.

Eftec, 2006. Valuing our Natural Environment. Report for DEFRA.

Environment Agency, 2010 Tidal barrages and barriers: Position Statement < http://www.environment-agency.gov.uk/research/library/position/41199.aspx> Last Accessed on 30 July 2010.

Friends of the Earth Cymru (FoE) . 2007 *The Severn Barrage* Friends of the Earth Cymru: Cardiff.

Fisher, B., Costanza, R., Turner, R. K., and Morling, P. 2009. *Defining and Classifying Ecosystem Services for Decision Making*. CSERGE Working Paper EDM 07-04.

Frid CLJ, Paramor OAL, Brockington S, Bremner J (2008) Incorporating ecological functioning into the designation and management of marine protected areas. Hydrobiologia 606: 69-79

Frontier Economics. (2008). *Analysis of a Severn Barrage.* London: Frontier Economics Ltd.

Gerlach, J. 2008. Turning the Tide of Opinion – The Severn Barrage and Spaces of Public Consultation ,Oxford University Centre for the Environment, Oxford

Ginige, T.A., 2002 Mining Waste Part I & II -The Aznalcóllar Tailings Pond failure, *European Environmental Law Review* . Amsterdam: Elsevier
pp76-88 & 102 – 113.)

Haynes -Young, R., and Potschin, M., 2008 *England Terrestrial Ecosystem Services And The Rationale For An Ecosystem-Based Approach*. Overview Report London:DEFRA

Haines-Young, R. and Potschin, M. (2007): *The Ecosystem Concept and the Identification of Ecosystem Goods and Services in the English Policy Context.* Review Paper to Defra, 21pp.

HMSO. (1989) *The Severn Barrage Project: General Report: Energy Paper 57*. London: HMSO

Krämer, L., 2009 .The European Commission's Opinions under Article 6(4) of the Habitats Directive J Environmental Law .2009 21: 59-85

Kirby, R., and Shaw, T.L., 2005. Severn Barrage, UK-environmental reappraisal, *Proceedings of the Institution of Civil Engineers. Engineering Sustainability* 158 (ES1) (2005), pp. 31–39

Kyoto Protocol." *United Nations Framework Convention on Climate Change*. Web. 30 July 2010. <http://www.unfccc.int>.

Joint Nature Conservation Council, 2010. *UK SAC/SCI sites summary. Special Areas of Conservation/Sites of Community Importance in the UK as at 14 December 2009*. Peterborough: JNCC. Available from http://www.jncc.gov.uk/page-1456 [Accessed 23 July 2010].

McEldowney, S., & McEldowney, J., 2009 Environmental Law, Pearson Education, Harlow.

Mettam, C. 1978. Environmental effects of tidal power generating schemes. *Aquatic Ecology* , 307 - 321. Springer Netherlands

Millennium Ecosystem Assessment, 2003. *Ecosystems and Human Well-being: A Framework*

for Assessment. Island Press, Washington, DC. World Resources Institute.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Biodiversity Synthesis*. Island Press, Washington, DC. World Resources Institute.

Mott MacDonald Limited. (April 2007). *Appraisal of Costs & Benefits of Smart Meter Roll Out Options.* London: BERR.

Morris, R. K .A, 2008. *A Severn Barrage - planning for environmental consequences.* Presentation for the Renewable Energy Association Wave and Tidal Technologies Symposium 23 September 2008, Cardiff

Morris, R.K.A. 2009. The impact of tidal energy barrages on estuarine geomorphology. *In*: Aranoff, J.B. *Handbook of Nature Conservation: Global, Environmental and Economic Issues*. Nova Science Publishers.

National Audit Office, 2008. *Natural England's Role in Improving Sites of Special Scientific Interest* (19 November, 2008) HC 1051 Session 2007-08.

Pahl-Wostl, C., Tabara, D., Bouwen, R., Craps, M., Dewulf, A., Mostert, E., Ridder, D.,Taillieu, T., 2008. The Importance of Social Learning and Culture for Sustainable Water Management. Ecological Economics Volume 64, Issue 3, 15 January 2008, Pages 484-495

Parsons Brinckerhoff Ltd and ABP Marine Environmental Research Ltd for DECC ,2008. *SEVERN TIDAL POWER - SCOPING TOPIC PAPER. Marine and Estuarine Water Quality.* London: Department of Energy and Climate Change (DECC)

Pethick, J. S., Morris, R. K. A. and Evans, D. H., 2009. Nature conservation implications of a Severn tidal barrage – A preliminary assessment of geomorphological change. *Journal for Nature Conservation* 17, 183 – 198.
(Price, 2007)

Remoundou,K., Koundouri,P.,Kontogianni, Paulo, A.,Nunes , A.L.D., and Skourtos, M., (2009) Valuation Of Natural Marine Ecosystems: An Economic Perspective. *Environmental Science & Policy* ,Vol 1 2, pg1 0 4 0 – 1 0 5 1. Amsterdam: Elsevier

Royal Academy of Engineering (2008). The Severn Barrage Conference 22 May 2008. London: The Royal Academy of Engineering.

Royal Commission on Environmental Pollution, 2000. 22nd Report: Energy - the Changing Climate. Norwich: HMSO.

Royal Society for the Protection of Birds, 2010. *Severn Tidal Power RSPB briefing on the implications of the Eastern Scheldt (Oosterschelde) for the Severn Estuary.* Available from: http://www.rspb.org.uk/ourwork/casework/details.asp?id=tcm:9-228221 [Accessed 18 July 2010].

Ruhl, J.B., Kraft S. E., and. Lant, C. L., 2007, *The Law and Policy of Ecosystem Services*, Island Press, Washington, DC, USA.

Sally A. Keith, Adrian C. Newton, Michael D. Morecroft, Clive E. Bealey and James M. Bullock . **2009 .**Taxonomic homogenization of woodland plant communities over 70 years Proceeding of the Royal Society B (2009) 276, 3539–3544

Salter, M. and Walker, C., 2010. *Severn Barrage Digest: An Environmental Gamble Too Far.* Available from: http://www.martinsalter.com/index.php/reports/severn-barage-report/ [Accessed 10 June 2010].

Sentinells Petitcodiac Riverkeeper.2010. Petitcodiac River Restoration Moncton, New Brunswick, Canada< http://petitcodiac.org/ index.php?page=petitcodiac-river-restoration&hl=en_US> accessed on 20 July 2010

Scott, J., 1989 *EC Environmental Law.* Addison Wesley, Longman: Essex.

Sustainable Development Commission, 2007. *Turning the Tide: Tidal Power in the UK.* London: Sustainable Development Commission.

Taylor, S. J., 2002. *The Severn Barrage – Definition Study for a new appraisal of the Project.* Final Report by Sir Robert McAlpine Limited on behalf of the Severn Tidal Power Group. ETSU Reort No. T/09/00212/00/REP.

TEEB – The Economics of Ecosystems and Biodiversity (2008) The Economics of Ecosystems and Biodiversity: An interim report. European Commission, Brussels. URL:

www.teebweb.org
(last access: July 2010).

TEEB – The Economics of Ecosystems and Biodiversity for National and International Policy Makers –Summary: Responding to the Value of Nature 2009. URL: www.teebweb.org (last access: July 2010).

The Offshore Valuation Group (OVG), 2010. *A Valuation of the UK's Offshore Renewable Energy Resource.* Powys: Public Interest Research Centre.

UKELA 2008 . Response of 25 March 2008 to UK Government on Implementation of the Aarhus Convention. Working party on Environmental Litigation. Dorking.

United Nations, 1997. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Conference of the Parties on Its Third Session, FCCC/CP/1997/L.7/Add.1, 10 December.

United Nations Environment Programme.2006.Marine and Coastal Ecosystems and Human Well-being: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment.Nairobi: UNEP.

Watson, R., 2010. *The Ecosystem Approach.* Presentation to the Institute of Ecology and Environmental Management Conference 24 March, 2010.

Xia, J.Q., Falconer, R. A., Lin, B. (2010). Impact Of Different Tidal Renewable Energy Projects On The Hydrodynamic Processes In The Severn Estuary, UK. *Applied Energy,* Volume 87, Issue 7, July 2010, Pages 2374-2391

Zanten, E. van, Adriaanse, L. A. 2008. *Sand demand Oosterschelde: An analysis of the erosion of the tidal flats of the Oosterschelde after construction of the storm surge barrier and its effect on flood safety, nature, shipping and fisheries.* Available from: http://www.rspb.org.uk/Images/RSPBbriefEasterScheldtreportfinal_tcm9-240984.pdf. [Accessed 18 July 2010].