THE SEVERN BARRAGE – DEFINITION STUDY FOR A NEW APPRAISAL OF THE PROJECT.

FINAL REPORT: JANUARY 2002

ETSU REPORT NO. T/09/00212/00/REP

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on behalf of
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The work described in this report was carried out under contract as part of the Sustainable Energy Programmes, managed by ETSU on behalf of the Department of Trade and Industry. The views and judgements expressed in this report are those of the contractor and do not necessarily reflect those of ETSU or the Department of Trade and Industry.

First published 2002

EXECUTIVE SUMMARY

The objective of this Definition Study was to examine whether a reappraisal of the Severn Barrage Project is justified since the tripartite studies reported in Energy Paper 57 in 1989.[1]

We conclude that a reappraisal is indeed justified, on the grounds of:

- significant reductions in the cost of capital that have a substantial impact on such a capital-intensive project;
- following Kyoto, the creation of a market value for savings in greenhouse gas emissions;
- the potential impact of climate change on flood incidence in the Severn basin, and therefore the greater value of the Barrage in terms of flood mitigation;

all of which have occurred or been appreciated since Energy Paper 57.

Revived interest in the Project has stemmed from:

- the Government's stated energy policy to encourage a greater proportion of the UK's electricity generation to be derived from renewable sources;
- publication of the Royal Commission on Environmental Pollution's Report " Energy – The Changing Climate" which suggests cuts in the UK's emissions of carbon dioxide of some 60% from current levels by the middle of this century and recommends that the construction of tidal barrages is kept under review as an option for the longer term;
- concern expressed regarding potential threats to the security of supply arising from increasing reliance on gas-fired power stations that, in turn, will depend on imported gas for their fuel supply;
- recognition of increasing flooding risk in the Severnside region as a possible consequence of global warming;
- political and public attitudes to sustainable development.

The main issues arising from the changed and changing circumstances since the publication of EP 57 have been identified and their impact on the viability of the project discussed with a wide range of consultees, government organisations and industry representatives.

The principal conclusions from these discussions are set out below.

[1] 'The Severn Barrage Project: General Report': Energy Paper 57; HMSO 1989
The tripartite studies, funded equally by The Department of Energy, the Central Electricity Generating Board and the Severn Tidal Power Group, examined further the design and construction of an electricity generating barrage from Cardiff to Weston-super-Mare to capture the energy form the tides in the Severn Estuary, the second highest tide range in the world. The main conclusions are set out in Appendix A.

Electricity Market Issues

Contribution to security and diversity of supply

The Government predicts that by 2006 the UK could be a net importer of gas, the primary fuel for over 50% of its electricity supplies, and by 2020 it could be importing between 55% and 90% of its gas needs. Furthermore, most of its nuclear stations could be shut down by 2020 leading to a possible greater reliance on gas as the primary fuel source for electricity generation.

Tidal power is fully predictable and highly reliable as demonstrated by 35 years of successful operation of the 240MW La Rance Barrage near St Malo.

The Severn Barrage could generate annually 6% of the present electricity demand of England and Wales from an installed capacity of 8640 MW and would therefore add to diversity of supplies.

The generation scheme recommended in EP 57 was estimated to make a contribution to firm capacity of 1.1GW. The study has identified two ways of improving this contribution to further increasing security of supplies:

(i) varying the start time of generation;

(ii) provision of a low head pump storage reservoir capable of generating at any stage of the tide, constructed integral to the Barrage.

The viability of such schemes and their environmental impact require further study.

A means of valuing the worth of the contribution to security and diversity of supplies is considered essential to the proper economic assessment of the Project, and such techniques have become available over the last 10 years.

The New Electricity Trading Arrangements

The introduction of competition to the electricity market and more recently the New Electricity Trading Arrangements has brought significant changes to the electricity market.

The cost of electricity has continued to fall and is now trading at under £20/MWh for annual base load generation under NETA. Power sold through the balancing mechanism can attract a higher price and the ability of the Barrage turbine-generators to meet a fluctuating demand and also provide a peak-lopping capability would also enable the Barrage to compete in this section of the market.

Because the marginal cost of Barrage generation is very low it will always be better to generate than not and the view was expressed by those consulted that because of its large size (8.6GW) entry of Barrage electricity could distort the market and, therefore, it may need to be ring-fenced.

The Renewables Obligation

The Renewables Obligation gives strong support to the development of renewable energy projects and enables the development of a market that values electricity from such sources. The earliest date that Barrage electricity could be available is approximately 2012 with full power by 2014. The Barrage cannot therefore contribute to the original Obligation target of 10% of electricity from renewable sources by 2010. However, the Government has

indicated that this target may be increased in the future. Doubling of size of the Obligation would require a further 29-33TWh pa to be generated from renewable sources and would introduce more favourable conditions for the development of the Barrage which, if sanctioned, could contribute 17TWh per annum by 2015. The Barrage would certainly be an important option if more increases in renewable electricity generation are required post 2020.

Grid strengthening

The estimated cost of Barrage power includes the full cost of the grid reinforcement identified in EP 57, escalated to 2001 prices (approximately 13% of total capital cost). Discussions with the National Grid Company plc concluded that it is not possible to identify what strengthening may be needed in the future - there are so many variables in the analysis, which has to extend far beyond the current Seven Year Statement planning horizon. Furthermore, although the Barrage would itself not be considered an embedded generation project, the current debate on the potential financial barriers to such projects if they are charged with the full reinforcement costs raises the question of the appropriate allocation of such reinforcement costs to the Barrage, both initially and in the long term.

Timescale for entry to the Market

Barrage electricity should be treated as displacing domestic coal-fired generation, since this offers the similar security of supply. The carbon offset benefit is therefore much larger than for the average generation portfolio. There is no reliable means of predicting when existing plant will become uneconomic, but Phase I of Drax, the UK's most modern coal-fired power station, will be 40 years old in 2014.

The Environment

Climate Change Strategy

The Government has taken a leading role in the implementation of the Kyoto Protocol and has set ambitious targets for reducing the UK's emissions of the greenhouse gases. The Performance and Innovation Unit is reviewing UK Energy Policy to 2050 in the light of the recommendations of the RCEP report for even greater reductions.

By comparison with coal-fired generation, the electricity generated from the Barrage would avoid the emission of 18million tonnes of CO_2 per year (4.6million tonnes of carbon), 3% of the UK's carbon emissions from all sources. By comparison with gas-fired generation, the saving would be 3.1million tonnes of carbon.

No other source of renewable energy has the scale, reliability, predictability or proven technology of tidal power from the Severn Estuary, nor make the same contribution to security and diversity of supplies from a single project.

Mitigation of flooding risk in the Severnside Region

A recent study for DEFRA[2] details the assets at risk from flooding and coastal erosion, including the potential impact of climate change. The area of urban development and high grade agricultural land at risk in the Severnside Region has been estimated as some 40,000ha. The DEFRA report estimates the current annual average damage cost associated with this risk as £1,000-£5,000/ha and expects this to increase by at least 100-fold by 2075 as a result of climate change. This annual average flooding damage cost risk, which currently totals £40-200M pa is expected to rise due to climate change to at least £4,000M pa by 2075. This risk and the associated capital expenditure costs to improve flood defences would be avoided if the Barrage were constructed.

Sustainable Development

The Barrage is recognised as a major infrastructure project. The more placid sea-state and improved water quality in the basin would be expected to bring socio-economic benefits to the Severnside Region through increased tourism, job-creation, inward investment and improved land and property values - particularly in areas where waterfront development is possible. It is thought that local, Regional and National sustainable development objectives may be maximised when compared with other options for generating the same amount of power from predictable renewable energy sources.

Conservation

Conservation objectives for the Severn Estuary have been formalised since the tripartite studies. The effect of climate change on these objectives needs to be quantified to enable proper assessment of the impact of the Barrage and appropriate mitigation measures.

The currently proposed shoreline management plans include "set-back" as the preferred management option for approximately two-thirds of the 90 cells of the Severn Estuary Shoreline Management Plan. In the absence of the Barrage it is predicted that the possible effects of climate change will greatly increase the rate of coastal erosion, which, in turn, will result in the loss of valuable habitats. It is this prediction of habitat loss without the Barrage that should form the baseline when assessing the impact of the "with Barrage" case.

Any further development of the Project would therefore require a consensus view of the impact of construction and operation of the Barrage, in particular which habitats would be preserved that may otherwise be destroyed, which may be changed and to what extent, whether new ones will and/or could be created and with what consequences, and what compensatory measures may be practicable.

Transport Infrastructure

Provision of shipping locks

The size of vessels visiting the ports in the Bristol Channel and Severn Estuary has increased since 1989 and the feasibility of accommodating vessels

[2] "National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England and Wales" DEFRA, September 2001.

up to 250,000dwt is under investigation The issue of the size of vessel allowed to pass through the Barrage is one of the most significant changes since the tripartite studies were carried out. Agreement as to the optimum size of lock that would be incorporated in the Barrage is of fundamental importance to the future development of the Project.

Transport links on the Barrage

Since 1989 the Second Severn Crossing has been constructed at the English Stones location. At first sight this would appear to remove the justification for the Barrage contributing to the provision of fixed transport links. However, this assumption should take into account the need for an adequate transport infrastructure to support the anticipated inward investment expected to result from the construction and operation of the Barrage, including an increase in tourism in South and West Wales and the South West of England.

Economic Evaluation

Optimum arrangement for Barrage generation

The ebb-generation scheme for a Barrage on the Cardiff - Weston super Mare alignment developed in the tripartite studies, which includes reverse pumping at high tide to increase the amount of water available in the basin, would maximise output at the most economic cost. Because the Barrage has a very long life it is concluded that short-term considerations should not be allowed to determine the design of the Project and the scheme reported in EP57 is thought to remain the most appropriate basis for its development.

Capital Cost

The capital cost of the Severn Barrage scheme described in EP57 is estimated to be between £10.3-£14.0Bn at 2001 prices. This estimate is derived from the EP57 cost estimate adjusted by escalation indices for the past 13 years. This adjustment does not take into account improvements in construction methods and productivity since 1988.

Indicative cost of Barrage electricity

There have been several changes in project finance since EP57 which have led to an estimated 40% reduction in the cost of capital for the Project.

A straightforward project financing model has been prepared by PricewaterhouseCoopers assuming the full cost of the Barrage and associated grid strengthening is recovered through electricity sales. This indicates a reasonable prospect of achieving a generating cost of less than £60/MWh in 2001 terms for an equity return of 15% and a range of maturities and cover ratios. This is only just above the Renewables Obligation price cap.

If only 50% of the grid strengthening capital costs are charged to the Barrage, this would save some £5/MWh on the cost of Barrage power.

The accuracy of the cost estimate on which this analysis is based is considered to be ± 15%.

Competitiveness

Assuming that the current market price for base load power is £20/MWh, and that Barrage electricity could attract a premium of (say) £7/MWh for its contribution to security of supply and its ability to meet a fluctuating demand, the average selling price of Barrage power would be £27/MWh.

If tidal power is assumed to substitute for coal-fired power of equivalent energy security status, then tidal power would save approximately 1tonne CO_2 per MWh. At the long-term estimate for the value of CO_2 so saved this would give an environmental credit to Barrage electricity of £30/MWh. This figure has also been quoted as the likely penalty to be imposed on public electricity suppliers for failing to meet their Renewable Obligation.

Construction and operation of the Barrage would also avoid the average annual flood damage cost in the Severnside Region currently valued at some £120M pa. If the avoidance of this cost is credited to the 17 TWh of annual generation from the Barrage it would amount to a credit of £7/MWh. This avoided cost is predicted to rise substantially by 2050 as a result of climate change. Over its 120 year life, an average avoided cost of (say) £20/MWh might reasonably be attributed to the Barrage.

The value of the wider social and economic cost-benefits arising from the Project have not been quantified in the study. However, the prospects for inward investment giving rise to improved land and property values and job creation are expected to have improved since the EP57 report.

At current values, therefore, electricity generated from the Barrage could be worth at least £77/MWh (£27 for the electricity itself, £30 for the value of its carbon credits and £20 flooding cost avoided), compared with a cost of £60/MWh (capital and operating cost).

The £17/MWh surplus of worth over cost – admittedly subject to a wide range of uncertainty –suggests that there is a *prima facie* cost-benefit case for building the Barrage.

Organisational Structure

The case for Government support for the Project

The Severn Barrage would be a major infrastructure project with wide social, environmental and economic benefits resulting from its construction and operation that meet many of the Government's policy objectives. The value of these benefits must either be monetised directly for benefit of the Project, or taken into account to justify any Government support. The development of the Private Finance Initiative and of Public Private Partnerships provides the means for doing this and would enable an appropriate vehicle to be developed to take this complex infrastructure project forward.

Financial Studies

Examination of the organisational and financing aspects for project implementation was withdrawn from the tripartite studies because of the disruption in the electricity market caused by privatisation. A study of the organisational structure for the development and financing of the Project

would complete the tripartite studies and enable the Government to make the decision whether or not to support the Project.

The Way Forward

There would appear to be three options for taking the Project forward.

(i) Undertake, initially, only sufficient further studies necessary to inform the Government on issues fundamental to the decision of whether it will support the Project. These studies could be managed by STPG and funded by Government. They should cost no more than £500,000 and take no longer than twelve months to complete.

(ii) The Government could sanction a full re-appraisal of the Project following approval of the scope of work and its cost This option is likely to include competitive bids for some or all elements of the work.

(iii) The Government could decide to promote the Project and seek partners to develop it to the stage of preparing the enabling legislation. This option would include establishing the organisation to implement the Project assuming the legislation receives Royal Assent.

Conclusions

The Definition Study has concluded that the viability of the Project has improved due to a number of factors, in particular:

- the changes in the electricity market, especially the increased emphasis on generation from renewable sources and the introduction of NETA are favourable for development of the Project;
- the Project would have positive environmental impacts in addition to the carbon dioxide avoidance, in particular the mitigation of coastal erosion and flooding risk, and the avoidance of flooding damage costs in the Severnside Region;
- the reduction in the cost of capital stemming from the emergence of project finance as the mainstream route for funding major infrastructure projects;
- the Project can potentially demonstrate a surplus of benefits over costs, once its positive externalities are taken into account.

It is therefore concluded that a re-appraisal of the Project is justified and it is recommended that further study of the specific areas identified in the report is put in hand.

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1. INTRODUCTION

The Severn Estuary possesses the second highest tide range in the world, an enormous source of fully predictable renewable energy, which presents the opportunity and challenge to both British engineering and the UK Government to develop the Severn Barrage Project. This substantial infrastructure project would not only provide a very significant carbon-free electricity generation capability for this century and beyond, but would also trigger other sustainability benefits including protection from flooding due to sea level rises of a considerable length of the Severn Estuary coastline and the provision of another fixed crossing of the estuary.

The last studies of the Project were undertaken by the Severn Tidal Power Group[3] at the request of the Government because of concerns in regard to security of electricity supplies caused by the oil price rise in the 1970s, the miners' strike in 1983-84 and the Chernobyl catastrophe in 1986. They built on the results of the Bondi Committee[4] which had examined the broader issues of the Project and had compared different alignments for a barrage. They were completed just prior to privatisation of the UK electricity industry and were reported in 1989 as Energy Paper 57[5].

The objectives of the studies were to:

- reduce uncertainty of costs and performance;
- examine further the regional and environmental effects;
- re-assess the economic viability;
- collect and collate information on the legal aspects;
- examine the organisational and financial aspects of project implementation.

They were funded equally by the Department of Energy, the CEGB and STPG and hence are referred to as the 'tripartite studies'. The principal conclusions are attached as Appendix A.

The ebb-generation scheme developed in the studies, which includes reverse pumping at high tide to increase the amount of water available in the basin, would maximise output to meet base-load demand at a cost (1988 values) comparable with coal-fired generation. It proposed a barrage from Lavernock Point, near Cardiff, on the Welsh shore to Brean Down, near Weston super Mare, on the English shore having an installed capacity of 8640MW. (Figure 1.1).

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[3] The members of the Severn Tidal Power Group are:
Sir Robert McAlpine Ltd
Balfour Beatty Major Projects
ALSTOM Power UK Ltd
Rolls Royce plc
Taylor Woodrow Construction Ltd
Carillion plc.

[4] "Tidal Power from the Severn Estuary" - Volume 1:Energy Paper 46; HMSO 1981

[5] 'The Severn Barrage Project: General Report': Energy Paper 57; HMSO 1989

Figure 1.1: Location of the Severn Barrage

It would generate an estimated average 17,000 million kWh (17TWh) annually, equivalent to some 6% of the present electricity demand of England and Wales. The Barrage has a planned life of at least 120 years.

The Project is much more than a very large renewable energy power station, however, and as a major infrastructure project it would trigger significant wider social and economic benefits which satisfy the Government's policy objectives in other areas, including mitigation of some of the likely consequences of climate change.

Renewed interest in the Project has been generated because of the contribution it could make to cutting the UK's emissions of greenhouse gases and the protection the Barrage would provide to areas at risk from flooding in the Severnside Region.

There have been many changes since 1989 that could affect the viability of the Project including:

- privatisation of the electricity supply industry;
- Government's energy policy;
- attitudes to the environment in terms of both conservation and climate change;
- the transport infrastructure in the Severnside Region;
- the way major infrastructure projects are financed.

A new appraisal of the Project has therefore been proposed by STPG to take into account these changed and changing circumstances.

In order to determine whether such an appraisal of the Project is justified, this Definition Study was commissioned by the Department of Trade & Industry Sustainable Energy Policy Unit as part of its New and Renewable Energy Programme. It considers the issues arising from changes since the last studies of the Project were completed in 1989 and reported in Energy Paper 57. The work has been managed by Sir Robert McAlpine Ltd on behalf of the Severn Tidal Power Group.

The objectives of the study are:

- to identify the changed and changing circumstances since the last studies of the Severn Barrage were completed;

- to identify the issues arising from the changed and changing circumstances that may affect the viability of the Project;
- to form a view as to whether a new appraisal of the Project is justified;
- identify issues where further study is recommended.

In the sections that follow, Chapters 2, 3 and 4, discuss the changes in the key areas of the UK electricity market, the environment and the transport infrastructure of the Severnside Region. Chapter 5 addresses the economic evaluation issues relevant to the Project, including the socio-economic case for the Barrage Chapter 6 examines issues for the advancement of the Project.

This definition study has also informed the Performance and Innovation Unit of the Cabinet Office (PIU) in its review of UK energy policy[6].

[6] "Renewable Energy - Further Note", Performance and Innovation Unit, PIU Energy Review, Cabinet Office, August 2001.

2 ELECTRICITY MARKET ISSUES

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2.1 Changes Since the Tripartite Studies

The tripartite studies were initiated when the electricity industry was a monopoly public sector utility. Generating plant was brought on-stream according to a pre-determined merit order and the price of electricity was fixed according to a shopping-list of tariffs which varied with the time of day and degree of interruption acceptable to the consumer.

Privatisation of the UK electricity industry occurred towards the end of the tripartite studies. It had two significant effects on the electricity market:

- the burning of gas for power generation and the ensuing "dash for gas";
- the major changes in the way electricity is traded, firstly through the Pool mechanism and more recently by the introduction of the New Electricity Trading Arrangements,

both of which have encouraged greater competition and resulted in lower prices.

The other significant change affecting the electricity market has been the growing recognition of the effects of global warming and of the need to reduce emissions of the greenhouse gases. The UK Government has taken a leading role in implementing the Kyoto Protocol and has introduced policies to encourage investment in renewable energy technologies.

The effect of these changes on the viability of the Barrage is discussed below.

2.2 Diversity and Security of Supply

2.2.1 Fuel Sources for Electricity Generation

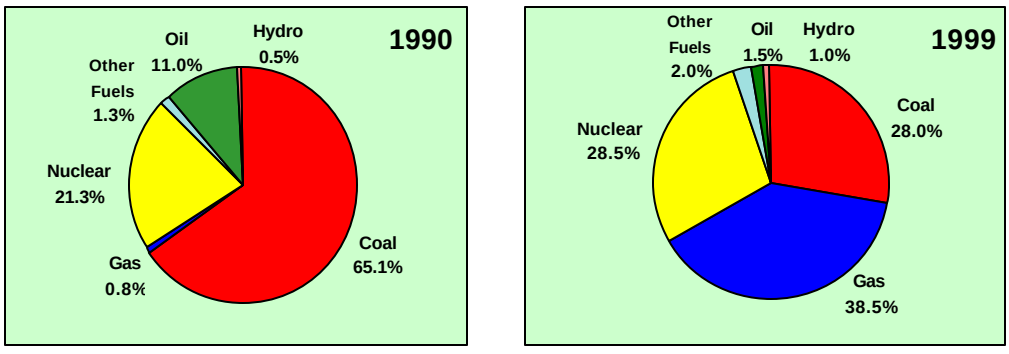

Figure 2.1 Fuel Sources for Power Generation

Figure 2.1 indicates the growth of gas for electricity generation between the end of the tripartite studies and 1999 (last statistics available) [7].

[7] Digest of UK Energy Statistics 2000 - DTI

Recent announcements by the Government in regard to Section 36 Consents for new CCGTs will probably mean that by 2005 over 50% of the UK's electricity will use gas as the primary energy source. The Government predicts that by 2006 the UK could be a net importer of gas[8] and by 2020 it could be importing between 55% and 90% of its gas needs. Furthermore, most of its nuclear stations could be shut down by 2020 leading to a possible greater reliance on gas as the primary fuel source for electricity generation.

2.2.2 Barrage Contribution to Diversity and Security of Supply

Tidal power is fully predictable and highly reliable as demonstrated by 35 years of successful operation of the 240MW La Rance Barrage near St Malo. The Severn Barrage could generate annually 6% of the electricity demand of England and Wales from an installed capacity of 8640 MW and would therefore add to diversity of supplies.

Security of electricity supplies has been a major driver in the development of the Severn Barrage Project in the past, in particular the vulnerability of the UK to a reliance on fuel sources subject to sudden variations in price and availability.

The generation scheme recommended in EP 57 was estimated to make a contribution to firm capacity of 1.1GW. Our discussions with the National Grid Company plc included the potential benefits both to firm capacity and to security of supply of a more flexible operating regime.

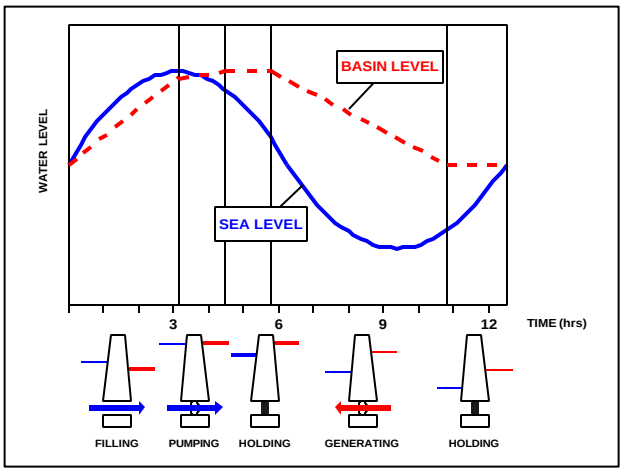

Figure 2.2 Barrage Operating Regime

Figure 2.2 indicates the operating regime developed in the tripartite studies to yield the maximum output at optimum cost. The cycle starts on the flood tide when the sluices are opened and the basin fills as the tide rises. Just before high tide, the sluices are closed and the turbines are operated in pumping mode

[8] Energy Policy Project Scoping Note, Performance and Innovation Unit, Cabinet Office June 2001.

to force more water into the basin. Pumping is stopped as the tide starts to fall quickly and when the differential head between the basin level and the sea level outside the Barrage is sufficient to enable efficient generation, the turbines are started and the water flows out, generating electricity. When the differential head between the basin level and sea level outside the Barrage is insufficient for further generation, the turbines are shut down and the sluices remain closed until the next rising tide.

Figure 2.3 indicates the electrical output from Mean Neap and Spring Tides for the Barrage operating in this way compared with the typical winter electricity demand of England and Wales and the base load electricity supplied by nuclear, gas and imports[9].

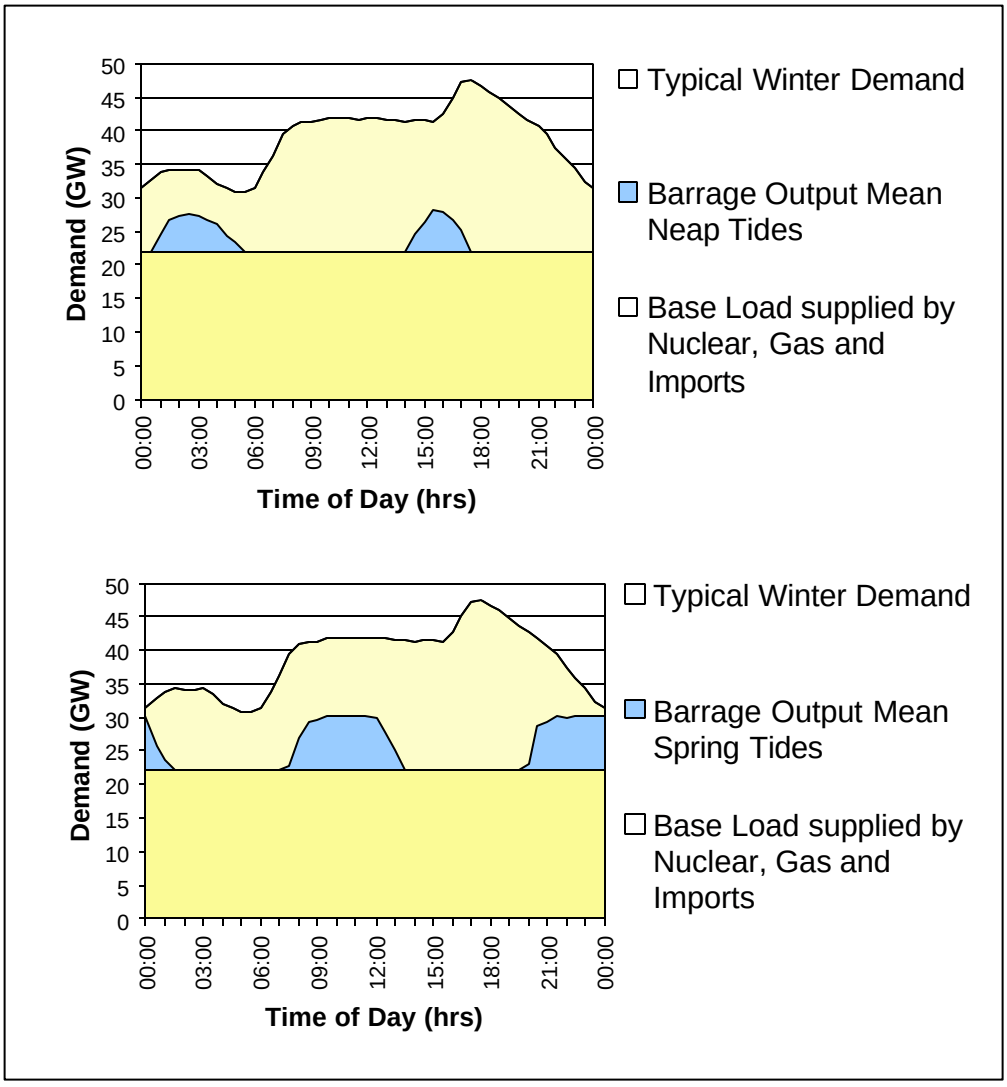

Figure 2.3 Barrage Output for Mean Neap and Spring Tides compared with Typical Winter Demand and Base Load typically supplied by nuclear, gas and imports.

[9] Demand curves kindly supplied by National Grid Company plc

The study has addressed two ways of improving the contribution to security of supplies from the Barrage:

- the simplest modification would be to vary the time of the start of generation within the 6-7 hour window of each tidal cycle. This would have the greatest effect for lower range tides because there is then more plant available than is needed to harness the energy potential of those tides.
- A more complex solution would be to form a second basin in deep water adjacent to the main Barrage to serve as a low level reservoir with generating plant linked either to the sea or to the main basin, or to both. The Bondi Committee[10] studies included possible two-basin designs and whether such arrangements could produce a regular daytime output. Although the merits of this latter option and its wider implications do not appear to have been investigated since, the information needed to do so is available.

Flexibility of Output

One of the factors determining the value of the electricity generated from the Severn Barrage is the timing of the tides in the estuary. (See Figure 2.4).

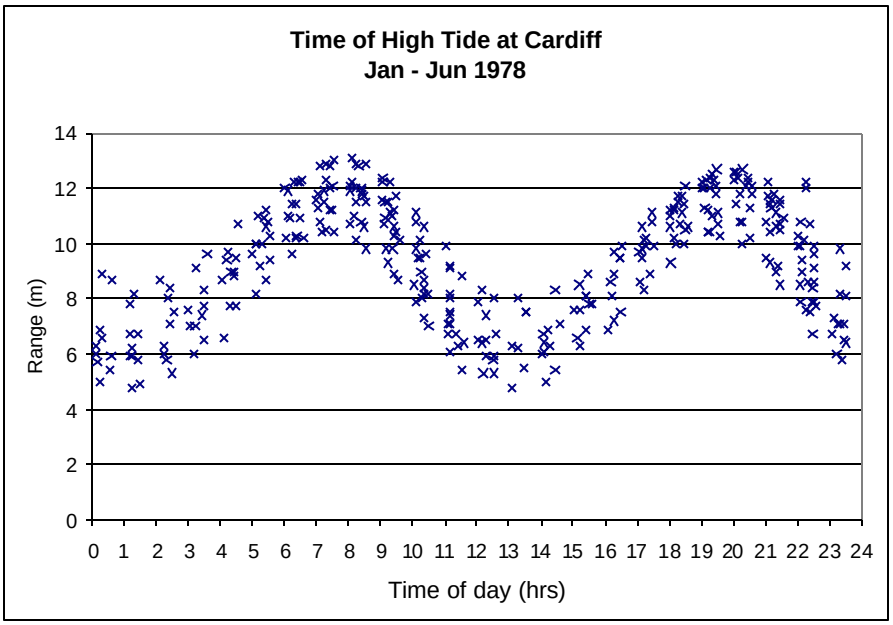

Figure 2.4 Variation in Spring and Neap Tides for the Severn Estuary

It may not be generally appreciated that in the Severn Estuary the times of high water on the higher Spring tides lie within the period from 0600-0900 and from 1830-2130, and for the lower Neap tides from 0000-0300 and 1130-1430. Altering the start of generation following high tide, either by bringing the start forward or by delaying it would allow greater flexibility to supply power for non-base load demand.

[10] "Tidal Power form the Severn Estuary" – Volume 1: Energy Paper 46; HMSO 1981

An exploratory investigation, as part of this study, has been undertaken by Shawater Ltd into whether such a change to the EP57 operating regime, which in general assumes start of generation some 2 to 3 hours after high tide, would significantly reduce the electrical output from the Barrage. Operational solutions ranging from using less of the full generating capacity over more of the possible generating period to using more capacity for a lesser period within that available for generation have been examined. The investigation shows that operating flexibility improves with decreasing tide range and does not appear to seriously prejudice the amount of energy produced per tide cycle. The results are sufficiently encouraging to warrant further study. Figure 2.5 demonstrates the flexibility of output possible by changing the start time of generation following high tide.

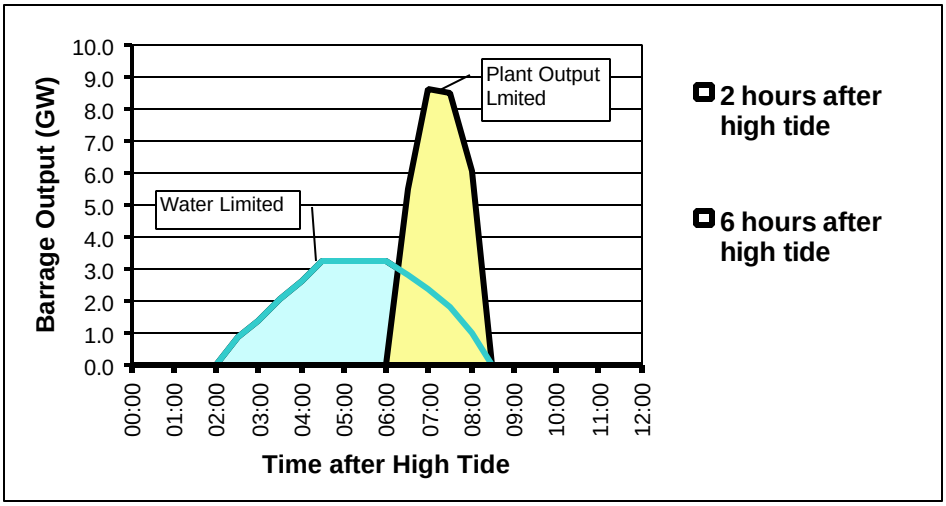

Figure 2.5 Flexibility of Barrage Output by Varying the Start of Generation (Mean Neap Tide)

The worth of the loss of some generating output for greater flexibility in the timing of the output can only be judged with full knowledge of the variations in the market price for electricity. NETA went "live" on 29th March 2001 and therefore, following such a short period of operation, there is no knowledge of how UK electricity prices may compare in the future. However the current output-weighted price is considerably higher than the time- weighted price[11].

The other and most important qualification to modifying the Barrage operating regime from that reported in EP57 is that no work has been undertaken of the environmental consequences of such modifications.

[11] "The New Electricity Trading Arrangements – A review of the first three months" OFGEM, August 2001.

Storage

At the present time, there is a surplus of generating capacity and the need for electricity storage to ensure grid stability and meet high peak demand is managed by the NGC through the NETA Balancing Mechanism. The only "storage" of electrical energy in England and Wales, as opposed to storage of the energy source itself such as distillate fuel for gas turbines, is in the high head pump storage schemes at Dinorwig and Ffestiniog. A "black-start" capability is being constructed at Little Barford as a demonstration scheme for the new "Regenesys" chemical storage system being developed by Innogy plc. However, the conversion from electrical energy to a different form of energy to be reconverted to electrical energy at a later date carries a cost penalty due to the overall loss of efficiency.

The "system" storage capability represented by Dinorwig and Ffestiniog (some 2GW capacity) has been completely adequate for the present market which is supplied mostly by reliable and predictable generating plant. However, if a greater reliance is to be placed in the future on relatively unpredictable and less reliable sources of renewable energy, either a greater capacity of system storage may be needed or, alternatively, individual generating plant will need its own storage. In the latter case, the electricity "retrieved" from storage will be at a higher price than when first generated and must be taken into account in comparing the overall economics of conversion of the original energy source.

A low head pump storage capability of (say) 1.5 to 2GW to enhance the system storage could be constructed integral to the Barrage which would be capable of generating at any stage of the tide. Because it would make use of some of the Barrage structure it would be more cost effective than other tidal power storage schemes.

However, the decision as to whether or not to proceed with such a storage system can only be made once the likely changes to the present generation mix have been identified and the extent and merits of any additional system storage is known. A storage system integral to the Barrage could probably be added at a later date following commissioning of the scheme. We understand that the NGC is undertaking a study of the risk from intermittency and the need for increased storage capacity as input to the PIU energy review.

2.3 UK Electricity Market

2.3.1 Electricity Trading Arrangements

Privatisation of the ESI introduced competition within the industry through changes in the way electricity was traded. The Pool mechanism introduced with privatisation was successful in reducing prices, from over £35/MWh in 1990 to £24/MWh in 2000, partly through the influence of the lower prices from the gas-fired generators, but also because outstanding capital debt on

existing coal and nuclear generating plant was not transferred at the time of privatisation and the new owners were operating at marginal cost.

The New Electricity Trading Arrangements, have created a commodity market requiring prediction in a forward bilateral market of both supply and demand. A balancing mechanism allows the real time demand to be met and electricity traded in this market can attract a premium. The aim is to increase competition and to involve the demand side in setting prices. It favours predictable electricity sources and those able to meet fluctuating demand. NETA therefore fundamentally alters the way the electricity market operates. Following its first few months of operation, electricity has been trading below £20/MWh for base load supply and the offers in the futures market are currently as low as £17/MWh[12] .

The introduction of NETA should enable the cyclic output from the Barrage to be more easily absorbed in the market. Because the electrical output from the Barrage is fully predictable it can be sold in forward markets. However, the ability of the Barrage turbine-generators to meet a fluctuating demand and also provide a peak lopping capability would also enable it to compete in the balancing mechanism.

If the Severn Barrage were to enter the market now, and assuming, for example, that 50% of its output was traded at £20/MWh, 30% at £30/MWh and 20% @ £40/MWh the output-weighted average price for its electricity would be some £27/MWh. This compares with electricity prices of £40/MWh-£50/MWh in 1989.

2.3.2 Impact of the Barrage on the Market

Concern was expressed by some of those consulted in the preparation of this report that because the energy source is free and fully predictable, it will always be better to generate from the Severn Barrage than not. Entry of Barrage power to the electricity market could therefore lead to its distortion and it was suggested that because of the large size of the Barrage output (8.6GW) it may be necessary to ring-fence Barrage electricity.

2.3.3 Grid Strengthening

The tripartite studies examined the extent to which the national grid 400kV transmission system would need to be reinforced to absorb Barrage power, based on predictions of likely power demand in 2000.

The recent closure of Hinkley Point A power station (475MW) and the possible closure of Oldbury power station (440 MW) before 2010 will create a sizeable gap in the electricity supplies of South West England. The closure of the Hinkley Point B power station (1327MW) which will be 40 years old in

[12] "The New Electricity Trading Arrangements – A review of the first three months" OFGEM, August 2001.

2016 could further exacerbate the security of the grid in the South West unless a replacement is planned.

Discussions with the NGC concluded that it is not possible to identify what strengthening may be needed in the future - there are so many variables in the analysis, which has to extend far beyond the current Seven Year Statement planning horizon. Furthermore, although the Barrage would itself not be considered an embedded generation project, the current debate[13] on the potential financial barriers to such projects if they are charged with the full reinforcement costs raises the question of the appropriate allocation of such reinforcement costs to the Barrage, both initially and in the long term.

A further consideration is the 2000MW European connector. At present the flow is almost entirely into the UK. When the European electricity market is opened-up to UK suppliers, reversing the flow through the connector would contribute a swing of 4GW in net demand. NGC confirmed that there are no theoretical barriers to prevent export of Barrage electricity through the interconnector.

2.3.4 Timing of Entry to the Market

Because of the impact Barrage power could have on the electricity market, the timing of its entry into this market may need to be linked to the planned closure of those elements of existing generation capacity which it would replace.

Barrage electricity should be treated as displacing domestic coal-fired generation, since this offers the same security of supply. The carbon offset benefit is therefore much larger than for the average generation portfolio.

The age profile of the UK's generating capacity indicates that the majority of major coal-fired power stations, representing some 45% of total installed capacity[14], were commissioned between 1966 (Ferrybridge) and 1974 (Drax).

There is no reliable means of predicting when existing plant will become uneconomic, but Phase I of Drax, the UK's most modern coal-fired power station, will be 40 years old in 2014.

In the foreseeable future, the best "window of opportunity" for entry of Severn Barrage power to the market would appear to be between 2012 and 2020. This timescale coincides with the time needed for the enabling legislation for the Barrage to be put in place, preparation of an appropriate environmental assessment and construction and commissioning of the power station were the Project to proceed within the next few years.

[13] Embedded Working Group Report: Dept of Trade and Industry, January 2001.
[14] Electricity Industry Review 4

2.4 The Renewables Obligation

As part of its commitment to the Kyoto Protocol, the Government has set targets for electricity generated from renewable sources. To encourage investment in suitable technologies to achieve this target, the Government has introduced the Renewables Obligation under the Utilities Act 2000, which requires Public Electricity Supply companies to provide 10% of electricity from renewable sources by 2010 or pay a penalty – proposed as £30/MWh. The Obligation is planned to run to 2027.

The Renewables Obligation gives strong support to the development of renewable energy projects and enables the development of a market which values electricity from such sources.

Unfortunately, the timescale required for the development of the Barrage (see Chapter 5) means it is unable to contribute to the initial target. However, Government has indicated that this target may be increased in the future[15]. Doubling the size of the Obligation would require a further 29-33TWh pa from renewable sources and would introduce more favourable conditions for the development of the Project which, if sanctioned, could contribute 17TWh pa to the revised target by 2015.

2.5 Optimum Generating Capability for the Severn Barrage

The renewed interest in the Severn Barrage Project is not only because of the contribution it could make to the Government's targets for renewable energy, but also stems from the project's other benefits including: reduction in carbon emissions; protection against flooding and coastal erosion aggravated by rising sea levels; stimulation of job creation; and encouragement of tourism.

The further development of the Project will therefore need to take into account these other benefits and it will be necessary to reconcile the conflicting interests of the principal stakeholders, namely:

- investors will take a short term view (relative to the 120-year minimum life of the Barrage) and require that the revenue is maximised in order to repay the construction debt as soon as practicable;
- Government will take a long term view which seeks to maximise carbon emission savings, alleviate flood risk and secure the best socio-economic benefits;
- the electricity market will require flexibility of output, reliability, predictability and contribution to security and diversity of supplies to counteract the effect of intermittent sources of generation which are expected to form a greater part of UK electricity supplies.

[15] "Wilson Predicts 2002 will be 'The Year of Renewables'." DTI Press Release P/2002/004 – 4th January 2002.

The generation scheme developed in the tripartite studies for a Barrage on the Cardiff - Weston super Mare alignment would maximise output at the most economic cost. Because the Barrage has a very long life it is concluded that short-term considerations should not be allowed to determine the design of the Project and the scheme reported in EP57 is thought to remain the most appropriate basis for its development.

2.6 Conclusions and Recommendations for further study for Electricity Market Issues

1. The principal changes since EP57 stem from the privatisation of the Electricity Supply Industry in 1990. Natural gas was allowed to be burnt for electricity generation and the ensuing "dash for gas" displaced some 50% of coal and most of the oil-fired generating capacity of the UK. It is predicted that by 2005 more than 50% of the UK's electricity will be generated from gas, which will be increasingly reliant on Eastern European sources of supply.

2. Privatisation introduced competition, and thus falling prices, in the electricity market with electricity being traded through the Pool mechanism. In March 2001, the market was made more competitive by the introduction of the New Electricity Trading Arrangements which established a commodity market for electricity. This new market would appear to be more favourable to the Barrage which can take advantage of the predictability of its supply.

3. The fuel sources for electricity generation have been balanced over the past ten years between coal, gas and nuclear, ensuring both diversity and security of supply. The possible closure of the nuclear plants over the next 10-20 years, the emergence of a growing capacity from renewable sources, many of which may be intermittent in nature, and a reliance on imported gas for much of the UK's electricity supplies have led to renewed concerns in regard to security and diversity of UK electricity supplies. There is a growing recognition of the contribution that could be made by the Barrage in supplying some 6% of the demand of England and Wales from a fully predictable renewable source.

4. The Government has played a leading role in the adoption of the Kyoto Protocol for a world-wide reduction of carbon emissions and has included targets for renewable energy as part of its energy policy. The publication of the 22nd report of the Royal Commission on Environmental Pollution in June 2000 recommended much larger cuts in CO_2 emissions by the middle of the century and included the Barrage as an option for achieving this, thereby reviving Government's interest in the Project.

5. The Renewables Obligation gives strong support to the development of renewable energy projects. The earliest date that Barrage electricity could be available is approximately 2012 with full power by 2014 and is therefore unable to contribute to the original target of 10% of electricity by 2010. However, the Government has indicated that this target may be increased in

the future. Doubling the size of the Obligation would require a further 29-33TWh pa from renewable sources and would introduce more favourable conditions for the development of the Barrage which, if sanctioned could contribute 17TWh pa to the revised target by 2015.

6. The generation scheme on the Cardiff – Weston super Mare alignment reported in EP57 remains the most appropriate basis for the further development of the Severn Barrage Project. Its contribution to firm capacity could be improved by varying the start time of generation and/or the provision of a low head pump storage capability integral with the Barrage.

7. The age profile of the UK's generating stock indicates that a "window of opportunity" exists for entry of Severn Barrage power to the market between 2012 and 2020.

8. The allocation of the cost of grid reinforcement requires examination in the light of the concern that these costs are perceived as a barrier to development of large generation projects.

9. Recommendations for further study:

Recommendation 1: The cost-benefit and environmental impact of varying the start time of generation within the tidal cycle should be examined. Updating the energy capture computer model developed for STPG by Binnie and Partners would assist this task.

Recommendation 2: The requirement, feasibility and cost-benefit of providing a low-head storage facility integral to the Barrage to augment the present system storage facilities at Dinorwic and Ffestiniog should be investigated.

Recommendation 3: The issues of grid reinforcement, the advantages of flexibility of output from the Barrage and the contribution it could make to firm capacity and security of supplies should be discussed further with the National Grid Company plc.

CHAPTER 3 ENVIRONMENTAL ISSUES

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3.1 Changing Attitudes

The recent heightening of attention for the need to implement the Kyoto Protocol, in which the UK Government has taken a leading role, has focused public debate on the implications of the long-term environmental changes that are taking place. International pressure for a shift to zero carbon energy life-styles is reflected in the everyday advertising of popular commodities such as cars and domestic goods that generate less pollution, consume less energy, produce less waste, etc. Predictions of changes in world climate are emphasised for the public through direct contact with the effects of increased risks of flooding and gales, and indirectly through more distant effects such as severe droughts and loss of coral reefs.

In this situation it is to be expected that there will be enhanced public support for the principles of sustainability. This change in attitude since the tripartite studies and the reawakening of interest in the Severn Barrage Project created by the RCEP report and by the PIU Energy Review can be expected to exert a considerable influence on public perception of the overall effects of the Project.

The effects of rising sea level resulting from atmospheric warming and initial consideration of its implications for the design of the Severn Barrage were addressed in EP57 together with the consequences for annual energy output. The report also discussed how the presence of the Barrage would add protection to the 140 mile coastline of the basin above the Barrage and thereby mitigate the economic, environmental and social consequences which could arise from higher tides and storm surges in the estuary.

This chapter discusses how these changed attitudes affect the viability of the Project in terms of the impact on local, regional and global issues and whether the benefits of development have improved or decreased since the EP57 Report.

3.2 Greenhouse Gas Emissions

The UK Government's commitment to reducing greenhouse gas emissions, the RCEP's recommendation for much larger cuts in CO_2 by the middle of the century and its recommendation that tidal power be kept under review have placed a greater emphasis on the contribution to the avoidance of carbon dioxide emissions that could be made by the Project compared with attitudes at the time of the EP57 report.

The estimated average annual output of electricity generated by the Barrage for the scheme reported in EP57 is 17TWh (17,000 million kWh). Compared with coal-fired generation, which emits some 270g of carbon for each kWh generated, electricity from the Barrage would avoid the emission of approximately 18 million tonnes of carbon dioxide (4.6 million tonnes of carbon) per year. Compared with gas-fired generation (180kgC/ kWh) the annual saving would be some 12 million tonnes of carbon dioxide (3.1 million tonnes carbon).

The UK currently discharges to the atmosphere approximately 150 million tonnes of carbon annually from all sources [16]. By generating electricity from the tides in the Severn Estuary the Barrage could reduce these emissions by about 3%.

The Government has made a commitment as part of a parcel of measures agreed within the European Union to reduce the UK's greenhouse gas emissions by 12% from 1990 levels by 2012. Because of the timescale needed for the implementation of the Project, power from the Barrage is unable to contribute initially towards this target. However, because of its extremely long life, if constructed the Barrage would make a significant contribution to ensuring that the reduced level of emissions likely to be achieved by 2012 could be sustained. The RCEP recommendation for much larger cuts in CO_2 emissions by the middle of the century is being examined in the PIU's Energy Policy Review.

The Government's sustainability policy includes targets of 10% electricity generation from renewable sources by 2010 and 25% by 2020[17]. The Renewables Obligation introduced to encourage investment to meet the first target is scheduled to come into effect at the end of March 2002. The favourable effect on the development of the Project of a possible extension of the Obligation has been discussed in Section 2.4 of this Report.

3.3 Conservation

3.3.1 The Legacy of the Tripartite Studies

The database of environmental information collected during the tripartite studies provided much valuable information about the ecology of the Severn Estuary. The predicted changes that would be brought about by the construction and operation of the Barrage, as reported in EP57, would appear to be generally accepted as a reasonable estimate.

The diverse range of this environmental research and the further information obtained since 1989 has led to a significant advancement of knowledge of ecological features associated with the Severn Estuary that has enabled key conservation issues to be specified. The research has also allowed a better understanding of the ecosystems associated with the estuary, the regimes within which they exist and the measures needed for their protection.

It is unlikely that the new information now available will be sufficient to permit the questions unanswered in EP57 to be resolved. Rather, it will help to narrow down and define what remains to be done. A summary of this new data is included as Appendix B.

[16] Digest of UK Energy Statistics 2000: Stationery Office
[17] "In Trust for Tomorrow" Report of the Labour Party Policy Commission on the Environment, 1994.

3.3.2 Conservation Objectives

New environmental legislation introduced in the 1990s (see Appendix C) has formalised expectations of the environmental assessment of the Project, and the work undertaken in defining the conservation objectives of the various Directives applicable to the Severn Estuary since 1989 has brought a better understanding of the ecosystems that are most likely to be affected. However, the data are dispersed amongst several bodies, including the Environment Agency, the Countryside Council for Wales, English Nature and the National Assembly for Wales, none of which existed in its present form when EP57 was prepared.

The Habitats Directives and the Ramsar Convention currently represent the principal ecological legislative structure within which the project would be assessed. To these have been added the revised Environmental Impact Assessment Regulations (97/11/EC) and will shortly include the Water Framework Directive (2000/60/EC). The content of this latter Directive is generally expected to constitute the main plank for both the Project's future evaluation as well as the identification and assessment of the means of mitigating any adverse effects or, where practical, any proposed compensatory measures.

The shoreline management plans currently proposed include "set-back" as the preferred management option for approximately two-thirds of the 90 cells of the Severn Estuary Shoreline Management Plan, (see Appendix B). In the absence of the Barrage it is predicted that climate change will greatly increase the rate of coastal erosion, which, in turn, will result in the loss of valuable habitats. It is this prediction of habitat loss without the Barrage that should form the baseline when assessing the impact of the "with Barrage" case. Recent evidence which will assist in this regard includes the National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England and Wales (DEFRA, 2001), DETR's Climate Change and UK Nature Conservation Report[18] and the British Trust for Ornithology paper[19] outlining possible reasons for the falling numbers of over-wintering wading birds in the Severn Estuary and an increase in observed numbers on estuaries along the East Coast.

3.3.3 Impact of Barrage on Conservation Objectives

If constructed, the Barrage would alter the nature of the estuary. It may cause some habitats to be changed, but it will provide protection to others that would otherwise be destroyed if the causes of climate change are not remedied.

Any further development of the Project will therefore require an understanding of the impact of construction and operation of the Barrage in regard to which habitats would be preserved that may otherwise be destroyed, which may be

[18] "Climate Change and UK Nature Conservation" ADAS for DETR, October 2000

[19] "Regional trends in coastal wintering waders in Britain", G E Austin, I Peachel & M M Rehfisch, Bird Study (2000) Vol 47, 352-371.

changed and to what extent, and whether new ones will and/or could be created and with what consequences.

Compared with the position at the end of the tripartite studies, the better understanding of the conservation objectives together with the better state of knowledge about the estuary enables measures to be incorporated in the design and operation of the Project that avoid or offset perceived adverse effects.

It should be noted, however, that within the basin formed by the Barrage the hyper-tidal nature of the estuary would alter significantly and no measures to compensate for the loss of this particular feature could be engineered.

Letters from The Environment Agency Wales, on behalf of the Environment Agency, and the Countryside Council for Wales, on behalf of English Nature, containing recommendations for the environmental issues to be addressed in the further development of the Project are attached as Appendix D.

3.3.4 Proposed Special Area of Conservation Designation for the Severn Estuary

The European Habitats Directive puts a different perspective on conservation objectives than envisaged at the time of the tripartite studies and STPG has formally recorded its objection to the proposed SAC designation for the Severn Estuary, albeit with some reluctance. This objection is principally because of the absence of a proper analysis of the issues raised by the proposed SAC designation. Requirements in relation to the Habitats Directive continue to evolve, both at National and European level and many issues remain unclear.

3.4 Coastal Protection and Flood Alleviation

Flooding of parts of the hinterland of the Severn Estuary has long been a serious social and economic cost. The Wentlooge and Somerset levels, for example, have had to contend with inundation for many centuries, and it is an established feature of the rivers discharging to the estuary, both within and above the limits of tidal influence.

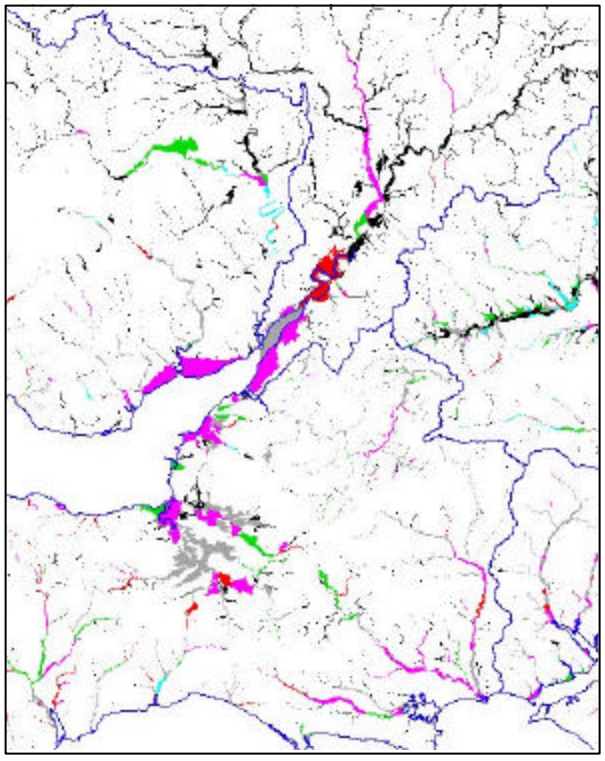
Recent years have brought more regular flooding events throughout the UK and in many other countries. The DEFRA report[20] was prompted by widespread appreciation that direct and concerted action is needed to counter what otherwise promises to become an ever more serious social problem.

The projections of tide levels throughout the Severn Estuary and Bristol Channel reported in EP57 suggest that the Barrage would reduce highest levels on both the seaward and landward sides of the structure. With the exception of part of the coast of the Somerset Levels, little of the coastline

[20] "National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England and Wales" DEFRA, September 2001.

which lies to seaward of the Barrage is at risk from sea level rise, although the predicted reduction in the highest tides may afford protection to the tidal reaches of rivers such as the Parrett which discharges to Bridgwater Bay. Landward of the Barrage some 140 miles of coastline will be afforded protection from sea level rise, high tides and more frequent storm surges which are expected as a consequence of global warming.

The Barrage would also have a significant influence on the flood risk within those lengths of the waterways landward of the Barrage where the tidal process is a factor in determining water levels, in particular when river flows are high. For example, the effects of the tide on river levels are felt upstream of the weirs on the River Severn at Gloucester. This influence is of increasing importance having regard to the density of population and the value of infrastructure involved. Because the Barrage provides the capability to manage water levels in the basin, the opportunity exists to ensure that any effect of the tide on river levels at times of high river flows is controlled and the risk of fluvial flooding lessened. In such circumstances, management of the operation of the Barrage will need to be a careful balance between the needs of flood protection and the generation of electricity.



Reproduced from Figure 3b, National Appraisal of Assets at Risk from Flooding and Coastal Erosion, including the potential impact of climate change. Final Report, July 2001:DEFRA

Figure 3.1 Comparison of Assigned and Indicative Flood Defence Standards in the Severnside Region

Figure 3.1, reproduced from the DEFRA report identifies areas of the Severnside Region where the flood defence standards are below the indicative standard. The area of urban development and high grade agricultural land at

risk has been estimated as some 40,000ha. The DEFRA report estimates the current annual average damage cost associated with this risk as £1,000-£5,000/ha and expects this to increase by at least 100-fold by 2075 as a result of climate change. This annual average flooding damage cost risk, which currently totals £40-200M pa is expected rise due to climate change to at least £4,000M pa by 2075. This annual flooding damage cost risk and the associated capital expenditure costs to improve flood defences would be avoided if the Barrage were constructed.

3.5 Appropriate Environmental Assessment

There appears to be a general presumption under both the Environmental Impact Assessment Regulations and the Habitats Regulations that developers will be required to provide mitigation for any significant environmental impacts. The nature and scale of the Project suggest that there may be an anticipation that such impacts will be considerable.

It is essential, therefore, that a consensus view of the overall framework for an appropriate environmental assessment of the Project is established between all interested parties. In view of the proposed SAC status of the estuary, it is probable that the starting point for such a consensus will be a demonstration that for reasons of over-riding public interest no other project for generating such a large quantity of electricity from a fully predictable renewable energy source would meet so many of the Government's other policy objectives. These include:

- contribution to sustainable development;
- climate change benefits;
- alleviation of flooding;
- job creation and provision of employment;
- boost to tourism;
- contribution to rural development.

In such circumstances, under the Habitats Regulations, the relevant Secretary of State is required to ensure that the overall coherence of Natura 2000 [21] is protected.

EU legislation introduced in 1997 (97/11/EC) requires an Environmental Assessment to be carried out in depth. The diverse implications of the project, which include consideration of migratory birds over-wintering on the mudflats, ensuring that fish can pass through the Barrage, the substantial contribution the Project would make to reducing the UK's carbon emissions, job creation in the disadvantaged areas of the Severnside Region, flood alleviation and coastal protection to a large part of the estuary, must all be taken into account in the interpretation of the overall position.

[21] The European network of Special Protection Areas and Special Areas of Conservation.

3.6 Sustainable Development

The concept of Sustainable Development has become increasingly relevant to decision making processes since the tripartite studies, particularly in regard to the wise use of valuable resources and avoidance of the discharge of harmful pollutants. UK Government policies embrace sustainability through the Sustainable Development Strategy (1999) and the Welsh Assembly has adopted a policy which aims to ensure that projects are designed, built and operated such that the objectives of sustainable development are maximised.

The changed attitudes to sustainable development since 1989 are epitomised in the Severnside Region by the waterfront developments that have regenerated areas of Cardiff, Bristol and Gloucester. However, a new threat to the prosperity of the area has emerged recently with the announcement by Corus of the closure of some of the steel making plants in South Wales.

The Barrage is recognised as a major infrastructure project. The more placid sea-state and improved water quality in the basin are expected to bring further socio-economic benefits to the Severnside Region than envisaged in 1989 through increased tourism, job-creation, inward investment and improved land and property values.

The impact of the development of the Project on the UK's commitment to reducing CO_2 emissions would be considerable and it is thought that no other source of renewable energy has the scale, reliability and predictability of tidal power from the Severn Estuary, nor make the same contribution to security and diversity of supplies from a single project.

The largest wind farm in Europe planned to date is the recently announced 600MW Isle of Lewis scheme with 300 wind turbines. Another ten similar schemes would be required, depending on location, to generate the same annual output as the Barrage. In unveiling the plans for the wind farm project[22], the Energy Minister, Brian Wilson MP, cited the long term investment for the local community and job creation as the benefits that would result. In the case of the Barrage, EP57 reports an estimated 35,000 jobs at peak for its construction, many away from the Barrage site in the manufacturing regions of the UK, and an estimated 30,000 new jobs in the Severnside Region on its completion.

3.7 Conclusions and Recommendations for Further Study for Environmental Issues

1. The greater emphasis since the publication of EP57 of the need for development of low and zero carbon technologies puts a more positive value on the avoidance of the emissions of carbon dioxide attributable to the Project. Compared with coal-fired generation the Barrage would avoid the emission of

[22] DTI Press release P/2001/714, 13th December 2001

18 million tonnes of CO_2, equivalent to some 3% of the UK's carbon emissions from all sources.

2. The recent DEFRA report "National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England and Wales" indicates that many of the flood defences of the Severn Estuary are below the indicative standard, putting an estimated 40,000ha of urban development and high grade agricultural land in the Severnside Region at risk.

3. Construction of the Barrage would prevent flooding in these areas thereby avoiding an estimated current average damage cost of £40-200M pa. It would also provide protection against coastal erosion and avoid the need for widespread capital works. Furthermore, management of sea level in the basin above the Barrage at times of high run-off in the rivers discharging into the estuary could lessen the associated fluvial flooding risk further upstream.

4. Conservation objectives in the Severn Estuary have been formalised since the publication of EP 57 and further data is now available which enhances the database of environmental information developed in the tripartite studies. New legislation in regard to Environmental Assessments requires a more rigorous approach than previously. A consensus view of all interested parties of the overall framework for an appropriate EA for the Project is essential. This must take into account the prediction of habitat loss resulting from climate change and the environmental management proposals for the estuary that would occur were the Barrage not to be constructed.

5. The Barrage is recognised as a major infrastructure project. The more placid sea-state and improved water quality in the basin is expected to bring further socio-economic benefits to the Severnside Region compared with the situation at the end of the tripartite studies, through increased tourism, job-creation, inward investment and improved land and property values - particularly in areas where waterfront development is possible. It is thought that local, Regional and National sustainable development objectives may be maximised when compared with other options for generating the same amount of power from renewable energy sources.

6. Recommendations for further study:

Recommendation 4: Further studies should be undertaken to quantify the influence of the Severn Barrage on coastal protection and the mitigation of flooding risk and the effect this would have on the estimated annual flood damage costs in the Region. These studies would include:

(i) flood defence against storm surge and high tides;

(ii) prevention of coastal erosion;

(iii) mitigation of fluvial flooding.

Recommendation 5: The key issues arising from the statutory conservation objectives should be identified, including:

(i) an assessment of the possible effects of climate change on these objectives;

(ii) an assessment of the possible effects of the construction and operation of the Barrage on these objectives to identify any perceived adverse effects and the compensatory measures that may be practicable.

CHAPTER 4 TRANSPORT INFRASTRUCTURE ISSUES

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4.1 Introduction

Significant changes have either occurred or are now foreseen in all of the Transport sector since the tripartite studies were completed, viz:

- Road transport;
- Shipping and ports in the Bristol Channel and Severn Estuary;
- Rail freight and passenger transport;
- Airport development.

4.2 Road Crossing and Links to Motorway Network

The tripartite studies foresaw construction of a service road and a separate public road across the Barrage, providing a link between Somerset/North Devon and South Wales. They envisaged that the public road would be financed and maintained through toll charges and expected that the new crossing of the estuary would stimulate inward investment and the creation of new jobs in the region.

The main changes in the road infrastructure in the Severnside region since the tripartite studies were completed are:

- completion of the Second Severn Road Crossing and its associated link roads;
- the planned M4 Newport By-Pass;
- improvement of main roads in the Penarth and Cardiff Bay region.

The effects of these changes on the Project are not clear. The principal driver for inward investment and job creation predicted in the EP57 report is the improved environment for water-sports and other recreational activities in the basin because of the more benign conditions and improved water quality resulting from operation of the Barrage. It was anticipated that this would stimulate commercial and housing developments with a consequent improvement in land and property values. A road crossing on the Barrage was seen as beneficial to the road transport infrastructure that would be needed to stimulate this investment and to encourage investment West of Cardiff.

Passenger and freight transport needs within the M4/ M5/ A303/ A30/ A38 key transport corridors incorporating the parallel rail routes are currently being addressed in the SWARMMS study[23] which aims to make recommendations for a long term transport strategy for the South West of England. That part of the study dealing with the urban area of Bristol and the Bristol-Exeter transport corridor running parallel to Severnside, will provide valuable information for the assessment of the viability of a public road crossing on the Barrage. The recent traffic modelling study undertaken by the Highways Agency, dealing with the traffic implications of a large-scale development of land between the M49 and the Severn Estuary[24] will also provide a valuable

[23] "London to South West and South Wales Multi- Modal Study" (SWARMMS), GOSW.
[24] "M49 Intermediate Junction Study" W S Atkins for Highways Agency 1998.

reference. Consideration should be given to including a "with Barrage" scenario in these studies.

4.3 Ports and Shipping

4.3.1 The Main Ports

The main ports on which the Barrage would have an influence are:

Upstream of the Barrage,

- Sharpness;
- Royal Portbury and Avonmouth Docks, Bristol;
- Newport;
- Cardiff;

Downstream of the Barrage,

- Barry Docks;
- Port Talbot;
- Swansea.

All the ports are now in private ownership and most have benefited from major investment by the new owners. A review of the present capacity of the ports and the current pattern of trade is attached as Appendix E.

4.3.2 Shipping Locks

The Barrage scheme reported in EP57 included two shipping locks to allow the passage of 70,000dwt (Panamax) vessels, the largest then visiting the ports in the estuary. It was proposed that the locks would be located off the Welsh Shore to utilise the existing deep water channel used by vessels entering Cardiff Docks. Some additional dredging would be required to connect this channel to the main channel upstream of the Barrage. Shipping in the Bristol Channel and Severn Estuary now includes vessels up to 120,000dwt and the feasibility of accommodating vessels up to 250,000dwt is under investigation.

The cost of incorporating shipping locks in the Barrage, including associated breakwaters, was reported in EP57 as some £600 million (1988 prices). To allow uninterrupted passage of vessels during Barrage construction, the construction programme envisaged the locks being constructed prior to placing the turbine caissons in the deep water channel, thereby adding some two years to the overall construction programme needed solely for the Barrage. The provision of large shipping locks therefore has an influence on both the capital cost of the project and on the time to first power generation and hence on the overall economics of the Project. This is discussed further in Chapter 5, Economic Appraisal Issues.

The issue of the size of vessel allowed to pass through the Barrage is one of the most significant changes since the tripartite studies were carried out. Agreement as to the optimum size of lock that would be incorporated in the Barrage is of fundamental importance to the future development of the Project.

To clarify the issue it is recommended that a computer model of present and foreseen ship movements is undertaken to investigate the effect on transit times of ships passing through the Barrage.

4.3.3 Impact of the Barrage on the Ports

The extent to which the Project might affect the viability of the ports is a sensitive issue which could affect investment decisions for their owners. Until a decision is made in regard to the future development of the Barrage, no decision can be made in regard to the size of vessel that could pass through it, nor to the possible need for relocation of some port facilities for vessels unable to do so.

4.4 Rail Infrastructure

The UK railway system has undergone radical change since the tripartite studies, which did not seriously consider the provision of a rail line across the Barrage. Privatisation has resulted in separation of the infrastructure and its maintenance from provision of rolling stock and operation of passenger and freight services. Both passenger traffic and freight traffic have risen substantially, a fact not foreseen in the tripartite studies or the additional studies, and Government policy is likely to encourage further increase of both.

The Severn Tunnel, for many years a cause for concern, has been repaired to a standard that should keep it operable for another century, but only a single up line and a single down line pass through it, so its capacity is limited. Freight traffic paths are particularly constrained, restricting the amount of freight that can be transported by rail from the Welsh ports. Should the UK adopt the continental loading gauge the Severn Tunnel would have to be replaced.

Improvement to passenger transport services to and from South Wales is planned by the Train Operating Companies and Cardiff City has plans for a light rail system serving the Cardiff Bay area. Our discussions with Railtrack have indicated that there is expected to be an increasing demand for freight traffic in the Severnside region. The Barrage would present the opportunity for a rail connection across the estuary for either freight, passengers and freight, or passengers only. The provision of a light rail passenger service may be an option. Should deep water port facilities be developed to the seaward side of the Barrage, a rail link incorporated in the Barrage structure could encourage rail freight traffic to and from the port which may replace some of the present road transport traffic.

The viability of constructing a rail line across the Barrage will depend to a large extent on the size and frequency of ships passing through the locks. The height above water level necessary to allow the passage of ships up to the present size of 120,000dwt would preclude a fixed railway crossing over the locks. The viability of swing bridges would depend on the span over the locks and the frequency of ship/rail movements.

It is therefore apparent that the justification for and viability of constructing a rail line across the Barrage is linked to port development and a number of other regional factors.

4.5 Airports

The impact for the local airports of transport links incorporated into the Barrage was not addressed in the tripartite studies. The two existing airports of local significance are Bristol Airport and Cardiff (Rhoose) Airport. The National Assembly for Wales is considering plans to construct a new international airport close to the coast near Newport. This would be served by a connection to the M4 Motorway and by a rail loop from the London-Swansea main line.

Bristol Airport has developed a relatively flourishing tourist business and is now the more important of the two. It has no rail link and only limited road access from Bristol to the north and from the M5 motorway. Improved transport links to the airport could be an important factor in securing the anticipated inward investment resulting from construction and operation of the Barrage.

Cardiff Rhoose Airport is of doubtful commercial viability under to-day's conditions and needs the help that strengthening of the transport links westward of Cardiff would bring. It is considered likely that construction of the Barrage will contribute towards such strengthening.

Should a new international airport be built near Newport, the air traffic pattern in the region is likely to change significantly.

4.6 Conclusions and Recommendations for Further Study for Transport Infrastructure Issues

1. The key transport issue is the effect of the Barrage on the ports in the Bristol Channel and Severn Estuary resulting from the provision made for the passage of vessels through the Barrage

2. The consequences for the layout of the Barrage and for its generation capability will need to be examined in detail to establish if operation of vessels of up to 250,000dwt in the basin above the Barrage is compatible with construction and operation of the Barrage. This is a political as well as commercial matter, and includes issues of environmental impact and sustainable development objectives.

3. Recommendations for further study:

Recommendation 6: Present and foreseeable ship movements in the estuary should be modelled to assess the effect on transit times of passage through the Barrage and the probable impact on the ports.

Recommendation 7: A socio-economic and environmental cost-benefit analysis should be undertaken for the existing and possible new port locations in the Severn Estuary and Bristol Channel. It should take into account the changing business of the ports, the feasibility of providing large locks in the Barrage, the maintenance and dredging requirements to maintain deep water channels, and the alternative use of existing facilities for recreation and waterfront development for the "with Barrage" case.

Recommendation 8: Recent multi-modal transport studies should be reviewed to include the "with Barrage" case to assess the cost-benefit of both road and rail links on the Barrage.

CHAPTER 5 ECONOMIC EVALUATION ISSUES

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5.9 Conclusions and Recommendations for Further Study for Economic Evaluation Issues

5.1 Introduction

The aspects of the tripartite studies concerning the organisational structure and the financing of the Project were postponed because of the anticipated disruption that Privatisation of the ESI was expected to cause to the electricity market. Proposals in 1993 and 1998 to complete the financing studies were turned down by DTI and this essential part of the development of the Project remains to be completed.

The Treasury "Green Book"[25] sets out the process of economic evaluation including the sequence which should normally be followed and the various outputs required. The basis for an evaluation is normally a comparison with established precedents.

The methods for measuring socio-economic costs/benefits arising in regard to the issues of global warming and climate change are only just emerging.

This Chapter discusses the key elements for economic evaluation of the Project, including:

- how the capital cost and construction programme have changed compared with those published in EP57 ;
- an overview of the socio-economic case for the Barrage;
- export opportunities which would exist for the UK following successful completion of the Project;
- evaluation of sustainable development objectives.

Analysis of the cost of electricity generated by the Severn Barrage is addressed in Chapter 6.

5.2 Pre-construction Programme and Costs

5.2.1 Pre-construction Activities

The key pre-construction activities are:

- Identify a basis for funding the Project, establish a vehicle for Barrage development (see Chapter 6) and an Estuary Management organisation, including liaison arrangements with all relevant local authorities. SCOSLA already exists in this regard.[26]
- Project Management
- Identify and implement the further environmental studies needed and prepare an Environmental Assessment.
- Carry out sufficient design to support the Environmental Assessment and Consents process.

[25] "Appraisal and Evaluation in Central Government" – HM Treasury, HMSO, 1997.
[26] Standing Conference of Severnside Local Authorities

- Obtain Consents (Parliamentary and other approvals).
- Prepare detailed designs and obtain tenders for construction.

5.2.2 Legislative Base

The way major projects are procured, particularly those which involve collaboration between the public and private sectors, has become more complex since publication of EP57. However, the legislative base for the development and implementation of the Severn Barrage Project still appears to be through the UK Parliament.

5.2.3 Programme

The timescale for the pre-consent phase will depend in large part on the nature and level of detail undertaken and the extent and nature of support given by Government. The Project's environmental impact will generate debate, and more detailed work than reported in EP57 is now anticipated in this regard in order to resolve the key issues (see Chapter 3).

An outline programme for the pre-construction activities together with indicative costs, based on those published in EP57 escalated by a factor of 1.6 to give current prices, is shown in Figure 5.1. below.

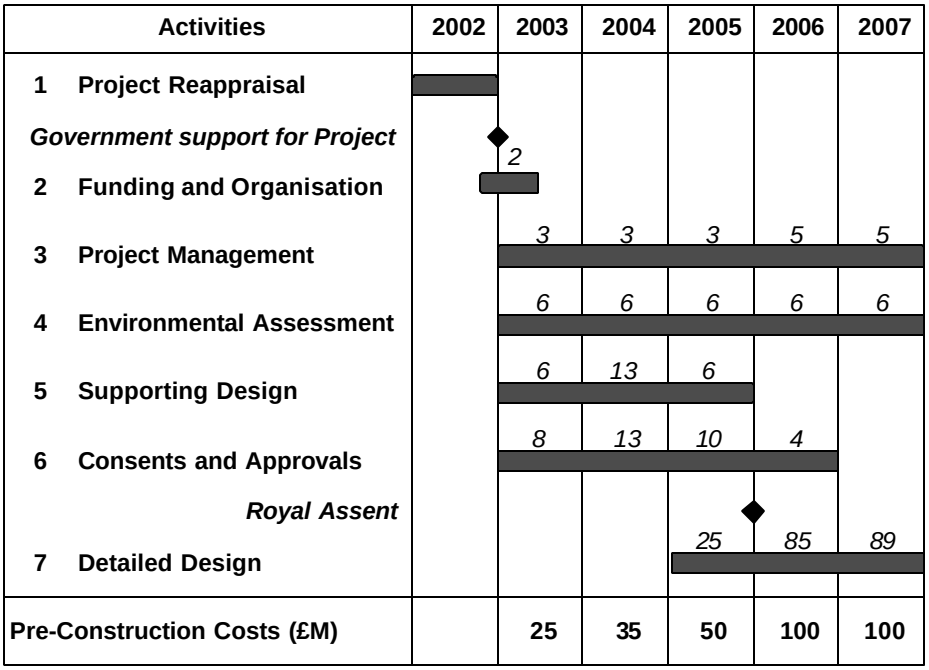

Figure 5.1: Pre-Construction Activities – Outline Programme and Indicative Costs

5.3 Design and Construction Programme

The construction programme given in EP57 shows detailed design commencing 2 years before the start of construction, 7 years from commencement of construction to Barrage closure and a further 2 years to installation of all turbine generators and full power generation. This "7-year programme" was considered a secure programme which included sufficient time contingencies to allow recovery of delays. An accelerated programme with 6 years from start of construction to Barrage closure was also presented as feasible but with a greater risk of delay.

The main features of the programme were as follows:

- Caisson construction was planned to be carried out in 6 yards (4 purpose built facilities in the Severn Estuary area and 2 existing yards in Scotland). The 161 caissons were to be completed by month 70.
- Caisson installation was planned to take place on 4 fronts with one caisson being placed per month on each front. Tides suitable for placing of caissons occur every 2 weeks. Thus the programme allowed a 100% contingency for inclement weather or unforeseen problems.
- Dredging and foundation works were planned to be carried out well in advance of caisson installation, because of the risk of delays in carrying out these operations.
- Manufacture of turbine generators was planned to take place at 2 purpose built facilities in the UK, at a rate of 44 units per year.

The key constraints on the programme were:

(i) The need to complete a ship lock to allow ships to be routed through the lock before caissons can be placed in the existing deep water channel.

(ii) Construction of new yards for caisson construction and new facilities for manufacture of turbine generators, prior to commencement of construction and manufacture respectively.

(iii) As the degree of blockage of the estuary increases, the number of tides suitable for placing caissons reduces.

(iv) Completion of turbine generator installation and full power output is dependent on the rate of manufacture of the units. Caisson construction is sufficiently in advance not to be a constraint on installation of turbine generators.

(v) The necessary electrical grid strengthening has to be completed on the English shore before substantial power export could commence.

Changes that have occurred since EP57 are as follows:

- There have been significant improvements in the management of major construction projects and in the efficiency of construction and manufacture in the UK. Major projects are now routinely delivered significantly faster than in the 1980s.
- There have been major advances in equipment and techniques for dredging and foundation preparation in deep water. The water depths at the Barrage

location are now well within current technology. (These operations have been carried out recently in water depths of up to 100m for offshore oil projects.)

- EC rules on procurement will require that all the major elements of manufacture and construction are put out to open tender in Europe. In addition, project funding arrangements are likely to require world-wide tendering for major equipment such as turbine generators and sluice gates.

As a result, a shorter construction programme should now be achievable. Hence the 6 year programme to Barrage closure previously put forward as an accelerated programme can now be regarded as a secure base case programme. If the large ship locks were to be omitted, a programme with 5 years to Barrage closure and 7 years to full power appears to be feasible. The measures to achieve this would include:

(i) Caisson construction at up to say 10 yards in the UK and Europe, making maximum use of existing yards in order to allow an early start to construction.

(ii) Installation of caissons at up to 6 working fronts, with provision of additional equipment to allow placing of 6 caissons per month (with the same 100% contingency for inclement weather as before).

(iii) Use of the latest equipment and techniques for dredging and foundation preparation. This will minimise the risk that these operations could delay caisson installation.

(iv) Turbine generator manufacture at 3 or 4 locations in the UK, Europe and elsewhere. Manufacture of gates for sluices, turbines and locks at locations worldwide.

(v) Re-assessment of the electrical transmission proposals to optimise grid strengthening requirements.

Programmes of seven years and five years to Barrage closure have been taken as upper and lower limits for the preliminary re-assessment of the Project's capital cost in Section 5.4 below.

5.4 Capital Cost

The capital costs given in EP57 were prepared from:

- material quantities taken from the outline designs for each element of the barrage;
- construction methods and programme given in EP57
- prices and labour outputs at January 1988.

The updated costs given in this report have been prepared by applying escalation indices to the original estimates and then, where there have been significant technical improvements, using judgement to adjust the index.

The escalation factors used are as follows:

Caisson construction	1.55*
Dredging, foundation preparation and caisson placing.	1.40
Turbine generators, electrical transmission and steel fabrication for gates.	1.40
Management, engineering design and maintenance activities.	1.60

* ie 55% increase

The use of escalation indices for the period of 13 years from 1988 to 2001 can only give an approximate updated cost. Construction indices will not generally take account of improvements in methods and outputs (as the index is built up from changes in costs of materials, plant and labour). Tender price indices will allow for all factors affecting cost but also include the effect on price of market conditions (which could be misleading for a project of long duration in the future). In view of these considerations, the accuracy of the updated cost is judged to be ± 15%. ie

for 7-year programme (incl. large ship locks): £10.3-£14.0Bn:

for 5-year programme (incl. smaller ship locks): £10.1-£13.7Bn.

Construction Programme Duration	EP57 £M (1988)	**7- year £M(2001)**	**5- year £M(2001)**
Pre-Consents Costs	69	**100**	**100**
Barrage Capital Costs:			
Civil Works	4896	**7270**	**6940**
Turbine Generators	2412	**3380**	**3530**
Transmission & Control	384	**540**	**540**
Management & Engineering	401	**640**	**640**
Environment	11	**20**	**20**
Drainage, Sea Defences, Port Works and Compensation	110	**170**	**170**
Total Barrage Capital Cost	8283	**12020**	**11840**
Off-Barrage Transmission Capital Cost*	1230	**1845**	**1845**
Annual Costs:			
Operation & Maintenance	40/yr	**64/yr**	**64/yr**
Off Barrage	30/yr	**48/yr**	**48/yr**

* Assume 10% lines underground

Table 5.1 Comparison of Construction Costs

The updated cost estimates compared with the EP57 values are given for the 7-year and 5-year construction programmes in Table 5.1. The estimate for the 5 year programme includes additional costs for extra construction yards, manufacturing and installation equipment (as described in Section 5.3) and also assumes that the large locks provided in the EP57 scheme are replaced by smaller locks to cater for vessels up to 10,000dwt.

A new cost estimate based on current methods and outputs is a prerequisite to the further development of the Project.

5.5 Employment During Construction

The total labour requirement for manufacture of equipment and Barrage construction was estimated in EP57 as 200,000 person-years. This requirement was spread over the 9 year period of construction and installation with a peak over years 2 to 5 of 30,000 to 40,000 persons employed, of whom about half would be in the Severnside Region.

The significant changes since EP57 are:

- improvements in methods and efficiency are likely to reduce the labour requirement, perhaps by 10 to 20%;
- EC rules on procurement and the requirements of project funding are likely to result in construction and manufacture being carried out at locations in Europe and world-wide, as well as in the UK;
- it will be preferable to spread caisson construction over more sites in order to minimise the risk of delays to installation and Barrage completion, particularly if the 5 year programme is adopted.

As a result of these changes the numbers employed both in the Severn Estuary region and in the UK as a whole are likely to be lower than the estimates given in EP57. However the numbers employed will still be very substantial.

The major labour demand is for caisson construction. The key requirement for a caisson construction site is deep water close to the shore. The tow away draught ranges from 10m for the shallower plain caissons to 22m for the deepest turbine caissons. Locations which can be considered include:

- existing offshore construction yards, for example in Scotland, Norway and Holland;
- some of the larger existing ship dry docks in the UK and Europe;
- new sites which have the necessary water depth, transport links and labour supply and for which planning permission could be obtained. Locations in the UK include East coast estuaries with deep water such as Teesside and locations previously identified in the Severn Estuary and Bristol Channel such as Port Talbot.

5.6 Overview of the Socio-Economic Case for the Barrage

5.6.1 The Wider Impacts, Costs, and Benefits

The Barrage would generate electricity that will have both a direct market value under the NETA system and an environmental value in terms of greenhouse gas emissions (GhG) displaced. Ultimately, one could reasonably expect both electricity and GhG markets to converge, with spot trading in GhGs operating to optimise electricity generation overall.

The Barrage would also have an impact on regional infrastructure investment in many ways:

- There would be (either politically or financially committed) investment programmes (eg flood alleviation) whose costs will be demonstrably lower because of the Barrage. There may be some whose costs would increase. In both cases, one would expect there to be a contribution to or from the Barrage to reflect the impact.
- The Barrage may reduce costs for future potential investments (eg a second Severn rail crossing). In some cases, the owners of the Barrage would be able to recoup a proportion of the saving from the promoters of such schemes, but in many cases there would be windfall savings that the Barrage would be unable to tax.
- There would be impacts on the regional economies on either side of the estuary, with measurable effects on employment, economic activity, and local land and property values, besides significant benefits to the construction sector across the UK and EU.

The question then arises of how such wide impacts should be taken into account from the UK Government's perspective when deciding whether, by what means, and by how much, it should provide support for the Project.

It is a commonplace that most investment in public transport infrastructure can never be justified on the narrow grounds of the money to be paid by direct users of the public transport. Central government expects to provide support for the difference between the total cost and the private value of the investment, so long as the wider benefits flowing to the public as a whole exceed the cost of government support. The processes of cost-benefit analysis are now well developed and are used as a matter of course in the transport sector.

The Hinkley Point C Inquiry dealt with many of these issues at some length, and indeed they were instrumental in providing the grounds for the Inspector's recommendation in favour of the planning application and the then Secretary of State for Energy's approval. The inspector accepted that nuclear power was likely to prove more expensive than coal, but this additional cost could be outweighed by its contribution to diversification of fuel supply and improving the global environment.

5.6.2 The Case for Private Sector Investment

One of the points of privatising the electricity supply industry by the previous Government was to remove the Government from making investment decisions. Private sector investment has indeed replaced public sector investment and has satisfactorily increased and renewed the capacity of the power system over the last 10 years. The current Government has reinforced the market-based nature of the power system by the introduction of the New Electricity Trading Arrangements (NETA).

One of the main reasons for the creation of a system of tradable carbon credits is similarly to privatise and market the greenhouse gas impacts of economic activity. In this way it is hoped to stimulate private sector investment in GhG-reducing investments.

Ideally, the private sector should be in a position to make the investment in the Severn Barrage without any economic support from Government. Investors would either take a view on the long-term evolution of electricity and carbon credit prices or enter into long-term contracts with other private sector players who are willing to manage these long-term trading positions.

However, both power and carbon credit markets are nascent, and so it is difficult to see how the private sector could take long-term views on prices starting in 10 years' time at a level which would represent value for money relative to reasonable beliefs about future prices.

5.6.3 Precedents for Government Support

The Conservative Government was forced to withdraw nuclear power from the ESI privatisation in 1989 because it was recognised that the private sector was not able to accept the risks involved. The AGR power stations were later privatised as British Energy, and, more recently, the Magnox stations absorbed into British Nuclear Fuels plc.

In order that the additional costs of nuclear power generation were not a burden on the public purse, the then Government legislated for a compulsory levy (tax) on the electricity consumer. This was passed on primarily to bridge the gap between the market price of power and nuclear generation costs.

Despite its characterisation as part of the Non-Fossil Fuel Obligation, the levy was seen as state-aid to nuclear power stations and so time-limited to end in 1998. The NFFO for truly renewable energy projects continued, with a much smaller levy, until abolished as part of the introduction of NETA.

The Government announced that this would be replaced by an obligation on public electricity suppliers to purchase a set proportion of their supplies as renewable energy. This obligation would be enforced by a fine, to be set at an initial level of, reportedly, £30/MWh.

Meanwhile, the Government has introduced a quasi-carbon tax in the form of the Climate Change Levy (CCL). This has been applied at varying rates to fuels at the point of supply to commercial and industrial consumers. It is applied to electricity supplied, rather than fuel consumed in electricity generation, and so reflects an average carbon content in electricity supply, initially at a rate of £4.3/MWh. Industry sectors have then been encouraged to negotiate energy efficiency programmes in order to qualify for 80% CCL rebates.

The CCL receipts will be partly recycled into the Carbon Trust, which has been tasked with encouraging innovation and dissemination of carbon-reducing technologies.

The World Bank and the Dutch Government have established carbon funds, which are essentially publicly-funded vehicles for procuring renewable energy production.

5.6.4 The Case for Government Support

The potential resource represented by the tidal energy of the Severn Estuary is of a world-scale, being second only to the Bay of Fundy. Arguably, the Severn Barrage is not just a potential contributor to the UK's GhG targets, but a global resource available for GhG reduction entrusted to the UK by the accident of geography.

More probably, it would be argued to be an EU resource, in the same way that fishing grounds surrounding the British Isles have been allocated on an EU-wide basis. The size of the project is such that the impacts on the electricity supply system will extend throughout the interconnected system in the EU. Both the potentially market-distorting effects of the Barrage and its carbon credits would need to be negotiated with and offered to the EU.

Finally, of course, the Barrage's output will have a major impact on the UK's electricity market. Depending on the number, location, and capacity of interconnectors with other power systems (there are plans for interconnectors with Ireland, Norway, and the Netherlands), the rest of the England & Wales system will have to balance the cyclic variation in output.

It would make sense for Government to impose that balancing obligation on the public electricity suppliers (PESs.) It would then be tempting to assign all the power and carbon price risk to the PES's and force them to contract with the Barrage at an all-in price which was sufficient to enable the project to proceed.

Government would then effectively be substituting its judgement for that of the market on the best way to achieve the GhG targets. The calculation involved would be restricted to assessing what price increase consumers would be willing to bear. Government would benefit from a windfall reduction in costs of flood alleviation.

But Government could choose to reduce the cost to the electricity consumer by making direct contributions to the cost of the Barrage, either in the form of grants or availability payments. Government would then have three limbs upon which to justify such contributions:

(i) the benefits accruing to regional infrastructure, local economies, and the construction and power equipment sectors;

(ii) the benefits of fuel diversity and security which are almost uniquely provided by the Severn Barrage scheme;

(iii) the ability both to achieve GhG targets in the short term and contribute to carbon reductions in the long term.

5.6.5 Cost-Benefit Analysis

Cost-Benefit Analysis is simply the attempt to quantify less direct and less tangible non-monetary benefits in order to compare with (usually direct, tangible, and monetary) costs.

Benefits accruing under limb (i) above fall broadly within the areas normally subject to formal cost-benefit analysis in the transport sector.

The Hinkley Point C Public Inquiry Inspector, and his economic assessor, appealed in vain for a quantification of the benefits under limb (ii). The Financial Times quoted a CEGB Board member as saying that "there was considerable difficulty in producing meaningful figures about the benefits of diversity as there were too many uncertainties". This suggests a lack of clarity of thought at the CEGB at the time, since it is of course all the uncertainties that give a value to diversity and security. It should have been possible – at the time – to construct a rational, mathematical, and statistical model that would value diversity strategies dependent on various input assumptions regarding fuel supply disruption probabilities. The more recent development of real option theory, however, now allows a more rigorous investigation of the value of diversity. We understand that this is a core area for the PIU Energy Review project.

Benefits under limb (iii) go to the heart of the Government's overall strategic policy on climate change. The Government is in principle prepared to recycle CCL receipts into further carbon-saving technologies via the Carbon Trust. In that case, it is hoping for significant carbon-saving multipliers from such investment. The very long life of the Barrage should mean similarly high multipliers for any Government contribution that helps to produce carbon credits for the private sector.

Where it is felt that the increase in carbon credits from this process should accrue to the Government, the question is then whether the Government is in the best position to take a long-term view on the value of such credits, whether there are additional benefits from having such a supply of credits for trading purposes, and whether there are benefits arising from greater assurance of meeting GhG targets.

5.7 Export Opportunities

If the Severn Barrage were to be built, this would leave the UK pre-eminent in the field of tidal power and in a strong position to export the expertise to other countries that have suitable sites. In addition, the successful completion of the Severn Barrage, would improve immeasurably confidence in the ability to finance and implement such large energy projects.

Figure 5.2 indicates that there are a number of sites where tidal power could be developed at a unit cost less than, or similar to, that for the Severn Barrage[27]. If all of this resource were to be developed, it would avoid the annual emission of some 100million tonnes of carbon cf equivalent coal-fired electricity generation.

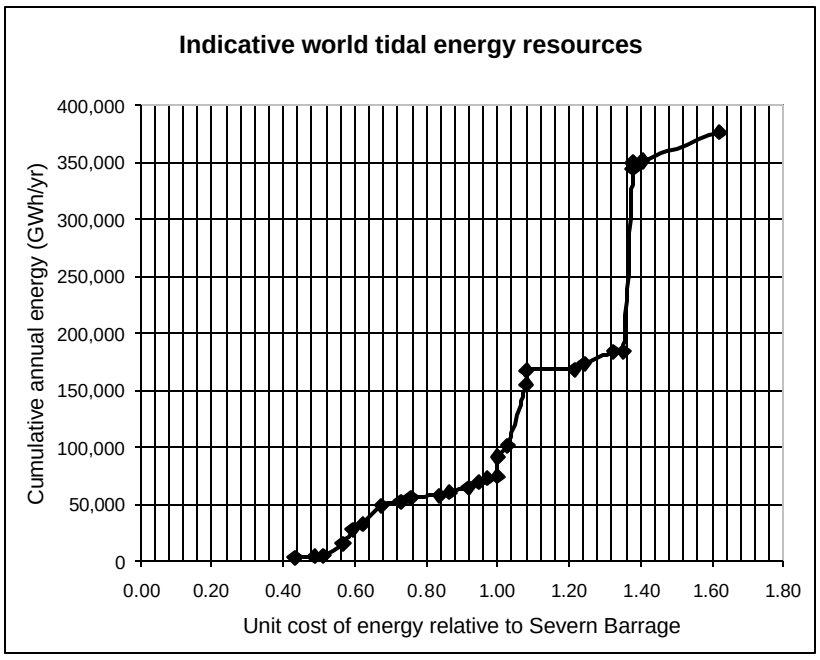

Figure 5.2 Cumulative World Tidal Power Resource Plotted Against Cost

The sites where there are good prospects are as follows:

- Bay of Fundy, Canada, which has the largest tidal range of any site in the world.
- Argentina, where there are several excellent sites, these ranging in potential annual energy output from 600 GWh to a massive 160,000 GWh.
- India, where government interest has been shown in two sites on the west coast, the Gulf of Cambay and the Gulf of Katchch.
- South Korea, Garolim Bay.

[27] "Tidal Power": Baker A C; Peter Peregrinus on behalf of IEE, 1991

- China, where there are several potential sites along the South West coast, three of which would be major schemes and could generate together up to 8,000 GWh/yr.

These sites represent a major carbon free world energy resource, development of any of which would present important export opportunities for UK industry, especially following completion of the Severn Barrage.

5.8 Sustainable Development

An assessment of the all-round sustainability of the Severn Barrage Project will most probably figure highly in any judgement of its case for promotion.

Most evaluation procedures involve an examination of what would have happened if the activity under consideration had not been implemented. In the case of the Barrage, this will involve an assessment of the possible effects of climate change resulting from emissions of greenhouse gases, not only for the Severn Estuary but also the British Isles and much of Europe. Moreover, because of the virtually indefinite life of the Severn Barrage, this assessment will need to look at least to the end of the 21st Century.

The balance between economic prosperity, environmental quality and social equity for the Project as a whole will be largely a subjective judgement and guidelines for assessment are needed. The European Commission "ExternE" study[28] is aiming to develop tools for measuring externalities and their application to different energy sources by examining the damage caused by the use of energy to a number of receptors; these include human health, natural ecosystems and the built environment.

A high level analysis of how the Severn Barrage Project meets the objectives of Sustainable Development will be an important part of the further development of the Project

5.9 Conclusions and Recommendations for Further Study for Economic Evaluation Issues

1. The current capital cost (2001 prices) of the Severn Barrage scheme defined in the EP57 Report (7-years to first power) is estimated to be between £10.3Bn-£14.0Bn. This estimate is derived from the 1988 costs adjusted by escalation indices for the past 13 years. These indices do not take into account improvements in construction methods and productivity since 1988.

2. The socio-economic case for the Barrage centres on:
   (i) the environmental value ascribed to greenhouse gas emissions displaced and the contribution to security and diversity of supplies;

[28] "Externalities of Energy" – European Commission, 2001

(ii) the damage costs/capital costs avoided due to coastal protection and the consequent alleviation of flooding risk afforded by the presence of the Barrage;

(iii) wider costs and benefits as a result of improved transport links, inward investment and job creation.

Whereas a preliminary assessment of the last of these was made for the circumstances prevailing in 1988 and reported in EP57, the methodology for the evaluation of (i) and (ii) is not properly developed.

3. The case for private sector investment in the Project relies on economic support from Government in recognition of its socio-economic benefits.

4. The case for Government support relies on the Project's potential contribution to the UK's greenhouse gas targets in exchange for a windfall avoidance of flood damage costs in the Severnside Region.

5. There are a number of sites world-wide where tidal power could be developed at a unit cost similar to or less than the Severn Barrage Project, any of which would present important export opportunities for UK industry following completion of the Severn Barrage.

6. Recommendations for further study:

Recommendation 9: A new cost estimate and associated construction programme should be prepared for the Project to take into account changes to construction methods and productivity since 1989. It would also take into account changes to the EP57 scheme arising from the recommended operational / environmental management studies and the conclusions of the recommended shipping and transport studies.

Recommendation 10: The wider social and economic benefits resulting from construction and operation of the Barrage should be reviewed in the light of the changes since EP57 and a new high level cost-benefit analysis prepared for the Project.

Recommendation 11: A high level assessment should be made of how the Project meets the objectives of sustainable development in accordance with the requirements of the Sustainable Development Scheme of the National Assembly for Wales.

CHAPTER 6 ADVANCEMENT OF THE PROJECT

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6.1 Financing the Project

6.1.1 Introduction

Since 1988 there have been major changes in the financial system in general and project financing in particular. These relate to the economic context in which projects are financed, the approach of banks and other lenders to assessing risks and making lending decisions, and finally to the way that project financing is constructed and optimised. A glossary of project finance terminology is attached as Appendix F.

Where infrastructure concessions are concerned, it is now customary that there has to be an open competition to decide which private-sector entity (usually, but not necessarily, a consortium of companies) should be granted the right to exploit that concession. Whether the Government is directly purchasing the service provided by the concessionaire (eg for a NHS hospital building) or on behalf of the users of the service (eg a major estuarial crossing), the concession will be awarded on the basis of the lowest availability charge or vehicle toll tendered by the bidders.

In most cases, the concession will be financed on a non-recourse project finance basis. The concession is granted to a stand-alone "special-purpose vehicle" (SPV), which exploits the "corporate veil" provided by the limited liability concept to insulate the SPV's shareholders from the risks associated with the project.

This is why the financing approach is termed "project finance": the SPV's corporate position is entirely determined and delimited by the scope of the concession. This means in turn that the concession economics must entirely satisfy the requirements of the SPV's funders, whether lenders or investors. In the case of infrastructure concessions the service price, a major element in the concession economics, is set by the SPV's owners during the bidding process. In this way, the economics are internalised to the SPV.

The service price tendered by each bidder will depend entirely on the key project variables as perceived by the bidder and its lenders (capital costs, operating costs, usage, reliability, taxation) and the financial parameters of the funders.

The key financial parameters are:

- the target return on equity;
- the servicing cost of the debt, ie the annuity rate, itself a function of:
  - the interest rate, and
  - the maturity of the debt
- the cover ratio required by the lenders

Together, these four financial parameters, when applied to the key project variables, will effectively determine the service price tendered by a bidder. Gearing (the proportion of capital costs met by debt) should not be an input

financial parameter – there is an optimum gearing that satisfies the requirements of both lenders and investors at the lowest possible service price.

6.1.2 Changes Since EP57

Prior to 1989, project finance was restricted to private sector promoted projects in the natural resources and process industry sectors, although the Channel Tunnel had been (and was continuing to be) financed.

Starting in 1989, there has been the privatisation of the electricity supply industry, with the consequent demand for the project financing of generation projects (IPPs).

In 1994 the first UK sterling project bond was sold to investors in respect of the Kilroot IPP (the Second Severn Crossing financing had involved a privately placed bond in 1992).

By late 1995, the first UK PFI project was reaching financial close and since then the PFI has burgeoned into a major project financing market in its own right.

Intense competition amongst bidding consortia to obtain PFI concessions led to competitive pressure on lending banks to improve terms, particularly in respect of maturity. The increasing availability of a project bond alternative helped considerably because bond investors were relatively insensitive to maturity considerations – indeed usually the longer the better. Eventually, the larger banks (particularly the ex-building societies) recognised that they were losing business because of an arbitrary self-imposed limit, and we now find that maturity is not an issue for most of the commercial banks for the typical 30 year concession period.

At the same time, competitive pressure amongst the lending banks has gradually eroded the cover ratios they require. We have also seen greater realism amongst project investors about the rates of return on equity they can reasonably expect.

Throughout this period, the British Government has been increasing efforts to bring inflation under control, and has been reasonably successful in achieving this. Not only has inflation come down, but the real interest rates required to exert that control have also come down.

Reduced interest rates and much longer maturities have a much more powerful impact in combination on debt capacity, as illustrated in Table 6.1.

Maturity (years)	Interest Rate	Increase in Debt Capacity
15	10%	-
	6%	19%
25	10%	28%
	6%	68%

Table 6.1 Effect of Maturity and Interest Rate on Debt Capacity

6.1.3 Impact of Changes

The Second Severn Road Crossing bond issued in 1992 had a 20 year maturity and a 6% real coupon. This is consistent with the 4.5% real interest rate at the time on index-linked gilts plus a typical corporate spread (eg LASMO) of 1.4%.

Index-linked gilts currently have a real yield of less than 2.5%, whilst the typical wrapped project bond would carry a spread of 1.2% and cost 0.3% for the monoline guarantee fee, giving 4.0% real in total.

The overall impact of the improvement in the typical financial parameters is a 40% reduction in the cost of capital for the project. The capitalisation factor (ie effectively the annual service price relative to the project's capital cost and approximately equal to the project rate of return) comes down from 10.0 to 6.0. (Table 6.2).

Typical Financial Parameters	**1989**	**2001**
Target equity return	20%	15%
Maturity	20 years	40 years
Interest rate, all-in	6.0% real	4.0% real
Loan life cover ratio (LLCR)	1.50	1.35
Project life cover ratio (PLCR)	1.75	1.50
Capitalisation factor (£/y per 100 £ capex) = project return, approx.	**10.0**	**6.0**

Table 6.2 Impact of Project Finance Changes Post EP57

Whilst the calculations above are notional, they are supported by the significant potential gains currently available on the refinancing of the early PFI projects from 1995 to 1997. These gains are simply a mechanical reflection of the change in the ruling financial parameters in the relatively short time since the original deals were concluded. It is also a feature of the current market that project financing structures are being proposed to acquire utility assets because the cost of capital is now lower than that allowed by regulators when setting tariffs (typically in the region of 6.5% to 7.5%).

It is also worth pointing out that the typical terms for 2001 do not reflect the particular situation of the Severn Barrage. It should be possible to improve on these terms as far as maturity and cover ratios are concerned, assuming that the construction risk can be adequately addressed for such a large project.

6.1.4 Indicative Cost of Barrage Electricity

Using the updated capital and operating assumptions set out in Chapter 5, PricewaterhouseCoopers (PwC) has carried out a cashflow projection for the scheme over a 120 year horizon from which the levelised cost per MWh was calculated at various discount rates. Table 6.3 sets out the results for both the 5-year and the 7-year programme, with the various discount rates given broad characterisation:

Levelised Cost of Power	**Real Discount Rate**	**2001 £/MWh**	
		7-year programme	**5-year programme**
1988 Cost of Private Finance	10%	120	108
1988 Test Discount Rate	8%	92	85
2001 Cost of Private Finance	6%	68	64
2001 Test Discount Rate (?)	4%	46	44
2001 Cost of Government Debt	2%	28	27
Zero Time Preference	0%	15	15

Table 6.3 Comparison of Levelised Cost of Barrage Power

It may be seen that, at the lower discount rates, the faster construction programme has a diminished benefit in terms of the levelised cost, as would be expected. At the 6% project return requirement indicated for a typical project financing in 2001, the indicated service cost would be of the order of £65/MWh in 2001 terms.

PwC also prepared a straightforward project financing model (which includes a tax computation) to verify the broad conclusions from the capitalisation

factor analysis and the levelised cost calculation, and to investigate some further improvement from longer maturities and/or lower cover ratios. (See Table 6.4)

Maturity - years	40	70	100	40	100
Cover ratio	1.35	1.35	1.35	1.25	1.25
Gearing	91.4%	92.7%	93.1%	93.8%	95.0%
Equity return	15.0%	15.0%	15.0%	15.0%	15.0%
Project return	5.9%	5.3%	5.1%	5.6%	4.9%
Cost - £/MWh	**69.5**	**59.7**	**57.0**	**65.6**	**53.9**

Table 6.4 Effect of Maturity and Cover Ratio on Cost of Barrage Power

There would therefore appear to be a reasonable prospect of achieving a power cost of less than £60/MWh in 2001 terms. The levelised breakdown of this cost is indicated in Table 6.5 below.

	£/MWh
Transmission Capex	5.0
Transmission Opex	3.0
Barrage Opex	5.0
Tax	2.5
Barrage Capex	33.0
Equity Return	11.5
Total	**60.0**

Table 6.5 Indicative Levelised Power Cost

6.1.5 Value of Barrage Generation

If the Project will be required to employ private finance for the whole of the capital and operating cost, then from the foregoing it may be assumed that the cost of Barrage electricity will be in the region of £60/MWh. Assuming also that the current market price of base load power is in the region of £20/MWh, then the excess cost of tidal power over the revenue from sales of electricity is in the region of £40/MWh.

If tidal power is assumed to substitute for coal-fired power of equivalent energy security status, then tidal power would save approximately 1 tonne CO_2 per MWh. At the long-term estimate for the value of CO_2 so saved this would give an environmental credit of £30/MWh. This figure has also been quoted as the likely fine to be imposed on public electricity suppliers for failing to meet their renewable obligation.

Barrage power costing in the region of £60/MWh might therefore be worth £50/MWh. (£20/MWh for electricity plus £30/MWh carbon credit). The gap could be closed by some or all of the following considerations.

- A premium on the basic price of electricity to take into account the ability of the Barrage to meet a fluctuating demand, including peak lopping (See Chapter 2 which assumes this could be of the order of £7/MWh).
- The wider socio-economic benefits produced by the Barrage and discussed in Chapter 5, in particular the avoidance of flood damage and coastal protection costs. Chapter 3 discusses the extent of the flooding risk for the Severnside region and indicates that the current average annual value for the flooding damage cost that would be avoided by construction and operation of the Barrage is some £120M, equivalent to £7/MWh if spread over the 17TWh pa of electricity generated by the Barrage. This cost is predicted to rise substantially over the next 50 years as a consequence of global warming and an average avoided cost of (say) £20/MWh might reasonably be attributed to the Barrage over the 120 year life of the Project.
- 100% of the Off-Barrage Transmission Costs have been attributed to the Barrage in the foregoing analysis; they represent 13% of the total capital costs and 43% of the total operating costs. Attributing only 50% of these costs to the Barrage reduces the cost from £60/MWh to £55/MWh; removing 100% of the costs reduces the cost to £50/MWh. It should be noted that the cost of grid strengthening has been assumed to be the same as that reported in EP57, escalated by a factor of 1.6.
- A 2% pa improvement in construction productivity and generating plant specific costs would potentially save 20% of the capital costs. (See also comments in Chapter 5 regarding the revised cost estimate.)
- Current UK power market prices are below the sustainable level which would be consistent with current gas market prices. If oil prices were to average $25/bbl, this would imply gas prices in the region of $3/GJ, or about 20p/therm. This gas price implies a power price closer to £25/MWh.

6.1.6 Implementation

It is one thing to demonstrate that the Barrage could be financed in principle at a cost that could be economically justified but another to show how such financing could be achieved. The sheer scale of the Project and the connected risks would have to be carefully managed in order for it to succeed.

A debt requirement in the region of £12.5 billion represents approximately twice the entire amount of UK sterling project bonds issued to date. The Eurotunnel project required a syndicate of over 200 banks to provide the necessary finance, though that was 15 years ago. It is probable that both bank and bond markets would have to be used, if only for capacity reasons.

The successful operation of the La Rance scheme for over 30 years demonstrates that the risks associated with the Project's operation would be so low that the Project's debt should be considered as gilt-edged. With the

Project's output secured, as it must be, the project risk would lie entirely in its construction. It would therefore make sense to consider the financing of the construction and operation phases separately.

Whilst the scale of the construction project would be considerable, the risks involved are potentially manageable in a number of ways. Over 200 separate turbine-generator units means that there is little technical risk to the Project's output, particularly if prototype trials are included in the pre-construction activities – as recommended in the Bondi Report. Multiple fabrication sites combined with multiple caisson installation workfaces reduces the risks associated with managing construction progress. However, a proper risk assessment for the Project, to quantify as far as is possible the major risks and their possible effects on construction time and cost, needs to be undertaken. Suitably incentivised construction management contracts together with the use of surety bonds to support individual contractor performance should also make for a manageable risk profile.

The question would then arise as to the extent to which the construction financing banks would be prepared to accept the refinancing risk. That is to say, at the time they committed to finance construction, would they be prepared to take a view of the terms that would be available from the capital markets in over 10 years' time? This risk could be managed by a structure which involved issue of the long-term operating phase bonds at the outset of the Project, with completion guarantees provided by the construction phase banks. Such a structure, which obviates the requirement for the construction banks to fund their obligations, would assist the syndication process.

It is therefore possible to envisage the Severn Barrage Project being financed by the private sector, subject to the Government policy instruments necessary to achieve the long-term security of supply contracts and with capital grants to recognise the value of the non-energy benefits.

6.2 Organisational Structure for the Further Development of the Project

6.2.1 Responsibility for Development Post EP57

The direct outcome of privatisation for the further development of the Barrage was that no successor company to the CEGB was given responsibility for the power station aspects of the Project, including its operation and marketing of the electricity generated, and responsibility for continuing the development of the Project and liaising with the Department of Trade & Industry and ETSU was left with STPG.

The lack of a suitable developer or a suitable customer for the amount of electricity generated were cited by John Battle MP when he was Minister of State for Energy and Industry as one of the reasons for turning down STPG's request in early 1999 for Government support for a financing study.

6.2.2 Barriers and Constraints

There are two possible routes available to Government if it wishes to develop the Project further at this stage. One route would be that it could recognise that the Severn Barrage is a project worthy of further investigation. The Government could implement the studies recommended in this report and fund these itself. In due course there would be a competition for the concession, and STPG would compete for this concession if it so wished.

This has a purity from competition issues, but has one major defect. There will be no commercial party involved at a principal level to drive the Project forward. This is a complex project which will need sponsors with risk appetite and understanding to ensure it has the best chance of succeeding.

An alternative would be to hold a competition once the Government has endorsed the concept of the Project. This would still allow a formal competition to occur and could be shaped in a way that maximises competition as the project develops. The Government could seek to offer a PPP, in which a private sector entity enters into a partnership with Government under a defined contract. The contract would lay out the obligations on both parties and a timescale in which such obligations should be fulfilled.

6.2.3 Optimising Government Support

It is clear that the Government would need to be a key part in the development and promotion of the Project. The number of parties involved across wide sectors and geography mean that only the Government would be able to achieve consensus to approve the Project. The Government could do this alone, but we believe that it would be more effective if the Government harnesses the private sector project management skills in evaluating project design and specification. The commercial issues and risks facing the development of the Project could be better handled through such a partnership.

The Government would need to accept a larger degree of risk in the Project at its early stages, until the risk of its implementation is reduced. Thereafter the private sector would be prepared to take more of the risk.

A route for Government would be to fund the initial work in return for preference shares in the SPV.

The initial work should be a joint feasibility study, which brings together at its conclusion the varying Project assessments. This would include the power project itself; transport infrastructure; recreation; employment; flood mitigation; and land values to name some of the differing issues. Government will also need to accept that it will have to provide some underpinning of the off-take agreements. This is likely to be in the form of supporting renewables obligations.

6.2.4 Maximising Competition

STPG could perform the role of partner with Government in a concession now and still provide satisfactory assurances over future competition. The members of STPG do not include an operator. Neither should the group be perceived as a construction group. The presence of both Rolls-Royce and ALSTOM in the group gives it a very different complexion.

The role of operator could be tendered once the Project is fully defined. There could be competition for parts of all the other asset provision and capital funding. There would be a gain sharing mechanism in the PPP contract with Government to ensure that Government benefited from such competition. It would also be able to control the level and extent of competition through the contract in the PPP.

The eventual capital raising for the Project would involve substantial amounts of debt and equity. These would be competitively sought to ensure value for money.

6.3 The Way Forward

There would appear to be three options for taking the Project forward.

(i) Undertake, initially, only sufficient of the further studies necessary to inform the Government on issues fundamental to the decision of whether it would support the Project. These are likely to include:

- operational aspects of the Barrage, including updating energy capture models;
- investigation of the viability of the options for enhancement of security of supply, including storage options;
- assessment of flood alleviation benefits, both in regard to coastal protection and the possible alleviation of fluvial flooding of rivers discharging into the basin;
- options for shipping and ports, in particular the optimum size of shipping locks and the alternatives for vessels unable to pass through the Barrage;
- new cost and programme estimates;
- high level project risk assessment;
- high level sustainable development assessment;
- examination of the organisational structure for project implementation to include the relationships between the Government, the Barrage promoter, the anticipated SPV and the power station operator.

These studies could be managed by STPG and funded by the Government. They should cost no more than £500,000 and take no longer than twelve months to complete.

It should be noted that further environmental studies would be required before an Environmental Assessment can be completed. An indication of the scope of these further studies is contained in the letters from the Environment Agency and the Countryside Council for Wales, on behalf of English Nature, included as Appendix D. The cost of these studies is not included above.

(ii) The Government could sanction a full re-appraisal of the Project following approval of a detailed scope of work, proposed methodology and cost. This option is likely to include competitive bids for some or all elements of the work.

(iii) The Government could decide to promote the Project and seek partners to develop it to the stage of preparing the enabling legislation. This option would include establishing the organisation to implement the Project assuming the legislation receives Royal Assent.

6.4 Conclusions and Recommendations for Further Study for the Advancement of the Project

1. The reduction in the cost of capital for major infrastructure projects stemming from the development of project finance since EP57 has improved the viability of the Project.

2. At current values, electricity generated from the Barrage could be worth at least £77/MWh (£27 for the electricity itself and £30 for the value of its carbon credits and £20 flooding cost avoided), compared with a cost of £60/MWh (capital and operating cost). The £17/MWh surplus of worth over cost – admittedly subject to a wide range of uncertainty – suggests that there is a *prima facie* cost-benefit case for building the Barrage.

3. There would appear to be three options for taking the Project forward.

(i) Undertake, initially, only sufficient further studies necessary to inform Government on issues fundamental to the decision of whether it will support the Project. These studies could be managed by STPG and funded by Government. They would include study of the organisational structure and financing of the Project to complete the tripartite studies. They should cost no more than £500,000 and take no longer than twelve months to complete.

(ii) The Government could sanction a full re-appraisal of the Project following approval of the scope of work and its cost This option is likely to include competitive bids for some or all elements of the work.

(iii) The Government could decide to promote the Project and seek partners to develop it to the stage of preparing the enabling legislation. This option would include establishing the organisation to implement the Project assuming the legislation receives Royal Assent.

4. Recommendations for further study:

Recommendation 12: A high level project risk assessment should be undertaken to confirm that construction and operational risks can be adequately managed.

Recommendation 13: The further studies identified in Option (i) for taking the Project forward should be put in hand.

CHAPTER 7 SUMMARY OF RECOMMENDATIONS FOR FURTHER STUDY

Electricity Market Issues

Recommendation 1: The cost-benefit and environmental impact of varying the start time of generation within the tidal cycle should be examined. Updating the energy capture model developed for STPG by Binnie and Partners would assist this task.

Recommendation 2: The requirement, feasibility and cost-benefit of providing a low-head storage facility integral to the Barrage to augment the present system storage facilities at Dinorwic and Ffestiniog should be investigated.

Recommendation 3: The issues of grid reinforcement, the advantages of flexibility of output from the Barrage and the contribution it could make to firm capacity and security of supplies should be discussed further with the National Grid Company plc.

Environmental Issues

Recommendation 4: Further studies should be undertaken to quantify the influence of the Severn Barrage on coastal protection and the mitigation of flooding risk and the effect this would have on the estimated annual flood damage costs in the Region. These studies would include:

(iv) flood defence against storm surge and high tides;

(v) prevention of coastal erosion;

(vi) mitigation of fluvial flooding.

Recommendation 5: The key issues arising from the statutory conservation objectives should be identified, including:

(iii) an assessment of the possible effects of climate change on these objectives;

(iv) an assessment of the possible effects of the construction and operation of the Barrage on these objectives to identify any perceived adverse effects and the compensatory measures that may be practicable.

Transport Infrastructure Issues

Recommendation 6: Present and foreseeable ship movements in the estuary should be modelled to assess the effect on transit times of passage through the Barrage and the probable impact on the ports.

Recommendation 7: A socio-economic and environmental cost-benefit analysis should be undertaken for the existing and possible new port locations in the Severn Estuary and Bristol Channel. It should take into account the changing business of the Ports, the feasibility of providing large locks in the Barrage, the maintenance and dredging requirements to maintain deep water channels, and the alternative use of existing facilities for recreation and waterfront development for the "with Barrage" case.

Recommendation 8: Recent multi-modal transport studies should be reviewed to include the "with Barrage" case to assess the cost-benefit of road and rail links on the Barrage.

Economic Evaluation Issues

Recommendation 9: A new cost estimate and associated construction programme should be prepared for the Project to take into account changes to construction methods and productivity since 1989. It would also take into account changes to the EP57 scheme arising from the recommended operational / environmental management studies and the conclusions of the recommended shipping and transport studies.

Recommendation 10: The wider social and economic benefits resulting from construction and operation of the Barrage should be reviewed in the light of the changes since EP57 and a new high level cost-benefit analysis prepared for the Project.

Recommendation 11: A high level assessment should be made of how the Project meets the objectives of sustainable development in accordance with the requirements of the Sustainable Development Scheme of the National Assembly for Wales.

Advancement of the Project

Recommendation 12: A high level project risk assessment should be undertaken to confirm that construction and operational risks can be adequately managed.

Recommendation 13: The further studies identified in Option (i) for taking the Project forward should be put in hand.

CHAPTER 8 ACKNOWLEDGEMENTS

We are grateful to the following people and organisations who have kindly discussed the various issues raised during the course of this definition study We are also grateful to Dr Tom Shaw for his helpful comments during the preparation of this report.

ABP Research & Consultancy Ltd
Associated British Ports
Binnie Black and Veatch
British Trust for Ornithology
Countryside Council for Wales
Department of Trade and Industry, officials of
Department for Environment, Food and Rural Affairs, officials of
English Nature
Environment Agency
Government Office for the South West
Highways Agency
Innogy plc
Jones Lang LaSalle
Lattice Group plc
N M Rothschild & Sons Ltd
National Assembly for Wales, officials of
OFGEM
PricewatehouseCoopers
Railtrack Great Western
Sharpness Dock Ltd
Shawater Ltd
South West of England Regional Development Agency
South West Regional Assembly
The Bristol Port Company
The National Grid Company plc
Welsh Development Agency, officials of
Mr Clive Baker
Mr W P Davey, CBE. DL.
Professor R W Edwards CBE.
Dr Robert Kirby
Mr R W Minter
Mr R H Moon