A Pragmatic Energy Policy for the UK

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Executive Summary

1.1 **Security of energy supply must now be seen as taking priority over everything else, even climate change. UK imports of both gas and oil are accelerating, just as the fragility of supplies from Russia and the Middle East becomes more apparent and the UK heads towards the loss of one third of its generating capacity over the next 12 years. A new energy policy must be scheduled to meet the impending energy gap with an overarching long-term vision that will ensure security of supply, protect the environment, and at the same time, be deemed feasible by the engineers, financiers and utility managers who will have to implement it.**

1.2 Current policy is set out in the 2007 White Paper.[1] It supersedes the White Paper of 2003[2], which had strong elements of wishful thinking, by suggesting that selective renewables, combined with energy efficiency, would satisfy the demand gap without the need to replace the nuclear baseload capacity – an error finally rectified with the January 2008 White Paper on nuclear power.[3] Nonetheless, the current 2007 paper is flawed. It misunderstands market prerequisites and technical barriers and is founded on weak energy arithmetic. Yet it is still the platform from which UK energy policy must implement the ambitious political targets of EU policy, in accordance with which 20% of all energy consumption across the EU must be from renewable sources by 2020.[4] The UK commitment is a renewable energy target of 15%.[5] The implications are alarming. We are currently at 1.3%[6] – third from bottom in the EU league table with only Luxembourg and Malta below us. This will require a monumental shift in investment and build rate for renewables across all energy sectors. Furthermore, it implies that 40% of electricity will have to come from renewables.[7] Currently renewables produce just 4.5%.[8]

1.3 These targets are demonstrably unattainable. In-depth discussions with engineers and utility managers to discover what can actually be done, and the probable consequences of such actions, should have taken place. It might have prevented bizarre pronouncements such as the construction and installation of 7000 offshore wind generators in the North Sea, which would mean installing 10 turbines a day from now to 2020 (utilising the average 60 possible working days per year). This is 10 times the best installation rate achieved anywhere for offshore installation, yet the UK has just one suitable heavy-lifting barge available at the current time. The rush to impose biofuel quotas in motor fuel serves as another example. The full impacts of the rapidly developing biofuels sector with regard to climate change and food supply seem not to have been understood.

1.4 This report addresses the failings that have led to a fundamental undermining of the UK's security of supply and serves to heighten the sense of urgency about the growing energy gap. Electricity generation in particular is becoming a matter of grave concern.

1 "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR
2 "Energy White Paper: Our energy future – creating a low carbon economy", February 2003
3 "Meeting the Energy Challenge – A White paper on Nuclear Power", January 2008
4 "20 20 by 2020 – Europe's climate change opportunity", speech to the European Parliament, Brussels, 23 January 2008
5 "UK renewable energy strategy and the EU renewable energy directive, written ministerial statement, John Hutton MP: Secretary of State for Business, Enterprise and Regulatory Reform, 23 January 2008
6 BERR Energy Trends March 2008
7 "2020 Vision – How the UK can meet its target of 15% renewable energy", Renewables Advisory Board, June 2008
8 Digest of UK Energy, Statistics (2007), table 7.4, "Capacity of, and electricity generated from, renewable sources", BERR, 2007

1.5 The current situation is fragile. Two nuclear stations, Hartlepool and Heysham (a total of 2.4GW) are offline until 2009, and two more, Hunterston and Hinkley, are on reduced output – examples of what to expect from an ageing fleet. The planned decommissioning of nuclear power plant of 7.4GW by 2020 and 9.8GW by 2023[9] (respectively 10% and 13% of current generating capacity) will leave just one plant, Sizewell B, operational. In addition, there is the expected closure of 12GW (15% of current generating capacity) of coal- and oil-fired generating plant by 2016[10] as a result of the EU Large Combustion Plant Directive (LCPD) of 2008, aimed at reducing emissions. In all a total of 23GW (30% of generating capacity) will need to be replaced by 2020, and from 30GW to 35GW by 2027.[11] This is almost entirely base load capacity. Renewables have a role to play, but unrealistic expectations have elevated them above their capabilities. Renewables will not replace base load. The default position is gas, yet our reserves are diminishing to the extent that we will be importing 80% of our gas requirements by 2020[12], increasing our dependence on supplies from unstable political regimes and volatile markets. Furthermore, this will derail attempts to reduce CO_2 emissions, which will continue to rise.

1.6 The 'market will deliver' philosophy is wishful thinking. The market cares nothing for the environment. It caters for today's generation, not tomorrow's. The market needs the right investment framework and incentives to contemplate long-term projects. The present Government's vacillation over energy policy, nuclear being the salient example, has severely hindered development. Additionally, procrastination over carbon capture and storage (CCS) is holding back the coal industry from utilising our indigenous supplies. Inconsistent intervention is not helpful either. The renewables market has been distorted through unbalanced support for low-capital renewables with least return in energy terms, such as wind.

1.7 A determined and urgent course of action is of paramount importance to address this major threat to the long-term economy, security and social well being of the United Kingdom. The key elements to a new energy policy are laid out below. They draw together to form a cohesive action plan, the **Route Map to Energy Survival for the UK** (see page 25), a strategy that determines the priorities and is deemed to be feasible by those who will have to implement it. It demonstrates how a new energy policy must now divide into two distinct timescales – a short-term strategy to deal with the impending energy gap without impeding the long-term strategy of ensuring our energy requirements in an era when oil and gas will become increasingly scarce and the role of electricity takes on an even greater importance in sustaining our civilisation.

2. The key elements of a pragmatic energy policy must satisfy the following three fundamental criteria.

- Ensure security of supply both in the short term (up to 2020) and the long term (2020 – 2050)
- Protect the environment by striving to achieve CO_2 and renewable-energy targets
- Remain technically feasible from an engineering perspective

[9] Energy Markets Outlook, BERR, October 2007
[10] Energy Markets Outlook, BERR, October 2007
[11] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR
[12] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR

The key elements of a pragmatic energy policy

1. **Adopt the Route Map to Energy Survival for the UK** (see page 25). This means making decisions now to meet short- and long-term demands. Only a visionary, overarching strategy will maintain sustainable economic development, satisfy our environmental obligations and keep the lights on.

2. **Security of electricity supply** should now top the political agenda, even above climate change. There will be a shortfall in UK power generation of 23GW by 2020, rising to between 30GW and 35GW by 2027.[13] An impending crisis in power generation is now emerging and could lead to a dramatic shortfall as early as 2012 – 2015. This arises from the closure of ageing nuclear and coal-fired stations. The default position is to build new gas-fired stations as they can be completed in four years, but only 4.5GW are currently under construction. In terms of security of supply and energy costs this is unsatisfactory, but new nuclear stations cannot be brought on stream in much less than 10 years. Neither can a Severn barrage. In the medium term a strong case can be made for replacing inefficient, polluting, old coal-fired stations with new coal-fired stations. They will be less polluting than the stations they replace and, if carbon capture and storage (CCS) can be demonstrated to work, it can be retrofitted. Presently, coal provides 34% of the UK's electricity. This would give an important element of security as coal is partly indigenous and partly imported from reasonably stable parts of the world. Considerable effort should go into demonstrating the feasibility of CCS. And if the collected CO_2 is then pumped into failing North Sea oil wells to give tertiary oil recovery, it will increase the contribution the North Sea can make to UK oil supplies, providing a further contribution to UK energy security.

   Other measures include a significant increase in gas and electricity storage. Germany has 70 days' supply of gas, the UK has 14.[14] Depleted gas fields in the North Sea can be used for gas storage. Onshore initiatives should be encouraged, such as the gas storage facility at Hornsea in East Yorkshire where nine man-made salt cavities have been leached into a salt layer 1.8 kilometres below the surface, creating 325 million cubic metres of gas storage space.[15]

   As a matter of urgency, security of electricity supply should be further increased by linking the UK with Norway, Germany, the Netherlands (now building the 1GW BRITNED) and France (an additional link). This could be achieved within two or three years using British technology, in time to help with the anticipated shortfall in electricity generation capacity.

   It would be timely to fully reassess fossil-fuel reserves in the light of "peak oil", "peak gas" and now coal, both in the UK and worldwide. The UK should also establish a depletion policy for the North Sea, rather than expecting the market to manage it strategically.

3. **Nuclear power** has been allowed to decline in the UK, despite its central role in providing CO_2-free electricity. New, more efficient stations are now available and are being planned and built elsewhere. The present Government has done a belated U-turn and now wants nuclear power as an essential part of the energy mix. In the meantime, it has sold off Westinghouse, one of only five builders of nuclear power stations in the world, and one with a large and growing order book – a significant error of judgement. The situation can be rectified, but it will take time and money. In the longer term, like the rest of the world we will have to move to generation IV reactors, which are breeder reactors and use uranium 60 times more efficiently than today's thermal reactors. If we take this route (the Russians have already taken it, with the BN600 breeder reactor having run successfully for over 20 years), we could effectively multiply the world's dwindling energy resources by 10.

4. **Financial** incentives will be needed to restore investor confidence after policy vacillation and injudicious market intervention. The sharp fall in electricity prices, instigated by the regulator in a vain attempt to address fuel poverty, led to the near collapse of British Energy. This must not be allowed to happen again. There may have to be a minimum floor price for low-carbon, new-build electricity. A possible model to stimulate new nuclear build, and also the construction of a Severn barrage, would be for the electricity price to be guaranteed by letting a 50-year contract (or concession) at a fixed price (with escalators) for electricity supply and inviting appropriate consortia to bid for the contract. Additionally, clear long-term carbon price signals are essential.

[13] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR
[14] "What's in store? Supply, demand and storage issues in the UK gas market", Deloitte, 2007
[15] Scottish and Southern Energy, available at http://www.scottish-southern.co.uk/SSEInternet/index.aspx?rightColHeader=26&id=412

5. **Re-examine the balance of renewables** and look at comparative costs to remove carbon using different technologies (wind is one of the most expensive methods[16]). Banded ROCs, just introduced, are a step in the right direction. Heat from renewables, particularly from wood, should receive more encouragement. Wood-fired CHP plant can replace gas-fired boilers in small and medium-sized locations. Wherever possible, the wood should be indigenous and some of the absurdities such as the import of hazelnut shells and wood from the US and Finland, to be used for co-firing coal-fired power stations, thus attracting ROCs should be discouraged. Provision of solar heating and cooling, and 'passive' building techniques, should be included in rigorous building regulations.

6. **Give the go-ahead to build a Severn barrage**, which would provide 5% of the UK's electricity. A Severn barrage should be looked at in comparison with offshore costs. Both will be needed to approach our EU obligations. Other barrage sites around the coast, such as the River Mersey, should be examined with the prospect of pumped storage in mind.

7. **Restructure the grid**. Considerable investment will be needed if the transmission and distribution networks are to accommodate the development of new build and distributed generators, many of them renewables. Scotland in particular, with a high density of wind, wave and tidal resources, faces connection difficulties as described by the Highlands and Islands Enterprise 2007 report.[17] Offshore projects will lose viability if onshore connections are not upgraded. The upgrade of the Beauly-Denny line (through central Scotland) from 132,000 (132kV) to 400,000 volts (400kV) is currently subject to a public enquiry which is due to report in 2008. The Scotland–England 2.2GW interconnector will have to be substantially strengthened if the renewable energy coming from the Western Isles is to be sold into England.

8. **The Climate Change Levy** should be scrapped (why it was applied to nuclear power and hydro is a mystery), and replaced with an obligation on generators and suppliers to provide 50% of low-carbon electricity as early as is realistically possible. This should include all forms of low-carbon generation, especially nuclear. The driver for this is the current renewable electricity obligation of 10% by 2010 (which we will not reach). This will give a strong incentive to both renewable and nuclear electricity to attract a premium plus an additional premium for providing consistent, on-demand power whenever required. This figure of 50% renewable electricity ties in well with the energy balance for the UK's 15% share of the EU renewable energy obligation by 2020, which implies 40% renewable electricity in the mix.[18] Unfortunately it will not be met by that date. BERR's best estimate, in the 2007 Energy White Paper, is 14% by 2020. There will be a huge discrepancy.

9. **Decentralised distributed energy** has been the focus of much misinformed attention. If gas is the preferred fuel, CO_2 emissions will rise because centralised power stations are much more efficient than many small, local, domestic units. They also bring economies of scale. Losses in transmission in the high-voltage grid are only around 2%, but 5% or more is lost in the local network.[19] So the perceived savings from local generation are small. This would be putting the clock back to the 1920s (see analysis by Paul Spare in Energy World, October 2006).

10. **Energy-saving** programmes should be reassessed and resources streamlined to support the most successful strategies. There is a promising trend towards individual responsibility for energy saving. However, it must be understood that the major changes in demand behaviour of the magnitude and in the timescale needed to have a significant impact on the supply gap are not possible.

    Domestic energy efficiency has taken on new significance. As we move to an increasingly electrified society, heat will be increasingly provided by electricity as oil and gas prices soar. Heat-pump technology has improved enormously over recent years, and now pumps are available with real coefficients of performance of four (that is, one unit of electricity providing four units of heat from the ground or the air). Heat pumps should replace gas for domestic heating. If CO_2-free electricity is used to power them, they will make a significant reduction in CO_2 emissions and reduce dependence on imported gas.

[16] National Audit Office, "Department Of Trade and Industry: Renewable Energy", report by the Comptroller and Auditor General, Hc 210 Session 2004-2005, 11 February 2005
[17] "Assessment of the Grid Connection Options for the Scottish Islands", Highland and Islands Enterprise
[18] "2020 Vision – How the UK can meet its target of 15% renewable energy", Renewables Advisory Board June 2008
[19] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR

11. **Skills shortages in electrical and nuclear engineering** must be addressed urgently. Areva is trying to recruit 11,000 new engineers and technicians in Europe. This is proving very difficult. Up to 40% of staff at British Energy are due to retire within the next 10 years.[20] The new National Skills Academy for Nuclear is to be commended, but it will be rendered ineffective if there are no universities offering degrees in nuclear engineering. The industry is expected to need 1,000 new graduates a year for the next 15 years. Incentive bursaries should be offered at both undergraduate and postgraduate level. Grants for mature students should be encouraged to upgrade existing, transferable skills. Engineering and construction workers are also urgently needed. At its peak, building a Severn barrage would need 35,000 people.

12. **Switch surface transport to electricity**. Transport, with the exception of some train systems, is predicated on oil for land, sea and air. It will have to be weaned off oil and onto electricity where possible. This means an even bigger demand for base-load electricity. Trains should be first, then cars, both electric and hybrid. New battery technology makes this a very real possibility. Car parks should be fitted with charging points and replacement battery packs should be obtainable from filling stations. Fuel cells for transport are already available and being trialled in buses. Hydrogen may not be the best fuel due to generation, distribution and storage difficulties. Liquid fuels such as methanol from second-generation biofuels may be an alternative.

13. **Air transport**. It is difficult to contemplate fuels other than kerosene-type hydrocarbons being used for air transport, but a move to more efficient, turboprop propulsion systems is already appearing. It is possible to manufacture jet fuel from coal and biofuels via the Fisher-Tropsch process, and also from methane, currently flared off, by a synfuel process. This may become a security imperative if oil from the Middle East comes under pressure.

14. **Rolling targets** should be the paradigm for future policy. These should be set every five years or so, with success or failure impacting on the figures for the next target, rather than looking 40 years ahead (often with targets having little chance of realization). It is constructive to look at the scenarios developed by the Royal Commission on Environmental Pollution when it set a target of 60% reduction in CO_2 production by 2050. Those scenarios have been largely ignored. One startling scenario suggests, "keep demand in 2050 the same as in 1998, multiply renewables 20-fold and nuclear power 4-fold with 46 Sizewell B sized stations".[21] Other scenarios are even more extreme, particularly where nuclear power is not included. They have to be realistically re-examined but are unlikely to be watered down.

    A rolling target approach is more likely to be effective. The present Government talks of an 80% reduction being necessary by 2050 to keep CO_2 emissions below 550ppm. The implications of accommodating this "challenging" 80% target remain no more than a political objective until clearly defined in engineering and cost terms.

15. **Reinstate the Department of Energy** to bring all energy policy under one department with cabinet representation in the person of a Secretary of State, emphasising and reflecting the central role that energy plays in every aspect of government, business and day-to-day life.

[20] "Skills crisis looming in UK nuclear industry", The Times, 5 November 2007
[21] Royal Commission on Environmental Pollution (June 2000). "Energy – The Changing Climate"

Conclusion

This proposed policy is intended to heighten awareness of the growing energy gap as a matter of urgency. Electricity generation in particular is becoming a cause for grave concern. While this is acknowledged by the present Government (this report utilises the Government's own data; industrial leaders predict even higher generation losses), it continues ostensibly to leave the gap to be filled by the market, which in reality has been distorted by counterproductive intervention. Vacillation, procrastination and the lack of an appropriate investment framework have all served to severely hinder energy-supply development and our ability to meet environmental objectives.

That there will be supply–side difficulties is inevitable. A risk management strategy that identifies the responsibilities of government, local authorities and businesses in the eventuality of power interruption is imperative. Particular care must be taken to safeguard hospitals, schools, care homes and other vulnerable sectors of society.

Our Route Map to Energy Survival for the UK (see page 25) sets out a step-by-step action plan to mitigate the risks of large-scale power cuts and electricity "famine" by defining priorities and timescales for energy development.

From a global perspective, the conviction that "peak oil" and "peak gas" theories, which predict worldwide supplies will peak in the next few years (perhaps they already have, with oil at 86mbbls a day), and then go steadily downhill, is gaining ground. This fuels the growing belief that gas from the Middle East and Russia may not be available to satisfy the growing demand from Europe and the UK over the next 10 years (before a new strategy of new-build nuclear, renewables in quantity from a Severn barrage and coal-fired stations with CCS come on stream). Competition from China and India further diminishes our ability to lever access to affordable, secure hydrocarbon supplies. We have drifted into a situation resembling a slow motion train crash. South Africa has already hit the buffers with disastrous effects on its economy. Energy is the lifeblood of growing civilisations. Without it we slide into anarchy. Fortunately, there are high-technology solutions if we care to take them.

1 A Pragmatic Energy Policy for the UK

Background

1.1 The UK approach to energy policy changed in 1982 when Nigel Lawson, then Conservative Secretary of State for Energy, announced in his speech, "The Market for Energy", that energy was a traded good like any other commodity and its supply was to be settled in the market place.

1.2 The changeover to this philosophy was slow, but by the late 1980s and early 1990s there was a rash of privatisations. Gas, electricity, coal and eventually nuclear power were all privatised, and the old command and control mechanisms of monopolies like the Central Electricity Generating Board (CEGB) were swept away and replaced, in the case of electricity, by a plethora of generating and distribution companies. Electricity was marketed by a pool arrangement. This was something of a compromise as the then (1989) Secretary of State for Energy, Cecil Parkinson, was in a hurry to sell off electricity, no doubt in an attempt to realise the promised competitiveness element missing from the privatisation of British Telecom and British Gas. The esoteric rules of electricity trading have been tinkered with over the years with the introduction of NETA (new electricity-trading arrangements) and now BETTA (British energy-trading and transmission arrangements). Unfortunately, NETA and BETTA focus on short-term prices, with little co-ordination with concepts of security of supply or climate change, and they require radical revision. A variety of regulators throughout the privatised energy industries have exerted different pressures from time to time, nearly bankrupting British Energy and other generators in 2002. British Energy had to be rescued as prices were forced down by the regulator to accommodate "fuel poverty" (an archetypal example of disjointed policymaking without a thought of the consequences in the wider arena).

1.3 Another casualty of privatisation has been research into energy provision and use, where investment has fallen by 50% in 10 years. This is at a time when a massive research and development effort into carbon capture and storage (CCS) is required, along with distributed generation, large-scale electricity storage, nuclear fusion and the impact on grid stability of large intermittent input from wind generation.

Current energy policy

2.1 Energy policy is now aimed at delivering the twin imperatives of security of energy supply and protection of the environment, particularly the deceleration of climate change by stabilising emissions of carbon dioxide (the major greenhouse gas) at levels which will restrict a global temperature rise to 2°Celsius or less. The latest EU targets are for 20% renewable energy and a 20% reduction in greenhouse gas (GHG) emissions across the whole of the EU by 2020.[22] The UK's 15% renewable-energy target,[23] which implies a contribution of 40% renewable electricity[24] (as fossil fuels for transport and heating are harder to substitute), will be challenging, not to say impossible. BERR's latest modelling for the UK, with banded ROC inputs included, gives an anticipated figure of 14% renewable electricity by 2020.[25] This does not even approach the contribution to which we are legally committed. It emphasises the urgency of producing a robust energy strategy which has firm foundations in engineering, technical and fiscal probabilities (not wishful thinking as in the 2003 Energy White Paper).[26] Furthermore, vacillation in energy policy has severely hindered progress. This is a particular problem with nuclear power, where the present Government has made a series of U-turns culminating in the Energy White Paper of 2007,[27] in which nuclear power was finally confirmed as part of the future UK energy mix. Following further consultations, a new White Paper on Nuclear Power was published in January 2008, under which the Secretary of State for BERR could invite energy companies to come forward with proposals for new nuclear power stations. The present incumbent, John Hutton, has since confirmed, in a speech to UNITE in March 2008, that there is every reason to believe that the industry "could be contributing a significantly higher proportion of the UK's energy in the decades ahead."[28] We discuss later why this will take more than political rhetoric to achieve.

2.2 Renewable-energy policy fares no better. Developed in a piecemeal fashion, there is no overarching strategy for integrating renewable energy into total energy use. Particular sectors and technologies are being targeted by different policy instruments – the renewables obligation only targets technologies aimed at power generation, the renewable fuel obligation is aimed to encourage the use of biofuel in the transport sector, the Climate Change Levy targets use of fossil-fuel energy in the commercial sector (and, illogically, large-scale hydro and nuclear power), the EU ETS is aimed at capping and reducing carbon emissions from large organisations, while the forthcoming Carbon Reduction Commitment Scheme is aimed at improving energy efficiency across businesses not covered by the ETS and Climate Change Agreement. Other countries have similar problems but have been more successful than the UK in promoting renewables, particularly Spain and Germany where feed-in tariffs have been applied. But this can be a costly exercise – in Germany a unit (1kWh) is typically 40p compared with 5p in the UK. Nonetheless, without an all-embracing policy on renewable energy over the entire energy spectrum (heating, cooling, transport and electricity) we will struggle to get near our objectives on total energy use.

2.3 Policy vacillation and procrastination are primarily responsible for leading the UK into the unenviable position of facing the multiple problems of ageing nuclear power plants, the premature closure of coal-fired stations due to the EU Large Combustion Plant Directive (LCPD), and an under-performing renewables sector, all of which will accelerate the dependency on gas imports from unstable political regimes, all subject to volatile global markets.

2.4 We stand to lose 23GW[29], a third of our generating capacity, by 2020. Yet CO_2 emissions are still rising. A determined and urgent course of action as proposed in the **Route Map to Energy Survival for the UK** (see page 25) demonstrates how a new energy policy must divide into two timescales – a short-term strategy to deal with the impending energy gap without impeding the long-term strategy of meeting our energy requirements in an era when oil and gas will become increasingly scarce and the role of electricity takes on an even greater importance in sustaining our civilisation.

[22] "20 20 by 2020-Europe's climate change opportunity", speech to the European Parliament, Brussels, 23 January 2008
[23] "UK renewable energy strategy and the EU renewable energy directive", written ministerial statement, John Hutton MP: Secretary of State for Business, Enterprise and Regulatory Reform, 23 January 2008
[24] "2020 Vision – How the UK can meet its target of 15% renewable energy", Renewables Advisory Board, June 2008
[25] Government response to the Renewables Obligation Consultation, BERR, January 2008
[26] "Energy White Paper: Our energy future – creating a low carbon economy", February 2003
[27] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR
[28] Available at http://www.timesonline.co.uk/tol/news/uk/article3624612.ece
[29] "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR

3

Market failure

3.1 The UK approach to energy policy changed in 1982 when Nigel Lawson, then Conservative Secretary of State for Energy, announced, in his speech "The Market for Energy", that energy was a traded good like any other commodity and its supply was to be settled in the market place.

3.2 The 'market will deliver' philosophy is wishful thinking. Followers of Adam Smith may dispute this, but the market in the energy sector fails on several levels. Markets fail to work in the face of scant supply. Furthermore, as recognised by the Stern report[30], one of its more spectacular failures is that the market cares nothing for the environment. It caters for today's generation, not tomorrow's.

3.3 The market will not provide new nuclear stations, neither will it provide a Severn barrage. Government intervention will be essential. Energy infrastructure, such as power stations, represents some of the largest single investments in modern economies.[31] The market must have the right investment framework and incentives to contemplate long-term projects. Unfortunate vacillation over energy policy (nuclear being the salient example), and procrastination, particularly over carbon capture and storage (CCS), have severely hindered development by serving to undermine confidence. To kick-start a new-build programme, long-term price guarantees for electricity output may be the best catalyst. Clear carbon signals will also be essential to enable investors to assess long-term risks.

3.4 Inconsistent intervention, by 'cherry picking' technologies on unscientific grounds, is not helpful either. The renewables market has been distorted through unbalanced support for low capital renewables with least return in energy terms, such as wind. Helm (et al)[32] would describe this as "regulatory failure", where interventionist policies have unintended detrimental consequences on the markets they seek to correct.

[30] "Stern Review on the Economics of Climate Change, available at http://www.hm-treasury.gov.uk /independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

[31] "The market for energy: modelling and performance" D Helm, J Anderson Kay, D Thompson, (1989), Oxford University Press for the Institute for Fiscal Studies

[32] "The Market for Energy: modelling and performance", D Helm, J Anderson Kay, D Thompson, 1989

Counteracting current energy policy

4

4.1 The stark horror of our situation, not alleviated by the promotion of various green agendas with strong anti-nuclear bias, is only now dawning on politicians, some NGOs and the EU (vulnerability to security of supply is a Europe-wide issue[33]). The urgency of the situation and the need for action appears not to be appreciated in the UK. We have 10 years to put strategies in place to provide a diversified, clean energy supply which is not dependent on Russia or the Middle East. We need to install technologies to replace fossil-fuel-based electricity generation and oil-fuelled transport systems, as well as using energy much more efficiently.

4.2 Just one example of irresponsible procrastination is the case of carbon capture and storage (CCS), which is still only at the discussion stage. It should be developed as a matter of extreme urgency, yet two major demonstration plants have been cancelled on account of escalating costs. (These plants are the BP Peterhead CCS scheme and the more ambitious US FutureGen plant, where costs have doubled to USD1.8bn.[34]) In the UK, a competition is being run to choose the best system to develop – a very English way of doing things. The result will be announced during the summer of 2008, with a completion date for a demonstration plant hopefully by 2014. So, for the time being, we have no alternative but to build new coal-fired stations to provide security of supply and replace ageing plant, and to make provision in the stations exhaust system for CCS to be attached if, and when, it becomes available. A more positive step in the UK would be to capture carbon dioxide from one of the large East Coast coal-fired stations, and use gas pipelines already in place to inject the liquid CO_2 into failing oil wells to extract more oil. As the price of oil escalates, it becomes imperative that the last drop is squeezed out of an oil field. Thus carbon dioxide injection assumes increasing importance and market forces, for once, aid the environmental imperative.

4.3 The EU has been more stringent, insisting that new coal plant built in the next two years must have carbon dioxide separation and liquefaction equipment included. Incentives will have to be provided to encourage use of CCS technology. (A carbon tax in Norway stimulated Statoil to sequester the carbon dioxide it would otherwise have emitted to atmosphere). Carbon credits could be another stimulus. Adding to the urgency of developing this technology is the realisation that the world is moving towards a peak in oil and gas production, and that post 2012, it will be downhill all the way for oil (a little later for gas). This means that coal, with 10 times the proven reserves of oil and gas, will have to step into the breach, but it will have to be burnt cleanly and with minimum emissions.

[33] "Europe's Vulnerability to Energy Crises", World Energy Council 2008
[34] Available at http://www.businessgreen.com/business-green/news/2208820/backers-protest- doe-scraps 5 February 2008

5

Restructuring the grid

5.1 Considerable investment will be needed if the transmission and distribution networks are to accommodate the magnitude of new build, distributed generators and renewables. The majority of renewables projects tend to be sited at remote locations away from centres of demand (a Severn barrage would be the exception). In particular, Scotland, with a high density of wind, wave and tidal resources, faces connection difficulties as described by the Highlands and Islands Enterprise 2007 report.[35] Offshore projects will lose viability if onshore connections are not upgraded (the upgrade of the Beauly-Denny line through central Scotland, from 132,000 (132kV) to 400,000 volts (400kV), is currently subject to a public enquiry which is due to report in 2008). Recent Ofgem initiatives and new price-control proposals are positive strategies, but a greater symbiosis between technology development, planning and connection is critical.

5.2 The Scotland–England 2.2GW interconnector will have to be substantially strengthened if the renewable energy coming from the Western Isles is to be sold into England.

6

Storage

6.1 Gas storage has long been recognised as a security of supply component, but insufficient action has been taken (we continue to lag behind required levels of storage). A significant increase in gas and electricity storage capacity is essential. Our principal partners in the EU have an average of 56 days' supply of gas – Germany has 70 days, we have 14.[36] Depleted gas fields in the North Sea can be used for gas storage. Onshore initiatives should be developed, such as the gas storage facility at Hornsea in East Yorkshire, where nine man-made salt cavities have been leached into a salt layer 1.8 kilometres below the surface creating 325 million cubic metres of gas storage space.[37]

6.2 Electricity storage, particularly batteries, is prohibitively expensive, although research continues. We have pumped storage capacity (for example, Dinorwig, at 1.7GW for up to six hours), but this capacity should be expanded at new sites if possible and in parallel with a programme of tidal-barrage developments designed to include pumped storage. The shortcomings of electricity storage emphasises the need for reserve capacity in the system.

[35] "Assessement of the Grid Connection Options for the Scottish Islands", Highland and Islands Enterprise
[36] "What's in store? Supply demand and storage issues in the UK gas market", Deloitte, 2007
[37] Scottish and Southern Energy, available at http://www.scottish-southern.co.uk/SSEInternet/index.aspx?rightColHeader=26&id=412

Balancing supply and demand

7.1 Analysts are largely in agreement that demand for energy will rise steadily to double the 2000 figures by 2050. The latest IEA[38] report forecasts a 50% rise by 2030. As far as oil is concerned, this means an increase in world daily output from 85 million barrels per day (mbbl/d) to 120mbbl/d. But at the influential Rimini Conference (Centro Pio Manzu) of 2006, it was concluded that a peak supply of 100mbbl/d could be anticipated by 2012, and thereafter a steady decline by 1 or 2% a year. In 2006, the Texan oil mogul, T Boone Pickens, said that he doubted if we could ever rise much above 85mbbl/d. The reasons for this are complex, and as much about engineering and investment as a simple resource limit. Nonetheless, oil shortages are beginning to bite. High oil prices[39] are already raising serious problems, particularly for transport.

7.2 It is apparent that the UK energy gap is opening up just as the developing world increases its demand and economic growth accelerates. A move away from oil and gas is imperative, for security of supply reasons as well as escalating prices. The EU currently depends on imports of 60% of its fuel. On current trends, this is forecast to reach almost 70% by 2030 if no adequate policy measures are taken in response.[40]

7.3 A reappraisal of UK and world fossil-fuel reserves would be timely. Reserve figures have often been inflated for political and economic reasons, and the quoted oil figures for some Middle East producers are possibly out of date.

7.4 In the UK, the strategic importance of the North Sea, already in decline, should be recognised by establishing a depletion policy rather than leaving it for the market to randomly manage.

7.5 The biggest impending problem for the UK is in electricity generation. Between 2008 and 2020, 23GW of electricity generating capacity will be decommissioned, representing about one third of our electricity supply. Post 2023, only one nuclear station will remain, Sizewell B (1.2GW). A further 10GW will go by 2027.[41] The EU Large Combustion Plant Directive (LCPD) of 2008 will cause the closure of six coal stations by 2015 and more will follow as emissions regulations are further tightened.

7.6 Electricity generating plant which has opted out of the Large Combustion Plants Directive

Type of station	**Stations**	**Capacity**	**Impact**
Opted-out coal	Didcot A	2100 MW	These stations are required to operate
	Kingsnorth	2000 MW	for no more than 20,000 hours after
	Cockenzie	1200 MW	1 Jan 2008 and must close by
	Tilbury	1100 MW	31 Dec 2015. The plants could reopen as "new" plant if they meet new plant
	Ferrybridge (part)	1000 MW	emission standards.
	Ironbridge	1000 MW	
	Total	**8400 MW**	
Opted-out oil	Fawley	1000 MW	These stations must close by
	Grain	1400 MW	31 Dec 2015. They are likely to be used for peaking only (as they only become
	Littlebrook	1200 MW	economical at high electricity prices). So the 20,000 hour limit is unlikely to constrain their running.
	Total	**12000 MW**	

Source: BERR Energy Markets Outlook, October 2007, pp 22

38 "World Energy Outlook 2007", International Energy Agency
39 "The puzzle of oil production", the Economist, 19 June 2008
40 "Europe's Vulnerability to Energy Crises", World Energy Council 2008
41 "Meeting the Energy Challenge, A White Paper on Energy", May 2007, BERR

The youngest coal-fired station is Drax, located near Selby, North Yorkshire, which was completed in 1986. Coal-fired stations can be upgraded by conversion to supercritical steam operation (planned new stations will operate with 46% efficiency compared with 35%) and new emission-control systems can be added, but this is not always economically acceptable. Integrated gasification combined cycle (IGCC) coal stations are even more efficient at over 50%. Another way of bridging the energy gap is to keep the opted-out coal-fired stations operating past 2015, in spite of EU emissions regulation. Although this is not conducive for the UK's "clean" image, it may be unavoidable.

7.7 The industry prefers to build new coal-fired stations. One is planned for Kingsnorth in the Thames estuary by E.ON, but a predicted 20% reduction in emissions compared with the coal stations it will be replacing is not enough to placate strong environmental opposition. If security of supply is to be maintained, the impact of the LCPD requires significant new plant in the middle years of the next decade, particularly if demand trends continue. As the Redpoint report explains[42], by 2016 "peak demand will have grown by between 5 and 8GW. The figure rises to 30% by 2020."

7.8 The mix of plant which will replace these old coal-fired and nuclear stations through the next decade will have a profound effect on the level of CO_2 emissions. It is worth noting that nuclear power currently reduces UK carbon emissions by between 7% and 14%.[43] The market, however, will deliver new gas-fired stations as they can be built in less than four years, and possibly new coal-fired stations as fuel costs are now lower. Renewables, probably on-shore wind, can make a contribution, but this must be kept in perspective. The shortfall is the equivalent of 23 stations of 1GW each by 2020. Notably, it takes 1,400 3MW wind generators to equate to one 1GW power station. A build rate of two new stations of one kind or another per year is needed. Two nuclear stations might just be available by 2020, but only if an urgent programme of new build is stimulated by Government. A new nuclear station will last for 60 years and an investor needs reassurance that he will still be getting a reasonable price for his electricity in 60 years' time. A modern station will cost £3 million to £3.5 billion and generate electricity at around 3p per unit, which compares very favourably with gas or coal and includes decommissioning costs.[44] As fossil-fuel prices rise, nuclear power will become a price-stabilising mechanism. Electricity from renewables such as wind is expensive but heavily subsidised, which distorts the market. The cumulative subsidy for renewables by 2020, according to BERR's modelling[45], will be £23 billion. Nonetheless, between them nuclear and renewables are the only two technologies currently available to generate carbon-free electricity, with the potential of generating 50% of UK electricity. It seems inescapable that in the short term, CO_2 emissions will continue to rise, not fall.

7.9 The short-term outlook is bleak. The table below shows the seven nuclear stations due to be decommissioned during the next 10 years, with just three remaining early into the next decade.

7.10 Longer-life extensions for our aging nuclear stations will have to be urgently investigated, with individual assessment of technical, financial and safety viability.

7.11 Estimated closure dates of nuclear power plants in Great Britain if operating lives are not extended

Station	Capacity	Type of reactor	Date for decommissioning
Oldbury	470 MW	Magnox	2008
Wylfa	980 MW	Magnox	2010
Heysham	1,200 MW	AGR	2014
Hartlepool	1,210 MW	AGR	2014
Hinkley B	1,260 MW	AGR	2016
Hunterston B	1,210 MW	AGR	2016
Dungeness B	1,080 MW	AGR	2018
Subtotal	**7410 MW**		
Heysham 2	1,200 MW	AGR	2023
Torness	1,200 MW	AGR	2023
Total	**9810 MW**		
Sizewell B	1,188 MW	PWR	2035

Source: BERR Energy Markets Outlook. October 2007, pp 24

[42] "Dynamics of GB Electricity Generation Investment", 18 May 2007, Redpoint, pp12-13
[43] "Nuclear Power Generation Development", BERR, available at http://www.berr.gov.uk/energy/sources/nuclear/technology/generation/page17922.html
[44] "The Cost of Generating Electricity", Royal Academy of Engineering, 2004
[45] "Renewables Obligation Consultation: Updated Modelling for Government Response (URN 08/555)", BERR, January 2008

Nuclear power

8

8.1 Nuclear power will have to provide the lion's share of CO_2-free electricity for reasons of both security of supply and cost. The injudicious statement in the 2003 Energy White Paper that nuclear power is unlikely to be part of the UK energy mix has lost us valuable time. In the meantime, the present Government sold off Westinghouse, one of only five builders of nuclear power stations in the world and one with a large and growing order book – a significant error of judgement. The Energy White Paper of 2008 is clear that nuclear new build is required. This has been endorsed by the Prime Minister, who has stated for the first time that building plans for nuclear plants should be expanded beyond merely replacements. [46] This will not be easy to achieve.

8.2 We need to build 46 new stations over the next 40 years (according to the Royal Commission of Environmental Pollution scenario of 2000).[47] In France, electricity supply is 78% nuclear, and at the height of their building programme they were commissioning a new reactor every two weeks. However, today, with a worldwide nuclear renaissance, there are a number of bottlenecks. Only five companies worldwide are capable of turnkey construction of nuclear power stations and, at the moment, only two companies are capable of making the huge forgings necessary for their construction. Both Japan Steel and Areva have long waiting lists as countries around the world move down the nuclear route and join the queue for new stations.

8.3 There is also a severe shortage of engineers and technicians with nuclear experience in Europe. AREVA alone is attempting to recruit 11,000, with great difficulty. Up to 40% of staff at British Energy are due to retire within the next 10 years.[48] The new National Skills Academy for Nuclear is to be commended, but it will be rendered ineffective if there are no universities offering nuclear engineering degrees. The industry is expected to need 1,000 new graduates a year for the next 15 years. Universities and colleges are belatedly trying to rectify matters, but it will take time. Skills training needs addressing across the energy sector. Engineering and construction workers are also urgently needed.

8.4 Certificating new designs, going through planning procedures and dealing with environmental and health and safety matters will also take time, although countries like Finland and France, who are each building a new European Pressurised Water Reactor (EPR), have addressed these problems as they dispose of the waste to the satisfaction of their population and politicians.

8.5 There are currently four Generation III designs on offer:

1. ACR 1000(CANDU II) of Atomic Energy of Canada (although this has recently withdrawn from the bidding)
2. European Pressurised Water Reactor (EPR) built by EDF/AREVA
3. ES Boiling Water Reactor (ESBWR) built by General Electric/Hitachi
4. AP 1000 of Westinghouse/Toshiba

All use enriched uranium fuel and light water coolant and derive from designs currently in operation.

8.6 The next stage of new build will be a move to high temperature, gas-cooled reactors which can be used for hydrogen production and can be modular units of 165MW, which would be particularly suitable for smaller or developing countries. Generation IV will be a move to High Temperature Breeder reactors, which use uranium fuel 60 times more efficiently than today's thermal reactors. The Russians have had such a reactor, the BN600, operating for over 20 years. A worldwide move to breeder technology would effectively multiply world energy resources by 10.

[46] "Brown expands nuclear ambition", BBC News, 28 May 2008, available at http://news.bbc.co.uk/1/hi/uk_politics/7424158.stm
[47] "Energy – The Changing Climate", Royal Commission on Environmental Pollution, June 2000.
[48] "Skills crisis looming in UK nuclear industry", The Times, 5 November 2007

9

Renewable energy contribution

9.1 It is now clear that renewable energy will have to play an increasingly important role in providing CO_2-free electricity, but the best that can be hoped for by 2020 is 14% of UK electricity. Any notion that the nuclear contribution to CO_2-free electricity can be replaced by renewables, particularly wind, does not stand up to scrutiny. Renewable electricity currently contributes 4.5% of the total supply, of which hydro is 25.5%, landfill gas is 25.5%, wind 23% and 27% from other sources.[49] The Renewables Advisory Board has pointed out that we will be lucky to get to 6% renewable electricity[50] (not 10%, the target for 2010). But in the process of attempting to get to 20% by 2020, the next UK target, we will have to run very fast just to stand still. The progressive loss of the nuclear, CO_2-free component will present the additional challenge of simply replacing one CO_2-free source with another while making no inroads on gas and coal. The phenomenal number of wind turbines required to do this demands serious consideration. An onshore turbine with an installed capacity of 2MW generates on average 500kW. In other words, it has a load factor of 25%. It takes 2,400 2MW wind turbines or 1600 3MW turbines to replace one 1.2GW nuclear station. Similarly, it would take 3,200 new 3MW turbines just to replace Scotland's two nuclear stations, which currently provide 40% of Scotland's electricity (and there are no plans to rebuild these stations). The unpredictable and intermittent nature of wind is best described by E.ON Netz GmbH, which has more experience of the practical realities of managing a large wind carpet in a modern grid than any other organisation in the world. Chief Executive, Martin Fuchs explains that:

a) the wind blows WHEN it likes;
b) the wind blows AS it likes (despite increasingly accurate forecasts it is difficult to predict its actual strength); and
c) the wind blows WHERE it likes, which unfortunately is rarely in places where large quantities of power are required.

These figures do not take into account that as the amount of wind-generated electricity in the system increases, so does the requirement for back-up or "shadow capacity" as it is termed in Germany.

9.2 The additional 25GW of offshore wind capacity, recently announced by BERR Secretary of State, John Hutton[51], is the nameplate capacity of the proposed 7000 turbines. In reality, assuming a load factor as high as 30%, they will provide an average 8GW of supply. But to achieve this will require installing 10 turbines every available working day (only 60 days per year in the North Sea) from now until 2020, which is 10 times the best installation rate achieved anywhere for offshore wind turbines. Currently there is only one heavy-lifting barge (MPI Resolution) capable of installing these huge machines in the seabed, and that cost £75 million. Furthermore, the difficulties in integrating large amounts of intermittent generation, as experienced by Germany and Denmark, are also now well understood.[52] Yet the Government's expectation is that wind power will provide two thirds of the 2020 target of 20% renewable electricity. Moreover, costs are rising rapidly. Shell has pulled out of the Thames Array 341-turbines project because costs have doubled in 12 months. Shortages of turbines and high grid-connection costs make matters worse.[53] Furthermore, the National Audit Office[54] identified wind power as one of the most expensive ways of reducing carbon emission, with recent reports[55] claiming that abating one tonne of carbon costs between £280 and £510. This compares with £10 to £20 per tonne in the European Emission trading scheme.

9.3 To date there has been strong growth in using biofuels, landfill gas and co-fired biomass, in addition to onshore wind, to generate electricity. But growth rates lag well behind target obligation levels. The new banding approach for ROCs, designed to allocate subsidy more efficiently to a wider range of technologies than the current system, is aimed at providing more support for emerging technologies such as marine renewables, tidal stream and wave power. These are as yet immature but are deemed to have potential.

[49] Digest of UK Energy Statistics (2007), table 7.4, "Capacity of, and electricity generated from, renewable sources, BERR, 2007
[50] "2020 Vision – How the UK can meet its target", Renewables Advisory Board, June 2008
[51] Available at http://nds.coi.gov.uk/environment/fullDetail.asp?ReleaseID=337237&NewsAreaID=2
[52] "UK Energy Policy: The Small Business Perspective & The Impact on the Rural Economy", C Whitmill, 2006
[53] ENDS Report, 13 December 2007
[54] National Audit Office, "Department Of Trade and Industry: Renewable Energy", report by the Comptroller and Auditor General, Hc 210 Session 2004-2005, 11 February 2005
[55] D Helm, Wall Street Journal, 18 March 2008

A Severn barrage (also see page 37)

10.1 Tidal power in particular could provide at least 10% of the UK's current electricity demand. Unlike wind it is a totally predictable energy source for centuries ahead. Tidal-stream energy is a nascent industry, but tidal-range energy uses proven technology. In Brittany, a barrage at La Rance has generated electricity successfully for the past 40 years. The concept of a barrage in the Severn Estuary has undergone 70 years of research and study, but building has not gone ahead because costs were perceived as too high. But now, with energy costs from all sources rising, bankers and investors are looking at the venture as economically viable, although the long lead-in time necessitates a form of guarantee for output price. The most researched option is the Cardiff-Weston alignment, which would have a capacity of 8640MW and produce 5% of current UK electricity demand. The capital costs are unarguably high – approximately £15 billion – but the barrage would have a lifetime of at least 120 years with low maintenance costs. Costs per kWh compare very favourably with offshore wind.

10.2 Pressure groups are beginning to realise that they cannot oppose all developments that affect the environment and risks must be balanced with benefits. As our special report identifies, while environmental changes are feared, the Severn Estuary is dynamic and already adapting to changing climatic conditions. There is also a growing body of evidence that predicts a more positive outcome for biodiversity than previously envisaged. External benefits should also be taken into account, such as flood protection for vulnerable urban and agricultural land and opportunities for sustainable economic development for both South Wales and the South West. Depending on the envisaged growth scenarios, a considerable number of new jobs, both direct and indirect, are inevitable. Construction alone will need 35,000 workers during the peak years. And 50% of jobs created will be in the Severnside region.

10.3 The generation options for the Severn Estuary are currently subject to the latest BERR Feasibility Study that builds on the Sustainable Development Study published in October 2007. It aims to reach a first conclusion on whether to proceed by the end of 2008, with further studies to be completed by early 2010. Environmental, social and economic impacts will be examined. Commentators construe that with a barrage, we will have insurance against rising fuel prices, a significant contribution to security of supply and flood protection, and a CO_2 saving of around 500,000 tonnes every month. Without a barrage, the Severn Estuary ecosystem will continue to adapt to environmental changes and face increased flooding. Nevertheless, what is clear is that the decision not to proceed with a barrage cannot be made without the decision on how renewable energy and CO_2 targets can be met another way. Whatever the decision, it will have far-reaching consequences on a cohesive energy policy and thus must be determined with the utmost urgency.

11

Reforming carbon taxes

11.1 The Climate Change Levy should be scrapped (why it was applied to nuclear and hydro power is a mystery) and replaced with an obligation on generators and suppliers to provide 50% of output in the form of low-carbon electricity as early as is realistically possible. All forms of low-carbon generation, especially nuclear, should be included in the definition "low carbon". The precedent for this is the current renewable electricity obligation of 10% by 2010 (which we will not reach). This will give a strong incentive to both renewable and nuclear electricity to attract a premium, with an additional premium for providing consistent, on-demand power whenever required. This figure of 50% renewable electricity ties in well with the energy balance for the UK's 15% share of the EU renewable energy obligation by 2020.[56] Unfortunately, it will not be met by that date. Projections by BERR[57] developed for the planned banding of the renewables obligation anticipate renewable electricity growth to 9%, 13.5% and 14% of UK electricity by 2010, 2015 and 2020 respectively. Even these figures are seen as optimistic and do not begin to approach the 15% renewable energy target of the EU Directive[58], which is described as "very challenging" by the Secretary of State and implies 40% renewable electricity. BERR's best estimate, in the 2007 Energy White Paper, is 14% by 2020. There will be a huge discrepancy.

[56] "2020 Vision – How the UK can meet its target of 5% renewable energy", Renewables Advisory Board, June 2008
[57] "Renewables Obligation Consultation: Updated Modelling for Government Response (URN/08/555)", BERR, January 2008
[58] "20 20 by 2020 – Europe's climate change opportunity", speech to the European Parliament, Brussels, 23 January 2008

Distributed and microgeneration

12.1 Much has been made of the potential for distributed electricity generation, combined heat and power (CHP), waste incineration etc and microgeneration (for example, domestic scale CHP, mini-hydro, biofuels, wind and solar). In a way this is putting the clock back to the 1920s and '30s when there were many local generating stations – 400 in the Greater London area alone. A grid system was introduced with centralised generation to improve efficiency of operation (by about 25%[59]). The centralised system consists of a number of large generating units (1 to 2GW) and medium units (around 100 to 400MW) and achieves considerable economies of scale. The same number of men is required to run a 40MW station as to run a 400MW station. However, the waste heat from a large power station is rarely used. (Millions of gallons of lukewarm water at 30 degrees Celsius could be used for agriculture or fish farming.) With smaller units, which are usually combined heat and power (CHP) systems, the waste heat can be at 120°Celsius and used for district heating and process heat, giving a high overall efficiency. If gas-firing is used, CO_2 emissions for the same power output are higher for the distributed system than for the centralised system, and growth in distributed gas-fired systems would increase the vulnerability of the UK to interruptions in gas supply. CHP accounts for 5,500MW of electricity generating capacity[60], which is half the Government's target of 10,000MW by 2010.

12.2 Other distributed systems are more environmentally friendly and are zero-carbon or carbon neutral. There are 2032 wind turbines in the UK (as at May 2008), installed over the last 17 years or so, with a nameplate capacity of 2,546MW[61] (which gives an average output at 25% load factor of just over 600MW). Total solar PV is 10MW, and 90 mini-hydro stations and biofuel/waste stations amount to around 1,500MW.[62] The largest biomass-fired generating station, Steven's Croft at Lockerbie, is 40MW, although the new wood-burning station at Port Talbot will be 350MW, using imported wood from USA and Canada.

12.3 There is a large potential for waste incinerators which recycle waste by combustion to generate electricity and heat in CHP systems. They can be built at the point of use in cities and would alleviate the landfill problem. Currently, 11% of municipal waste is incinerated and generates electricity.[63] This figure could rise to 25%.[64]

12.4 Distributed generation does not reduce transmission losses to any great extent as the local distribution losses are around 6%, compared with grid-network losses of less than 2%.[65] The slow growth in distributed systems can be attributed to a number of factors – high capital cost, meagre returns for exported electricity, high connection fees and the cost of metering arrangements. With domestic-scale micro systems, payback times can be disappointingly long – 35 years at least for a 1kW wind turbine[66] and 16 years for a solar electric roof (even with a 50% capital grant). Only 18,000 homes have been fitted for micro-generation in the last four years, despite grants of £86 million. Growth has been much faster in Germany with, for example, the 100,000-roofs project which has been stimulated by lavish feed-in tariffs, typically 40p per unit compared with 5p in the UK. This is an area with potential, but it needs continuing financial support and is unlikely ever to exceed 8000 to 9000MW, most of which will be CHP (currently 5,500MW).

59 "Micro-generation – what about the downside?", P Spare, Energy World, October 2006
60 Digest of UK Energy Statistics (2007), table 6A, "A summary of the recent development of CHP", BERR
61 BWEA, available at: http://www.bwea.com
62 Digest of UK Energy Statistics (2007), table 7.4, "Capacity of, and electricity generated from, renewable sources", BERR, 2007
63 Municipal Waste Management Statistics, Defra November 2007, available at http://www.defra.gov.uk/environment/statistics/wastats/bulletin07.htm
64 Available at http://www.defra.gov.uk/environment/waste/strategy/factsheets/energy.htm
65 "Meeting the Energy Challenge, A White Paper on Energy, May 2007, BERR
66 "Small Wind Energy Systems", BWEA Briefing sheet, available at http://www.bwea.com/pdf/briefings/smallsystems.pdf

13

Energy saving and efficiency

13.1 The "Save It" campaign was instigated in the 1970s (by Bernard Ingham, later Mrs Thatcher's press secretary but working for Tony Benn at the time) after the first oil price hike and similar campaigns have run during the intervening 40 years, but with only limited success. Grants have been made available (for example, for boiler upgrades and insulation), but they have always been inadequately administered and frequently oversubscribed within 24 hours of their announcement.

13.2 Energy-saving programmes should be reassessed and resources streamlined to support the most successful strategies. There is a promising trend towards individual responsibility for energy saving. However, it must be understood that the major changes in demand behaviour, of the magnitude and in the timescale needed to have a significant impact on the supply gap, are not possible.

13.3 A 10-year programme is needed, funded perhaps from a revenue-neutral carbon tax, to upgrade all the housing stock to an acceptable energy-efficiency standard, rather like the programme in the early 1970s to change all gas appliances from town gas to natural gas. It could bring about substantial energy savings.

13.4 In moving to an increasingly electrified economy, where electric heating replaces expensive oil and gas heating at domestic and commercial levels, heat-pump technology comes into its own. Pumps are available with coefficients of performance of 4 and sometimes more. That is, one unit of electricity is used to drive the pump and it provides four units of heat from the ground or ambient air. Heat pumps will make a significant reduction in CO_2 emissions and reduce dependence on imported gas and oil, but they will require increasing amounts of electricity, which will have to be generated by nuclear or carbon-capture coal.

14

Transport

14.1 Transport, with the exception of certain railway routes and systems, is predicated on oil for land, sea and air. It will have to be weaned off oil and onto electricity, and possibly hydrogen. This will create an even bigger demand on the nuclear sector to supply the electricity. The switch to electric operation would be focused firstly on trains not already electrified, then on cars (electric and hybrid). New battery technology makes this a real possibility. Car parks should be fitted with charging points, and replacement battery packs should be made available at filling stations. Trucks and buses could be more appropriately powered by hydrogen fuel cells. However, hydrogen may not be the best fuel due to generation, distribution and storage difficulties, and its low energy density (one 30th that of gasoline). Liquid fuels such as methanol from second generation biofuels may be an alternative.

14.2 It is difficult to contemplate fuels other than kerosene-type hydrocarbons being used for air transport, but a move to more efficient turboprop propulsion systems is already appearing. It is possible to manufacture jet fuel from coal and biofuels (via the Fisher-Tropsch process), and from methane, currently flared off by a synfuel process. This may become a security imperative if oil from the Middle East comes under pressure.

Rolling targets

15

15.1 Rolling targets should be the paradigm for future policy. These targets should be set every five years or so, with success or failure impacting on the figures for the next target. This is preferable to looking 40 years ahead, often with targets which have little chance of realization and which only make people shrug their shoulders and despair. It is constructive to look at the scenarios developed by the Royal Commission on Environmental Pollution when it set a target of 60% reduction in CO_2 production by 2050[67]. The scenarios are rather startling, but have been largely ignored. For example, one scenario suggests we "keep demand in 2050 to the same levels as in 1998, multiply renewables 20-fold and nuclear power four-fold (requiring 46 Sizewell B sized stations)". Other scenarios are even more extreme, particularly where nuclear power is not included. These all have to be realistically re-examined, but are unlikely to be watered down.

15.2 A rolling target approach is more likely to be effective. The Government now talks of an 80% reduction being necessary by 2050 to keep CO_2 emissions below 550ppm. The implications of accommodating this "challenging" 80% target are such that it remains no more than a political objective until it is clearly defined in engineering and cost terms.

Finance

16

16.1 The privatised nature of the UK Energy Market makes it difficult for the Government to be prescriptive, but the market will not provide new nuclear stations by itself[68]. Neither will it provide a Severn barrage. Government assistance will be essential.

16.2 Financial incentives will be needed to restore investor confidence after policy vacillation and injudicious market intervention. The sharp fall in electricity prices instigated by the regulator in a vain attempt to address "fuel poverty" led to the near collapse of British Energy. This must not be allowed to happen again. To encourage their construction, there may have to be a minimum floor price for low-carbon electricity from new-build sources. A possible model to stimulate new nuclear build and the construction of a Severn barrage would be for the electricity price to be guaranteed. A 50-year contract (or concession) could be let at a fixed price (with escalators) for the electricity supply and appropriate consortia invited to bid. Additionally, clear long-term carbon-price indications are essential. Hopefully, the conclusions of PricewaterhouseCoopers, who are commissioned to seek financial models for a Severn barrage as part of the BERR Feasibility Study, will prove innovative and encouraging for the private sector.

[67] "Energy – The Changing Climate", Royal Commission on Environmental Pollution, June 2000
[68] "Key adviser says the UK's nuclear policy is flawed", D Helm, The Times, 28 January 2008

17

Conclusion

17.1 This proposed policy is intended to heighten awareness of the growing energy gap as a matter of urgency. Electricity generation in particular is becoming a cause for grave concern. While this is acknowledged by the Government (this report is based on the Government's own data – industrial leaders predict even higher generation losses), it continues ostensibly to leave the gap to be filled by the market which, in reality, has been distorted by counterproductive intervention. Vacillation, procrastination and the lack of an appropriate investment framework have all served to severely hinder energy development and our ability to meet environmental objectives.

17.2 That there will be supply-side difficulties is inevitable. A risk-management strategy that identifies the responsibilities of government, local authorities and businesses in the eventuality of power interruption is imperative. Particular care must be taken to safeguard hospitals, schools, care homes and other vulnerable sectors of society.

17.3 The **Route Map to Energy Survival for the UK** sets out a step-by-step action plan to mitigate the risks by defining priorities and timescales for energy development.

17.4 From a global perspective, the theories that "peak oil" and "peak gas", which predict worldwide supplies will peak in the next few years (perhaps already with oil at 86mbbls/day) and then go steadily downhill, is gaining ground. This fuels the growing belief that gas from the Middle East and Russia may not be available to provide the growing demand from Europe and the UK over the next 10 years until a new strategy of new-build nuclear, and renewables in quantity from a Severn barrage and coal-fired stations with CCS come on stream, which will gradually improve the situation. Competition from China and India diminishes our ability to lever access to affordable, secure hydrocarbon supplies. We have drifted into a situation resembling a slow-motion train crash, South Africa has already hit the buffers with disastrous effects on its economy. Energy is the lifeblood of growing civilisations, without it we slide into anarchy. Fortunately there are high-technology solutions if we care to take them.

A Route Map to Energy Survival for the UK

"Electricity is the life blood of civilisation, without it we spiral down into anarchy and barbarism." Ian Fells

This paper forms part of the report "A Pragmatic Energy Policy for the UK".

Contents

Where we are today

The UK is facing an unprecedented energy crisis. A combination of ageing nuclear power plants, the premature closure of coal-fired stations due to the EU Large Combustion Plant Directive (LCPD), and an under-performing renewables sector, is accelerating our dependency on gas imports from unstable political regimes and our vulnerability to volatile global markets. By 2012 to 2015, shortages, such as those experienced by half a million people in May 2008 when seven power stations unexpectedly stopped working within hours of each other, could be frequent. The Government of the day will be held responsible, irrespective of mitigating factors. There are decades of evidence predicting today's scenario.

If energy policy continues on its present path, it will seriously threaten the economy, security and social wellbeing of the UK.

- The UK's total generating capacity during winter 2007-2008 was around 75GW, but operating capacity was only 65GW.[69] Peak demand is just over 60GW[70], worryingly close to 65GW. Peak demand is expected to increase to around 65GW over the next seven years (according to the National Grid Company's seven-year statement of 2008).
- Two nuclear stations (Heysham and Hartlepool), totalling 2.4GW of capacity, are off line until 2009, and two more (Hunterston and Hinkley) are on reduced output. This is an illustration of what to expect from an ageing fleet. The planned decommissioning of 7.4GW of nuclear power plant by 2020, and 9.8GW by 2023 (10% and 13% of current generating capacity), will leave just one plant in service, Sizewell B.[71]
- In addition there is an expected closure of 12GW (15% of current capacity) of coal- and oil-fired generating plant by 2016 as a result of the 2008 EU Large Combustion Plant Directive (LCPD), which aim to reduce emissions.
- Despite considerable financial support, renewables are currently only capable of producing a maximum of 4.5% of UK requirements, well below target. However, while renewables have an important role to play, unrealistic expectations may have elevated them above their capabilities. Renewables will not replace base load. The exception is tidal, which is totally predictable and can produce base load during its periods of operation.
- In all a total of 23GW (30% of generating capacity) will need to be replaced by 2020 and 30 to 35GW by 2027.[72] This is almost entirely base load capacity.
- The 'market will deliver' philosophy is simply delivering more gas-fired stations, being the fastest and cheapest to build. Meanwhile, our own reserves of gas are diminishing to the extent that we will be importing 80% by 2020, increasing our dependence on supplies from unstable political regimes and volatile markets.
- CO_2 emissions are rising, not falling, and are higher now than in 1997.
- There is no realistic possibility of meeting the present Government's targets of a 20% reduction in CO_2 emissions with a 20% renewables component by 2020.

Security of energy supply must now be seen as taking priority over everything else, even climate change. The UK's imports of both gas and oil are accelerating, just as the fragility of supplies from Russia and the Middle East becomes more apparent and the UK heads towards the loss of one third of its generating capacity in the course of the next 12 years.

Only an urgent, determined course of action can avert the looming disaster. A new energy policy must be timed to meet the impending energy gap with an overarching long-term vision that will ensure security of supply, protect the environment and, at the same time, be deemed feasible by the engineers, financiers and utility managers who will have to implement it.

This **Route Map to Energy Survival for the UK** is part of "A Pragmatic Energy Policy for the UK", and is a strategy that determines the priorities under two distinct timescales.

- **Short term** – up to 2020: replace urgently the 23GW of lost base load capacity
- **Long term** – beyond 2020: provide additional capacity to match further losses and allow for demand growth of approximately 1GW per year.

[69] Energy Markets Outlook, BERR, October 2007
[70] National Grid reserve data, Jan-April 2008
[71] Energy Markets Outlook, BERR, October 2007
[72] Meeting the Energy Challenge, A White paper on Energy", May 2007

Short-term strategy

Filling the energy gap

Nuclear power cannot help to fill this short-term gap. To be realistic, it takes at least 10 years from inception for a new nuclear power station to come online. If orders are placed immediately, two stations might be available by 2019. But there are bottlenecks in the supply chain – lack of capacity for large forgings, lack of skilled technicians, and a queue forming worldwide for new reactors.

Renewable energy can play a part, but it is not base load. Wind farms require 90% back-up to deal with windless days[73], so a large increase in wind-generated capacity actually exacerbates the problem. Wind currently has a nameplate capacity of 2546MW from 2032 turbines[74], which actually delivers an average production of 635MW. That could be doubled over the decade but wind power is intermittent and thus makes an unpredictable contribution. There is little short-term potential for large-scale increases in hydro and landfill gas. A Severn barrage is probably the only large-scale renewables project capable of realisation before 2020. It could be generating by 2018, and fully operational by 2020, if a building programme were instigated by 2010. And it would provide 5% of UK electricity (8.6GW at peak) from a predictable and perpetual source. This is dependent on the recently announced BERR feasibility study to be completed within its own timescale.

If the initiative is left to the market, without radical government rethinking, we will get more of the same – gas-fired stations, with their dependency on imported fuel, and unreliable, highly subsided wind.

Measures which could create capacity quickly

1. Extend the life of nuclear stations due to come off-line between 2010 through to 2023. Possibly four stations could be life-extended and an urgent, individual assessment of the technical, financial and safety cases is required. This could provide 3 to 4GW.
2. Extend the lives of coal-fired stations due to be retired by 2015 in accordance with the Large Combustion Plant Directive (LCPD). These plants are currently restricted to 20,000 hours operation over the period (c. 2,800 hours pa) due to their lack of flue gas de-sulphurisation (FGD). This may require us to seek derogation under the LCPD to allow more time to meet the directive requirements, but could provide up to 11GW of base load capacity.
3. There is no option but to build a number of new stations of a type which can be constructed reasonably quickly. This means primarily gas-fired stations, such as the new 850MW station at Uskmouth (which will derail CO_2 targets but this is unavoidable), but also new coal-fired stations, such as is proposed at Kingsnorth by E.ON. This coal-fired station will be 10% more efficient than the coal-fired stations it will replace – the result of using super-critical steam technology. An even greater increase in efficiency, up to 15%, is obtained by using Integrated Gasification Combined Cycle (IGCC) technology. New stations must be carbon-capture ready to be able to benefit from this technology when it becomes available. Currently only 4.5GW of new capacity, mainly gas, is close to the construction phase. This figure could be realistically doubled over the decade and should include biomass (wood)- fired stations such as the 350MW plant proposed for Port Talbot.
4. There is one electricity Interconnector with France (2GW capacity) and one with the Netherlands (BritNed of 1GW) due to be completed shortly. A connector with Norway of 1.2GW is currently on hold and should be encouraged, and an additional French connector of 2GW could be built. This could happen over a three-year timescale and add significantly to UK security of supply.
5. Currently 10% of municipal waste is converted to electricity but this figure could rise. On current figures, the DEFRA[75] analysis that up to 25% of municipal waste could be consumed in Energy From Waste (EFW) plant by 2020, could provide capacity of around 600MW per plant from say 40 to 50 typical 150,000 tonnes per year plants, or fewer plants of larger capacity. Combined heat and power plants currently provide 5.5GW, but new plant could be installed reasonably quickly, in the right locations, to take this figure up to possibly 10GW.

[73] "Carbon, cost and consequences", P Golby, E.ON UK, June 2008
[74] British Wind Energy Association (BWEA), available at http://www.bwea.com/ukwed/index.asp
[75] What's in store? Supply demand and storage issues in the UK gas market", Deloitte, 2007

Measures which make better use of capacity

1. Strengthen the Scotland to England Interconnectors which only have a capacity of 2.2GW. Scotland has spare generating capacity and will have more as renewable generation in Scotland accelerates. It cannot export this surplus to England until this constraint is addressed.
2. Strengthen and refurbish the grid and local distribution circuits to better accept distributed electricity supplies from CHP and renewables.

Measures which help to overcome temporary shortages

1. Build gas-storage facilities using depleted North Sea gas fields. Over 40% of UK electricity is gas-fired, so any major interruption to supply could adversely affect electricity generation. UK gas-storage capacity is 4% of annual consumption[76], equivalent to 14 days' supply on average. Germany's storage capacity is 19%, which is 70 days' supply.
2. Develop our ability to provide emergency capacity quickly, to cope with any unexpected plant outages. We have pumped storage capacity (for example, Dinorwig, at 1.7GW for up to six hours), but this capacity should be expanded at new sites if possible, and in parallel with a programme of tidal-barrage developments designed to include pumped storage.

Long-term strategy

Demand is expected to increase by about 1GW per year from the present day maximum of 60GW to reach 65GW by 2014 (NGC seven-year statement). If this is simplistically projected forward, demand will increase to 79GW by 2030 and to 101GW by 2050. This rough-and-ready projection gives us some idea of the scale of capacity we may need in the future if we carry on as we are. If, however, there is a large-scale replacement of oil and gas with electricity for home heating (e.g. by electrically driven heat pumps), road transport (batteries, hydrogen) and rail (electrification), then the generating capacity requirement will be even greater.

The programme must contain the following elements.

- It must be designed with security of supply in mind. That means reduced reliance on imported natural gas – imports will be 50% by 2010 and 80% by 2020. Coal will become increasingly important, which could stabilise, and even enlarge, the indigenous UK industry. Moreover, several years' worth of uranium fuel is easily stored.
- It must provide for large electricity-demand increases as society is increasingly electrified and dependence on oil and gas and is reduced.
- It must acknowledge the latest EU directive for all EU energy to be 20% renewable by 2020. Electricity is only one component of energy, although it is the major one and will increase as other energy sources, notably oil and gas, become scarcer. Chillingly, the 20% renewable-energy target extrapolates to mean that an impossible 40% of UK electricity must be from renewable sources. It is currently just 4.5%.
- It must be supported by conducive investment conditions. When considering large projects with a long lead-in time, financiers need to know, in simple terms:

  a) Is it proven technology?
  b) Can the project be built to time and budget?
  c) What are the price guarantees for operational output?
  The last mentioned is a key impediment to investment and must be addressed.

A rolling programme of power station construction must be started to provide, on average, 2GW of extra capacity, preferably CO_2-free, year-on-year from 2020. Planning processes must start by 2010 to have at least four nuclear new builds in progress by 2020. Nuclear stations take 10 years from planning to generation. Current capacity for coal, gas, oil and nuclear will all be life expired by the mid 2030s – Sizewell B, the last major power station to be built in the UK (1986), is due to cease operation in 2035. The new base load stations should be a mix of coal, nuclear, tidal and some gas. Renewables such as wind, both onshore and offshore, will top up supply. Energy from waste and distributed CHP will provide an element of supply. This will give a diversified supply portfolio. Carbon-free electricity must be paid a premium and should provide at least 50% of supply. Coal is an essential component of long-term base-load generating capacity, so for this to be low CO_2, carbon capture has to be developed urgently. The programme effectively means building two major power stations a year, each of 2GW capacity.

Timescale

Both the short-term and long-term programmes must be instigated urgently if we are to avoid shortages of supply. This means important government intervention to boost confidence by taking away the financial operating risk of nuclear and tidal stations. This could be achieved by letting a 50-year contact, or "concession", at a fixed "underpin" price for electricity supply and inviting appropriate consortia to bid for the contract.

The programme outlined under short-term strategy should provide 35GW of new capacity by 2027, by which time the long-term strategy should be well under way. This should give us 100GW of supply by 2050.

What can the Government do to make this happen?

Irrespective of its lack of direct control over electricity supply, which is left to private companies, it will be the Government of the day that will be blamed if there are power cuts. Nor will it be possible to deflect blame onto previous administrations or supranational factors (e.g. oil prices), particularly when other countries, notably France and Switzerland, have managed their energy economies more prudently. The concept "the market will deliver" just does not work when faced with a national crisis such as chronic electricity shortages. What should the Government do?

1. Explain the problem to the public. The programme outlined here will require unpopular measures. New gas- and coal-fired stations in the short term, life extensions to old nuclear and coal plant, fast-track planning, a reformed tax structure, and a big increase in nuclear power will be accepted if they are explained as the only way to avoid power cuts and protect the environment. People and businesses need assurance that corrective action is finally being taken if they are to maintain their confidence in the UK and its economy.
2. Underpin the long-term selling price of electricity and provide stability in the market. This is particularly important for nuclear power and large-scale tidal power.
3. Reform the regulatory, tax and subsidy system to do the following.
   - Amend planning law to allow "fast track" approvals for long-term base load, coal, tidal and nuclear stations.
   - Extend the use of interruptible supply contracts to reduce peak demand.
   - Work out an equitable arrangement for who pays for grid connections.
   - Establish feed-in tariffs (as in Germany and Spain) to speed the growth of renewable energy, particularly marine renewables and solar.
   - Amend building regulations to encourage solar heating and cooling, heating and cooling using electric heat pumps, and the use of 'passive' building techniques.
   - Reform and simplify the CO_2 emissions taxation system.
   - Substantially increase funding and support for developing carbon capture and storage as a matter of extreme urgency. Once technically established it could be used to encourage tertiary-oil recovery in the North Sea and so improve security of energy supply with more indigenous oil and gas.
   - Address the skills shortage in the energy industry, particularly the nuclear-skills shortage. Provide incentive bursaries at both undergraduate and postgraduate level. Grants for mature students should be encouraged to upgrade existing, transferable skills.
4. Reinstate the Department of Energy to bring energy policy under one department with cabinet representation via a Secretary of State, emphasising and reflecting the central role that energy plays in every aspect of government, business and day-to-day life.

Conclusion

This route map, if followed, could ensure a sufficient, secure and environmentally acceptable supply of electricity for UK needs. It will require strong political will and the confidence of engineers and investors to make it happen.

This route map should be read in conjunction with the main report "A Pragmatic Energy Policy for the UK".

Time for Tidal Power

A renewable force for the future

Contents

Executive summary

EU targets require the UK to produce 15% of its energy from renewable sources by 2020. This means that around 40% of electricity generation must be from renewables (it is currently 4.5%). Less than a quarter of that is generated by wind, yet there are expectations that wind will provide two thirds of the projected target. We argue that this is unrealistic. For the dual purpose of meeting legally binding targets and contributing to the forthcoming 23GW energy gap, government support needs to be redirected to renewables with greater capacity for long-term low-carbon generation. The UK tidal resource has been identified as capable of producing more than 10% of the UK's current electricity demand. Tidal power is perpetual and, unlike wind, highly predictable for centuries into the future. Indeed, no other source of renewable energy offers such scale, reliability and contribution to security and diversity of supply.

A Severn barrage, particularly the Cardiff-Weston option, is now the focus of national interest, not least because of its capacity to provide 5% of the UK's current electricity demand. We are entering a new era of extraordinary energy prices fuelled by oil reaching an unprecedented USD140 a barrel. Combined with diminishing home-grown energy supplies and legal obligations to substantially reduce CO_2 emissions, a Severn barrage is being seen in a new light. The initial capital costs are unarguably high – approximately £15 billion. This will build an installed capacity of 8640MW (8.64GW) and a life expectancy of 120 years or more, unlike the average 15 years for wind turbines. Recent reports estimate that offshore wind has risen from £2.4 million to £3 million per installed MW compared with £1.7m for the barrage. Energy costs per kWh also compare favourably with offshore wind.

This paper does not claim to offer a comprehensive review, but it aims to broaden the debate by illustrating some of the misconceptions on key issues. We question the recent criticism levelled at the economics of a Severn barrage. The concept that only the Government could fund such a project is misleading – the private sector is more than able given the prerequisites we discuss here. The environmental impact, as another example, is found to be not as entirely negative as historically portrayed. Estuaries are dynamic, continually adapting to changes brought about by both anthropogenic and natural causes. Riparian land use, industrialisation and intensive agriculture have all left their legacy. Similarly, the Bristol Channel is adapting to changes in climatic conditions. Indigenous fish species are increasing at a mean rate of 0.83 per year, or one approximately every 15 months. Inversely, birds are leaving in substantial numbers. A long-term decline in the population of dunlin (the most abundant bird) in the Severn has seen numbers drop from 55,000 in the early 1970s to below 14,000 in the late 1990s, according to the RSPB who ascribe this to a 1.5°Celsius rise in temperature. If the number of dunlin fell significantly below 14,000, the Severn would fail to qualify as a 'Maintained at Favourable Conservation Statue' as the dunlin numbers would no longer represent 1% or more of the national population. Furthermore, the Severn has declined from 9th most important UK Wetland (1990/1991) to 19th (2003/2004) with water birds showing a preference for more benign conditions on the east coast estuaries in the UK.

This paper goes on to describe how the harsh tidal regime and resultant turbid waters provide insufficient light and dissolved oxygen to support little more than immature invertebrates. It discusses in what way building the barrage would increase biodiversity, examining how the reduced hydrodynamic regime would deposit the fine suspended sediment on the bed, increasing the carrying capacity for a more prolific and diverse community of invertebrates and higher organisms. Evidence from La Rance, the 240MW barrage in Brittany operating for the last 40 years, would support this. Many parallels exist, notwithstanding the geophysical differences of the estuary structure. Fish pass safely through La Rance barrage due to the design of the turbines and relatively low revolutions per minute. Additionally, the increased 'slack time' between high and low water also maintains the feeding areas for longer, partly offsetting the reduction of the intertidal area. These arguments are explored, but it is not the brief of this paper to pass judgement on the comparative merits of different ecosystems, only to encourage awareness.

This paper goes on to discuss the flood protection a barrage would offer for vulnerable prime urban and agriculture land. Opportunities will open up for sustainable economic development for both South Wales and the South West, depending on the envisaged growth scenarios and improved transport links. A considerable number of new jobs, both direct and indirect, are inevitable. Construction alone will need 35,000 workers during the peak years (50% of jobs created will be in the Severnside region).

The additional jobs in tourism are also considered. La Rance has around 300,000 visitors a year. Furthermore, as a project of international importance, a Severn barrage is likely to attract interest across the scientific disciplines. An opportunity exists to establish a knowledge hub for tidal-power generation that will facilitate working relationships with other key barrage-developing countries such as Korea, China and Russia.

As with all major infrastructure projects, there are both positive and negative impacts. Evaluation of the economic, social and environmental aspects during and post construction is imperative. Thus the Government's Feasibility Study, launched in January 2008, is welcomed. Previous work needs updating, due to changes to estimated costs, electricity markets and financial models. However, while the knowledge base for such as project is incomplete, the Government must guard against duplicating the considerable evidence amassed by the 2007 Sustainable Development Commission Report and focus on identifying the knowledge gaps. In addition, the Government must be rigorous enough to comply with the EU Directives' requirement to demonstrate there are no alternatives, that overall cohesiveness of Natura 2000 is achievable and whether there is a case for "Imperative Reason for Overriding Public Interest". And it must also assure the private sector that its findings are transparent, robust and could provide a platform to take development forward at the earliest opportunity. Finally, assessments and decisions must be made in the context of an imminent UK energy crisis and our European responsibility to reduce CO_2 emissions.

Industry commentators believe that with a barrage, we will have insurance against rising fuel prices, a significant contribution to security of supply, and flood protection, and a CO_2 saving of around 500,000 tonnes every month. Without a barrage, the Severn Estuary ecosystem will continue to adapt to environmental changes and face increased flooding. What is clear is that the decision not to proceed with a barrage cannot be made without the decision on how renewable energy and CO_2 targets can be met another way. Whatever the decision, it will have far-reaching consequences on a cohesive UK energy policy and thus must be determined with the utmost urgency in conjunction with our recommended strategy outlined in "A Pragmatic Energy Policy for the UK".

1 Why tidal power?

1.1 EU targets require the UK to produce 15% of energy from renewable sources by 2020. This means that approximately 40% of electricity generation must be from renewables (as fossil fuels for transport and heating are hard to substitute). Currently the figure is 4.5%.[1] The expectation for wind power to account for around two thirds of renewable electricity by 2020 is unrealistic on several levels. From an engineering perspective alone there are issues over availability of turbine components, shortage of installation barges for construction of offshore turbines, resources for connection to the grid[2], and the overall ability of project developers to achieve the apparent construction rates that would be required to deliver the projected output. Assuming an onshore load factor of 25%, the necessary increase in nameplate capacity is around 360MW per year between 2006 and 2020. Over the same period, offshore wind, with a load factor of 30%, would imply sustained average build rates of around 402MW of new capacity per year. The highest build rates over recent years, according to the British Wind Energy Association (BWEA)[3], are 540MW onshore in 2006 and 100MW offshore in 2007. This suggest the onshore projected output may be achievable provided of course projects can continue to overcome planning issues and suitable financing can be obtained. However, the offshore build rate required seems to be very optimistic at around four times the best achieved so far. Empirical experience and collected data from Germany and Denmark also lowers expectation of the capacity credit of onshore wind energy.[4] The need for backup from coal, gas and nuclear to cover the intermittency and unpredictable nature of wind is frequently underestimated.[5] Furthermore, a number of salient studies analyse the inherent difficulties in incorporating more than 10GW into the national grid system.[6, 7]

1.2 Tidal power, unlike other renewables, offers carbon-free electricity in a highly predictable manner for centuries into the future. Energy production from tidal range, the difference between high tide and low tide, utilises established, proven technology. Generation occurs generally five hours in 12, although this can be extended through variations such as pumped storage, additional basins or altering the mode of operation (ebb only, ebb-and-flood). This would help supply be more in phase with peak demand. Initial capital costs are high, but maintenance costs are minimal. A barrage would be expected to generate carbon-free electricity for at least 120 years. Output and costs are now comparable with offshore wind, as we discuss later.

1.3 Tidal stream, utilising the kinetic energy in tidal currents, is described by the Sustainable Development Commission (SDC) as a nascent industry with “all devices in the demonstration and testing stage of development”[8], but it has acknowledged potential. Government investment to date is to be commended, but without further sustained commitment, it could be a case of “too little too late”. Increased government support will be needed to bring these innovations to commercial readiness, particularly through testing facilities such as NaREC (New and Renewable Energy Centre) in Blyth and the European Marine Energy Centre in Orkney. The Carbon Trust estimates that initial electricity costs from tidal stream devices would be between 9p/kWh and 18p/kWh, rather above the base cost of electricity but reducing to 7p/kWh once 1GW of installation is achieved.[9]

1 Digest of UK Energy Statistics 2007, BERR, p 171
2 ENDS Report, 13th December 2007
3 Available at: http://www.bwea.com/ukwed/index.asp 03 April 08
4 Whitmill, C. (2006) *UK Energy Policy: The Small Business Perspective.*
5 “E.On warns over back up for renewables”, The Guardian, 04 June 2008, http://www.guardian.co.uk/environment/2008/jun/04/energy.renewableenergy
6 Sharman, H. “Why the UK should build no more than 10 GW of Wind Capacity”, *Proceedings of the Institution of ICE: Civil Engineering* 158 (November 2005), 161-169
7 Oswald,J. (Dec 2006) “25GW of distributed wind on the UK electricity system” REF
8 Sustainable Development Commission (2007) “Turning the Tide – Tidal Power in the UK”
9 Carbon Trust (2006) “Future Marine energy. Results of the Marine Energy Challenge”

1.4 Together tidal stream and tidal range have the potential to supply at least 10% of the UK's current electricity requirements. This is taken as a conservative figure. The World Energy Council estimates 13% from tidal range alone "if all reasonably exploitable estuaries were utilised".[10] Potential tidal stream sites include Mull of Galloway, the Channel Islands, and Northern Ireland, although the majority, possibly 60%, is located at the Pentland Firth and is expected to provide 2292MW of installed capacity.[11] Interestingly, the currently accepted method of calculating tidal stream resource (the "Flux Method") is under question by leading academics, suggesting that there may actually be an underestimation by a factor of 10 or more.[12]

1.5 The tidal range resource is found in different locations to tidal stream – the Severn Estuary, Liverpool and Morecambe Bays, the Solway Firth, the Wash, the Duddon, the Wyre and the Conway. After the Bay of Fundy in Canada, the Severn Estuary has the 2nd highest tidal range in the world, reaching 14m on a spring high tide.

1.6 Experts suggest that rather than look at one tidal project in isolation, a contiguous strategy could take advantage of the varying tide times around the coastline as outlined below.

Location	Approximate time of high water spring tides	Approximate times of generation
Bristol Channel	08:00 & 20:00	11:00 to 15:00 & 23:00 to 03:00
Liverpool Bay	13:00 & 01:00	16:00 to 20:00 & 04:00 to 08:00
Solway Firth	13:00 & 01:00	16:00 to 20:00 & 04:00 to 08:00
The Wash	08:00 & 20:00	11:00 to 15:00 & 23:00 to 03:00
Dover Strait	12:30 & 00:30	15:30 to 19:30 & 03:30 to 07:30
Channel Islands	08:00 & 20:00	11:00 to 15:00 & 23:00 to 03:00

Source: Sustainable Development Commission Research Report 1, 2007, pp 42

As described by the SDC[13], "generation times would vary on a case-by-case basis, but typically would be expected to commence approximately three hours after high water". There have been suggestions that it might also be possible to advance generation by approximately one hour or delay it by two hours on spring tides, or advance by two hours or delay by one hour on neaps, although any increase in output value is negated by a significant reduction in power generated, probably in the region of 25%. Ebb generation with flood pumping is considered the most economic model, with pumping reducing energy output by 4% but with a corresponding 12% gain in value.[14] Wholesale electricity is currently bought and sold in half-hour slots with prices increasing at certain periods of the day in relation to peak demand. Thus system management is imperative to maximise available return.

[10] World Energy Council 2004 Survey of Energy Resources. Available at: http://www.worldenergy.org/documents/ser2004.pdf
[11] SDC (2007) Research Report 1 for "Turning the Tide – Tidal Power in the UK"
[12] MacKay, DJC. (2007) "Underestimation of the UK Tidal Resource" Available at: http://www.inference.phy.cam.ac.uk/sustainable/book/tex/TideEstimate.pdf and
and
Salter, SH. (2006) "Possible under-estimation of the UK Tidal Resources" Response to DTI Energy Review Available at: http://www.berr.gov.uk/files/file/31313.pdf
[13] SDC (2007) "Turning the tide – Tidal power in the UK" Research Report 1
[14] Department of Energy (1989); The Severn Barrage Project: General Report. HMSO Energy Paper

2

Worldwide tidal range projects

2.1 There are a limited number of tidal-range projects worldwide. Access to cheap energy has historically stalled motivation to invest in such capital intensive projects. The 240MW La Rance, in Brittany, northern France, is the world's first barrage. Built in 1967, it has operated successfully for the past 40 years with little maintenance and expects to continue for at least another 40 to 50 years. Other projects include the experimental 18MW Royal Annapolis in the Bay of Fundy in Canada (1984), Kislaya Guba 400kW in Russia (1968), and the 3.9MW Jangxia Bay plant in the East China Sea (1985).[15]

2.2 However, faced with increasing threats to security of supply, escalating global energy prices, and pressure to reduce CO_2 emissions, a growing number of countries are looking closer to home at their tidal power potential. An estimated 5GW of projects are under consultation in Russia, China, Australia, India and Argentina.[16] South Korea in particular is reportedly progressing rapidly with a tidal power programme to avoid economic vulnerability to high oil prices.[17] In 2005 South Korea spent USD66.7 billion on importing energy, 22.1% of its total import bill. The Shihwa tidal plant with a nameplate capacity of 254MW will supersede La Rance when it is completed in 2009. Work has commenced on the 480MW Garolim barrage and, in the final stages of consultation, the Incheon project is predicted to be producing 812MW by 2015. The partnership of Korea Midland Power Co and Daewoo Engineering & Construction plan to connect the islands of Ganghwa, Gyodong, Seokmo and Seogeom.

2.3 This brings perspective to the Severn Estuary options. The smaller Shoots alignment would have a nameplate capacity of 1050MW. On the Cardiff-Weston alignment a barrage would have a capacity of 8640MW, becoming unassailably the world's largest barrage and capable of producing 5% of the UK's current demand. Furthermore, it will save 6 million tonnes of CO_2 a year.

[15] World Energy Council
[16] Lindley, D (2006) "Operational and proposed Marine energy projects worldwide" Energy 2100
[17] http://www.iht.com/articles/2007/05/09/business/solar.php 09may07

Why a Severn barrage again? What is different this time round?

3

3.1 Credit for the idea of a Severn barrage is often attributed to Thomas Fulljames. His 1849 design was determined by motives that had nothing to do with electricity, but nonetheless, with some prescience, it reflected contemporary ideas for a rail and road link in conjunction with protection against flooding.

3.2 Interest in utilising the tidal power of the Severn Estuary for electrical generation began seriously in 1925, when a Sub-Committee of the Committee on Civil Research was established to investigate the practicability of a Severn barrage.[18] This Sub-Committee, which later became the Severn barrage Committee of the Economic Advisory Council, reported in 1933. It concluded that a barrage with a new road and rail crossing was technically feasible, sited at English Stones, the location for today's second Severn Crossing. Economic reasons were cited as the reason behind not going ahead with the 800MW single-basin ebb-generation scheme.

3.3 A small number of studies followed intermittently over the next 40 years, but it was the oil crisis of the 1970s that sparked renewed interest in energy sources closer to home. In 1975, the Central Electricity Generating Board (CEGB) published a study, in conjunction with Bristol and Salford Universities, for the Secretary of State's Advisory Council on Research and Development for Fuel and Power. The council concluded from the study that a barrage would not be economically feasible "unless the energy situation deteriorated significantly".[19]

3.4 In 1978, the Severn barrage Committee was set up by the Government to examine the engineering options and technical feasibility for the project, its contribution to the security of electricity supplies, and the wider regional benefits that would ensue. Under the chairmanship of Professor Sir Hermann Bondi, a major energy paper was published in 1981.[20] Out of the six possible locations examined, the recommended alignment for the barrage was from Lavernock Point near Cardiff to Brean Down, just below Weston-super-Mare. The proposed capacity was 7,200MW using 150 turbines, producing an average 12.9TWh per year based on ebb generation.

3.5 Building on this work, between 1987 and 1989 the £4.2 million Severn barrage Development Project was conducted. This was a tripartite study funded equally by the Department of Energy, the CEGB and the newly formed Severn Tidal Power Group (STPG) consortium of power engineers and constructors. Published in 1989[21], it contains the most extensive studies to date on the physical environment, ecological effects and regional impacts of building a barrage. A detailed description covers the engineering and project resources, costs of electricity output, and financing options on a barrage producing 8640MW (an average 17TWh per year or about 5% of current UK electricity demand). The privatisation of the UK electricity industry and the consequential loss of the CEGB left the project abandoned again.

3.6 In 2002, STPG published an update of the studies in light of the restructuring of the electricity market, new environmental legalisation, increased size of shipping in the Bristol Channel and major changes in project finance.[22]

3.7 Parsons Brinckerhoff subsequently updated a proposal for a barrage just downstream from the Second Severn Crossing. Known as the Shoots Barrage, the installed capacity of 1050MW would be significantly less than the 8640MW capacity at Cardiff-Weston.

3.8 On 1st October 2007, the Sustainable Development Commission (SDC) published "Turning the tide – Tidal power in the UK", a comprehensive analysis of the UK's tidal capacity and the potential barriers to growth. Its conclusion that a Severn barrage was worthy of further investigation was mistakenly taken by some parties as an endorsement of a tidal project. In reality, it is the costs related to the SDC's call for the creation of unprecedented levels of compensatory habitats that threaten to derail any proposals for development. Their call for public ownership of a barrage is not feasible either in a privatised electricity market.

[18] Palmer, A "The Political Overview" in "Tidal Power and Estuary Management" (1979) eds Severn, R. Dineley, D. Hawker, L., Colston Research Society

[19] Department of Energy (1977); Tidal power barrages in the Severn Estuary, recent evidence of their feasibility, HMSO, Energy Paper number 23

[20] Tidal Power from the Severn Estuary – Volume 1:Energy Paper 46; HMSO

[21] Department of Energy (1989); The Severn Barrage Project: General Report. HMSO Energy Paper Number 57

[22] The Severn Tidal Power Group (2002) "The Severn Barrage – Definition Study for a New Appraisal of the Project" ETSU Report No. T/09/00212/00/REP

3.9 In January 2008, the Government launched another Feasibility Study with a price tag of £9 million. A cross-Government team led by BERR will cover six aspects.

Environmental	impacts on biodiversity and wildlife; flood management; geomorphology; water quality; landscape; compensatory habitat
Engineering and technical	options appraisal; costs; design and construction; grid linkage
Economic	financing; ownership; energy-market impacts
Regional	impacts on business; regional social and economic impacts
Planning and consents	regulatory compliance
Stakeholders	engagement and communication

PricewaterhouseCoopers have been commissioned to advise on possible ownership options of a Severn tidal scheme and how it could be financed. Parsons Brinckerhoff is managing the Strategic Environmental Assessment (SEA).

3.10 Previous studies were conducted in an era of cheap energy and before the need to reduce CO_2 emissions was acknowledged. It is vital this assessment recognises that it proceeds under somewhat different circumstances, namely the challenging targets for energy from renewable sources and a reduction in emissions, the imminent closure of over a third of the UK's generating plant, and increasing concerns over the cost and availability of fossil fuels, particularly gas. Furthermore, impacts on climate change need to be taken into consideration. Substantial risk of flooding is expected through sea-level rises and increased storm surges. DEFRA has identified around 100,000 acres of prime urban and agricultural land as at risk in the Severn Estuary.

3.11 Significant in-depth study has consistently identified Cardiff-Weston as the most suitable site with proven technology. However, the BERR Feasibility Study will continue to question the number of options in utilising the tidal power of the Severn Estuary, both in terms of technology and location, and whether installing one will prohibit another.

3.12 The Shoots barrage, advocated by Parsons Brinckerhoff, is a smaller structure of 4km as opposed to the 16km Cardiff-Weston alignment, meaning a reduced capital cost per kWh, but with far less power output. Nonetheless, it has the added advantages of being above the ports of Cardiff, Bristol and Avonmouth, thus negating the need for expensive locks (although Sharpness in Gloucestershire will still be affected). There is also the potential to replace the ageing 150-year-old Severn Tunnel with a new rail link. It should remain a strong contender.

3.13 Another barrage option is the Minehead site, proposed for its potential to protect the Somerset Levels from flooding. But by increasing the length to 22km, the capital cost per kWh renders it uneconomic. Proposals such as the 1km-wide Severn Lake Scheme are based on speculative development with little contribution to either CO_2 reduction or security of supply, and should be dismissed accordingly.

3.14 No conflict exists with either tidal stream or tidal lagoons. As the SDC report explains, "the tidal stream resource is concentrated in deep water channels, which, along with large sedimentary deposits in the estuary, would present a number of engineering difficulties for most devices as well as being a navigational hazard for shipping".[23] Tidal stream devices could be positioned further downstream in the Bristol Channel, but there are potentially better locations in the UK, such as Pentland Firth, Strangford Lough in Northern Ireland and the Channel Islands. However, grid constraints are an issue.

3.15 Tidal lagoons are a theoretical innovation yet to be trialled, either in the UK or worldwide, and are unlikely to be able to contribute to the 2020 targets. Initial reports suggest they are more suited to shallower water due to the huge amount of aggregates required. The proposed Swansea Bay project would need up to 200m tonnes compared with 13m tonnes needed by the Cardiff-Weston Barrage.[24] Both the technology and environmental impacts are unknown quantities. Nonetheless, we concur with the SDC that further research into offshore tidal impoundments is prudent.

[23] SDC (2007) "Turning the tide – Tidal power in the UK pp 74
[24] Friends of the Earth Cymru (2004) "A Severn Barrage or Tidal Lagoons – a comparison"

Technical aspects

4.1 Tides are the regular and predictable movement of water caused by the astronomical relationship between the earth, moon and sun and the force of gravity.

High tides occur approximately every 12 hours 25 minutes in UK waters. Each location will be on a slightly different schedule as the geography of the coastline, variation in sea depth and the effects of the earth's rotation affect the movement of the water. However, the tide times are predictable for several centuries into the future.

4.2 In addition to daily tides, during the periods of the new and full moon, when the sun, moon, and earth are directly in line, the gravitation imbalances reinforce each other, creating what are known as spring tides, where the high tide is higher and the low tide is lower than usual. However, when the moon is in its first or in third quarter, it is at 90 degrees to the sun relative to the earth, and the height of the tides is subject to the opposing forces of the sun and moon. This produces neap tides, in which the high tide is lower than normal and the low tide is higher than normal. Neap tides occur approximately every seven days after a spring tide.[25]

4.3 The approach to harnessing the energy from tides essentially involves identifying an estuary or bay with a large natural tidal range and then building an artificial enclosure or barrage.

4.4 The electrical energy is produced by allowing water to flow from one side of the barrage, through low-head turbines, to generate electricity. A number of variations of design and modes of operation exist. After detailed study, the favoured option for the Cardiff-Weston barrage is a single-basin scheme using ebb generation with the capacity for flood-tide pumping. During the flood tide, incoming water is allowed to flow freely through sluices in the barrage. At high tide, the sluices are closed and water is retained behind the barrage. When the water outside the barrage has fallen sufficiently to establish a substantial head between the basin and the open water, the basin water is allowed to flow out though low-head turbines to generate electricity. An additional basin adjacent to the main barrage, for the dual purpose of storage and enhanced flood protection for the Somerset coast, would add considerably to the cost but has not been ruled out.

4.5 The Cardiff-Weston barrage would be built using concrete caissons housing 216 x 40MW turbines, giving an installed capacity of 8.64GW. The alignment, Lavernock Point near Cardiff to Brean Down, just south of Weston-super-Mare, was chosen as it offered a stretch of 4km with depths of about 30m (which are needed for the powerhouses), and depths of 15 to 25m for sluicing and to provide safe navigational routes.

4.6 The Shoots barrage alignment was chosen for its capacity to support a high-speed rail link between England and south Wales. The design allows for high-level sluice gates in conjunction with closing the turbines during the flood tide to reduce the sedimentation in the basin. However, insufficient work has been undertaken to resolve the concerns over siltation in the basin and possible sedimentation deposits on the estuary flanks seaward of the barrage. It is believed this may be addressed in the BERR Feasibility Study.

[25] Proudman Oceanographic Laboratory Available at: http://www.pol.ac.uk

4.7 Technical comparison between a Cardiff-Weston and a Shoots Barrage:

	Cardiff-Weston	Shoots
Length of embankments	16.1km	4.1km
Generating capacity	8.64GW	1.05GW
Annual average electricity output	17TWh	2.75TWh
Number of turbines	216	30
Type of turbine and diameter	Kapeller – 9m	Straflo with fixed runner blades – 7.6m
Number of sluice openings	166	42
Estimated cost of construction at 2006 prices	£15bn	£1.5bn
Estimated cost of output at various discount rates		
3.5%	3.68p/kWh	3.62p/kW
8%	9.24p/kWh	7.52p/kWh
10%	12.37p/kWh	9.54p/kWh

Source: Sustainable Development Commission, "Turning the Tide – Tidal Power in the UK", 2007

4.8 Detailed design modelling identified the horizontal-axis bulb-type turbine as the most productive. Hundreds have been installed worldwide. At La Rance, turbines installed 40 years ago have yet to be replaced. A small differential exists – La Rance uses the Kaplan turbine with double regulation (in other words having adjustable distributor and adjustable runner blades which enable both ebb and flood generation). The Cardiff-Weston still currently plans to use the single regulation kapeller with fixed distributor and adjustable runner blades. Each turbine will be 9m in diameter and 23.5m in overall length. Cyrille Perrier, General Manager at La Rance, explains that the slow rpm, large diameter and flexible design of the blades are fundamental to the negligible rate of fish mortality (fish pass freely through the La Rance barrage unharmed). This does not negate the need for further research on the migratory species found in the Severn, but engineering solutions should be acknowledged. Salmon ladders combined with tropic deterrents are common examples.

4.9 By comparison, the Annapolis Royal tidal plant, off the Bay of Fundy, installed a single 7.7m prototype, experimental 'Straflo' turbine. Before 1984, Straflo turbines had been used for run-of-river schemes with a maximum diameter of 3.7m. The generator rotor is mounted on the tips of the runner blades and the generator stator is located outside the rotor. A key component is the seal between the rotor and the fixed structure, which has to exclude water reliably from the generator space. As the Annapolis turbine has fixed runner blades, it is not suitable for reverse operation as a pump. [26] The power-house was built in-situ, in an island alongside an existing tide-control sluice. As a result, the tidal range is relatively small.[27]

4.10 Little detailed work is available on a projected construction programme for the Shoots Barrage. The Cardiff-Weston in-depth construction programme detailed in the Energy Paper 57 was last updated in 2002 by the Severn Tidal Power Group (STPG) due to improvements in techniques, materials and design.

New measures include the following.

i. Caisson construction at up to 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 six working fronts, with provision of additional equipment to allow placing of six caissons per month (with 100% contingency for inclement weather)

iii. Use of the latest equipment and techniques for dredging and foundation preparation (operations have recently taken place in water depths of up to 100m for offshore oil projects). This will minimise the risk that these operations could delay caisson installation

[26] Petty, D J. Macdonald. A. "Turbine generators for the Severn Barrage" cited in Developments in Tidal Energy (1990) Institution of Civil Engineers

[27] SDC (2007) Turning the Tide – Research Report 3

iv. Turbine generator manufacture at three or four 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

This would also keep construction activities at the site to the minimum. Caissons will be transported to the site by water.

4.11 A significant element of construction is the minimal disruption to shipping. It is acknowledged that since the 1989 Energy Paper 57, the size of vessels visiting ports in the Bristol Channel and Severn Estuary has increased. Shipping movements could also increase if the new proposed development of Bristol Ports goes ahead. Furthermore, the future attainment of 'clean' coal generation through CCS will both secure the UK coal industry and encourage a subsequent increase of coal imports to supplement indigenous supplies. Thus agreement on the optimum size of lock is fundamental to the project, and up to 250,000dwt is under investigation. Nonetheless, to allow uninterrupted passage of vessels during construction of the Barrage, locks would need to be constructed prior to placing the caissons in the deep water channel. The net effect would be to delay first power generation, and therefore revenue, by about two years, influencing the overall economics of the project.

4.12 If all consents are approved and construction can start in 2012, the revised schedule, including two large locks, could achieve barrage closure by 2018, allowing first power generation. Full generation will occur in 2020 with the installation of the final turbines, in time to count towards renewable targets.

More than an energy project?

5.1 Ancillary benefits

5.1.1 The primary objective of the Severn barrage is to provide large-scale, predictable renewable energy for at least 120 years, contributing to diversity and security of supply in a global market challenged by climate change and energy shortages. As with any large infrastructure project it will entail complex economic, social and environment issues that will have both positive and negative impacts locally and regionally. There are a number of ancillary benefits which are not in themselves reasons to justify a barrage, but must be part of the equation when assessing the long-term contribution of the project.

5.2 Flooding

5.2.1 Around 80% of the shoreline of the Severn Estuary is artificially defended.[28] Some of these coastal defences are hundreds of years old with a few dating back to Roman times.[29] Many low-lying areas are dependent on flood defences to prevent inundation at high tides.

5.2.2 A barrage will lower high-water levels, particularly for spring tides, by approximately 0.5m to 1m. Low-water levels will be raised, thus the overall mean water levels inside the basin would be raised by approximately 2.5 to 3m (according to the pumping regime adopted). In essence, at all locations within the basin, including the tributary river estuaries, the higher-tide levels would be reduced and the lower tides raised. This pattern is repeated seaward of the barrage but to a lesser extent. Mean tide levels downstream will not be particularly affected.

5.1.3 A barrage would protect against sea-level rises and storm surges for the tidal coastline upstream of the barrage as far as the Maisemore Weir near Gloucester. As the STPG explain, "when high sea levels are expected, the sluice gates would be shut shortly before high tide to control the water level within the barrage basin."[30] A Cardiff-Weston barrage would protect the low-lying areas on both sides of the estuary, including prime urban sites where residents are currently reliant on flood embankments. Furthermore, waves will be screened from prevailing winds, resulting in a 60% reduction in wave height in the vicinity of the barrage.

[28] "Impacts of Climate Change on the Severn Estuary" Meeting of Marine and Coastal Environment Research Group, Cardiff University, Severn Estuary Partnership, January 2007
[29] SDC (2007) "Turning the tide – Tidal power in the UK
[30] STPG (2008) "Severn Tidal Energy – Renewable power for three million people"

5.2.4 Conversely, there are studies that illustrate that if the Severn is left to its own devices, climate change is likely to cause flooding to 40,000ha (just under 100,000 acres) of urban development and high-grade agricultural land.[31] DEFRA states that average annual flooding costs are currently between £40 million and £200 million. The 2001 report estimated this to rise to £4 billion by 2075.

5.2.5 Commentators point out that flood defence should be a compulsory procedure by the barrage operating company. However, it must be recognised that flood-defence mechanisms could significantly reduce generation output when they were deployed. A financial agreement to balance the costs of flood protection against the loss of power generation will be required.

5.3 Economic development and employment

5.3.1 The UK energy industry will require a renaissance in skilled and qualified engineering personnel and construction workers over the next 10 years. As discussed in our report, "A Pragmatic Energy Policy for the UK", an urgent package of support needs to be targeted both at undergraduate and postgraduate level. Additionally, grants need to be offered to mature students with relevant experience to upgrade their existing, transferable skills.

5.3.2 Employment creation is a key factor of a barrage development. Project proposals suggest caissons are to be constructed in a number of locations throughout the UK (for example, at the yards that are used to build concrete platforms for the North Sea oil and gas industry).[32] Thus jobs and construction materials are spread nationally rather than simply overheating the local economy. However, a considerable number of workers will be needed (around 35,000 during the peak construction years), half of which will come from South Wales and the Severnside region. The SDC comment that a large percentage of workers would be expected from the new EU member states, although this would be a missed opportunity to upgrade the local skills base. Furthermore, there is potential, if a timely decision on a barrage occurs, to utilise the workforce from the 2012 Olympics. In February 2008, Olympics Minister Tessa Jowell opened a Plant Training Centre to boost numbers of construction workers. The Olympic Delivery Authority (ODA) will work with a range of public- and private-sector partners to help its contractors recruit the 9,000–10,000 construction workers that will be needed at peak in 2009/2010.[33] The initiative should help people develop sustainable skills and a long-term career path after the Olympics.

5.3.3 Post construction, the enhanced estuarine environment will improve land values, which is fundamental to attracting private-sector investment. Improved accessibility will additionally be a catalyst for residential and commercial development, subject to envisaged sustainable growth scenarios for South Wales and the Severn South West sub-region, and better road and rail crossings. The fundamental issue here is that the design, and the positioning of caissons and embankments, would need modifications to accommodate transport links and therefore must be integral to the Strategic Environmental Assessment programme from the start.

5.3.4 A barrage would also increase the wide range of employment opportunities related to the visitor economy.

5.4 The visitor economy

5.4.1 The construction of the world's largest tidal barrage will be of international importance and interest. It will place the UK at the front of the global stage for climate-change politics, science and engineering. An opportunity exists to establish a knowledge hub for tidal power generation that will facilitate working relationships with other key barrage-developing countries such as Korea, China and Russia. Furthermore, it will grow in status as a valuable research and educational resource across a broad range of academic disciplines.

[31] "National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England & Wales" DEFRA September 2001
[32] STPG (2008) "Severn Tidal Energy – Renewable power for three million people"
[33] Available at: http://news.icm.ac.uk/leisure/olympic-boost-for-uk-construction-jobs/

5.4.2 Encouraging public engagement at an early stage of development is a strategy the Eden Project in Cornwall has demonstrated to be highly successful for both local acceptance and establishing a strong customer-based profile. In its first year of construction, Eden attracted 100,000 visitors keen to view the building of this innovative project. Visitors now peak at approximately 1.5 million. Visitors to La Rance barrage in Brittany exceeded 300,000 while they operated a year-round programme of organised tours. This has subsequently been scaled back to access only during school holidays and bank holidays, thus visitor numbers have reduced accordingly.

5.4.3 In addition to offering a unique tourism experience in its own right, a barrage could be a catalyst for the development of recreational pursuits. The Energy Paper Number 57[34] describes how the barrage would stimulate water-based activities, particularly sailing, through reduced tidal currents and more benign conditions in the basin. Two leisure craft locks, in addition to separate shipping access, are integral to the barrage design. An enhanced demand for recreational activities would create demand for further water-sports facilities and accommodation. It anticipates tourism activity in the region to increase by between 5% and 20%.

5.4.4 In the South West, tourism is worth £8.5 billion[35], but little more than 11% of is in Somerset as 50% of tourists head further west to Devon and Cornwall. Somerset, and indeed South Wales, could potentially gain from both additional day visitors and staying visitors. The more mature seaside towns (Barry Island, Penarth, Burnham-on-Sea, Clevedon, Weston-super-Mare and Minehead) may identify with the regeneration opportunities while seeking assurance that their natural resources are not compromised. The Severn Estuary will certainly continue to support traditional activities such as birdwatching and angling, although it is unlikely that the Severn Bore will continue.

5.4.5 Tourism is a vital part of the regional economy, often in geographically disadvantaged areas with limited alternatives. Therefore, further work is recommended to assess the impacts of developing the visitor economy.

[34] Department of Energy (1989). The Severn Barrage Project: General Report. HMSO Energy Paper

[35] South West Tourism (2006). "The Value of Tourism"

6 The environmental position

6.1 The classic funnel shape of the Severn Estuary, with its distinctive physical and morphological features, is instrumental in creating the second highest tidal range in the world. The 14m tidal range produces extreme conditions – strong currents strip unconsolidated sediments from the beds of both the estuary and Bristol Channel leaving extensive areas of bare rock. The Severn's characteristic 'muddy waters' are a result of mobile, fine mud sediment, which in other estuaries mostly resides in what become stable banks and bed deposits.[36] Kirby, an expert in sedimentation with 38 years' experience of the Severn Estuary, goes on to explain that on a spring tide, an estimated 30 million tonnes of fine sediment are held in suspension between the Second Severn Crossing and Watchet in Somerset. Furthermore, "by the neap phase seven days later only about four million tonnes are suspended, the remainder settling to form deep 'fluid mud' layers in channels in the main estuary and in Bridgewater Bay."[37] . This harsh regime has two fundamental influences. The high turbidity reduces light penetration to such an extent that primary production of phytoplankton is severely compromised. Zooplankton is similarly constrained. Coupled with dissolved oxygen concentrations reduced below optimal level, few fish species survive. Secondly, substrate instability is a limiting factor both of settlement and survival of fauna.[38] Both rocky and sandy substrates demonstrate ephemeral faunas of juveniles unable to reach maturity.[39] Invertebrate communities are characterised by unevenly distributed abundant numbers but lacking in diversity.

6.2 However, where the mud does settle, species such as ragworms and lugworms are buried in the soft sediments, forming an important food source for over-winter and migratory birds. The joint position statement issued by the Countryside Council for Wales, English Nature, Natural England and the Environment Agency for the DTI in May 2006 recognised the importance of the intertidal mudflats, sand flats and salt marshes for waders and wildfowl such as dunlin, redshank and shelduck. The estuary is also an important area for migratory fish, such as river and sea lamprey, twaite shad, salmon and sea trout, while acting as a nursery for several species of juvenile fish.

6.3 Nonetheless, there is consensus that the Severn Estuary could best be described as a depressed ecosystem. It is this unique barrenness that is currently subject to environmental protection.

6.4 Various areas of the estuary are covered by important international, national and local conservation designations. The overarching legalisation is Natura 2000, the centrepiece of EU nature and biodiversity policy established under the 1992 Habitats Directive. It comprises of Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive, and also incorporates Special Protection Areas (SPAs) designated under the 1979 Birds Directive, creating an EU-wide network of nature-protection areas covering all the member states and a total area of around 850,000sq.km, representing more than 20% of total EU territory. This vast array of sites aims to protect the long-term survival of Europe's most valuable and threatened species and habitats. It is not, as stated by the European Commission, a system of strict nature reserves where all human activities are excluded.[40] Designation does not rule out the possibility of future development. If the damaging effects of a proposed development cannot be mitigated, or avoided by using an alternative solution, it may still be permitted on grounds of overriding public interest (OPI) in certain circumstances. It will demand, quite rightly, a vigorous challenge to any tidal project to ensure the overall coherence of the Natura 2000 network is protected. The difficulty is not diminished by the fact that since the EU Habitats regulations were interpreted and implemented into UK law, new legalisation that raises possible conflicts, namely the Renewable Energy Target and the CO_2 reduction by 2020, had evolved. Furthermore, the previous anticipated timescale for climate-change events has been superseded as impacts are already being witnessed. These points are not yet universally accepted. The environmental bodies and NGOs acknowledge the positive role tidal-generation schemes could play in reducing CO_2 emissions. There is consensus that climate change is the greatest threat to biodiversity. Yet the predominant argument against the Severn barrage is that it will alter the estuarine ecosystem's status quo.

[36] Kirby, R. Shaw, T. (2005) "Severn Barrage – UK environmental reappraisal". Institution of Civil Engineers Paper 13,810 pp 31-39
[37] Kirby, R. (1986) "Suspended Fine Cohesive Sediment in the Severn Estuary and Inner Bristol Channel" Energy Technology Support Unit, Harwell, UK. Report No. STP 4042
[38] Department of Energy (1989) .The Severn Barrage Project: General Report. HMSO Energy Paper
[39] Available at: http://www.berr.gov.uk/files/file29139.pdf
[40] Available at: http://ec.europa.eu/environment/nature/natura2000/index_en.htm

6.5 Estuaries are dynamic, continually adapting to changes brought about by both anthropogenic and natural causes. Industrialisation, riparian land use and intensive agriculture have all left their legacy. Legalisation has also played its part. The 1994 Urban Waste Water Treatment Regulations radically altered the chemistry of the water column. Furthermore, the Bristol Channel is already adapting to changes in climatic conditions. Indigenous fish species are increasing at a mean rate of 0.83 per year, or one approximately every 15 months due to the warming of coastal waters and decreasing salinity.[41] Inversely, birds are leaving the Bristol Channel in substantial numbers. In a Severn, a long-term decline in the population of dunlin (its most abundant bird) has seen numbers drop from 55,000 in the early 1970s to below 14,000 in the late 1990s (according to the RSPB, who apportion this to a 1.5°Celsius rise in temperature). If numbers fall significantly below 14,000 the Severn would fail to qualify as a 'Maintained at Favourable Conservation Status' as the dunlin numbers would no longer represent 1% or more of the national population. Furthermore, the Severn has declined from 9th most important UK Wetland (1990/1991) to 19th (2003/2004) with water birds showing a preference for more benign conditions on the east coast estuaries in the UK. Quoting impressive bird numbers without referring to the huge corresponding intertidal area fails to reflect the low density. Thus, while the Severn Estuary is host to important and threatened species, it has one of the lowest carrying capacities for birds in Europe. SDC argue that if the estuary were submitted today for classification it would still qualify for SPA, albeit with different species, as both individual and total numbers would still be of international importance.

6.6 It is relevant here to just briefly distinguish between the three main types of barrage to compare the differing impacts on the local ecology, best described by John Corlett in "The Likely Consequences of Barrages on Estuarine Biology".[42] These are, firstly, a barrage for freshwater impoundment where closure will be made with as little seawater as possible inside the basin. Non-mobile flora and fauna unable to adapt to freshwater will be eliminated, and the new reservoir will be colonised with freshwater plankton, insects and fish transported from the rivers. Secondly, a barrage built for coastal defence (for example, the enclosure of the Zuider Zee in the Netherlands) will have a basin of saline or brackish water as it is not 'flushed out' to be filled with freshwater. The basin becomes non-tidal, causing immediate intertidal mortality and a gradual change, over some years, to a freshwater flora and fauna. In the case of the Netherlands, drainage and change of use to prime agriculture land will sometimes follow. The third use of a barrage is for tidal power. The reduction in the tidal regime and changes in salinity pattern will result in a redistribution of intertidal fauna and adjustments to both the vertical and longitudinal range. Corlett concludes that there would be a considerable increase in biodiversity. However, he warns of the importance of not losing the tides in the basin during construction.

6.7 If the proposed Cardiff-Weston barrage were to be built, assuming ebb generation, mean water levels inside the basin would be raised by about 2.5m to 3m.[43] High-water levels, particularly for spring tides, would be lower by approximately 0.5m to 1m. Outside the barrage, the tidal range would be marginally reduced, but mean tide levels would hardly be affected (high tides would be lowered and low tides raised). The predicted impact of this is well-documented and subject to further investigation as part of the BERR Feasibility Study. However, the impact on the current limiting factors affecting the estuarine ecosystem is worth noting here. Except in the immediate vicinity of the barrage, the tidal current would be reduced. The reduced hydrodynamic regime would lead to the fine suspended sediment being deposited on the bed and stabilising sandy substrates. This in would in turn increase the carrying capacity for a more prolific and diverse community of invertebrates and higher organisms thus enriching the food supply. This is substantiated by research undertaken for the Energy Paper 57 (1989) and more recently by Prof Christian Retière, a former director of the Muséum National D'Histoire Naturelle for the past 40 years and thus well-acquainted with the La Rance estuary prior and post the construction of their tidal plant. In "Long term changes in muddy, fine sand communities of the Rance basin", he explains how samples taken between 1995 and 1997, when compared with samples taken in the early 1970s, demonstrated an increase in the maturity and diversity of species.[44]

[41] Kirby, R. (2006) Available at: http://www. Southwest-rda.gov.uk/media/SWRA/Assembly%20 Papers/20th%20October%202006/10_LinksBetweenEnvironmentalConsequences2.pdf

[42] Cited in Severn, R.T. Dineley, D. Hawker, L (eds) (1979) Tidal Power and Estuary Management. Colston Research Society, Bristol

[43] Department of Energy (1989) The Severn Barrage Project: General Report. HMSO Energy Paper Number 57

[44] Retière, C., "Long term changes in muddy, fine sand communities of the Rance basin", Journal of the Marine Biological Association of UK, 81/4 (2001), pp 553-564

6.8 Additionally, by raising the mean water level by 2.5m, a loss of about half of the intertidal area in some areas is expected, although again more research is needed to confirm this. However, shifting a variety of intertidal communities into the subtidal category should also “greatly enhance the species richness and invertebrate abundance of this zone”.[45] Kirby argues that the greater productivity offsets some of the loss of intertidal area. SDC questions this, stating there is insufficient evidence. Nonetheless, this prediction is borne out by experience at La Rance. Additionally, Eric Feunteun, Director of the Muséum National D’Histoire Naturelle in Dinard, explains that the increase in slack time or holding time between high and low-water levels leaves the feeding grounds available for longer. Commentators suggest that when evaluating the level of compensatory habitat required under the EU Habitats Directive, these salient points should be taken into consideration to temper the escalating estimation by the NGOs and environment bodies.

6.9 Uncertainties still remain. Further work is needed, not least on upstream coastal erosion, additional land drainage, and further detailed modelling of sedimentation profiles during and post-construction. It is hoped these issues will form part of the BERR Feasibility Study.

6.10 In conclusion, the ecosystem will inevitably be changed. As the SDC acknowledge, “not all change to the system is automatically ‘bad’ or negative, rather a holistic approach should be taken”. However, it is not the brief of this paper to pass judgement on the comparative merits of different ecosystems, only to raise awareness of the potential increase in biodiversity that may result from a Severn barrage.

[45] Available at: http://www. Southwest-ra.gov.uk/media/SWRA/Assembly%20Papers/20th%20October%202006/10_LinksBetweenEnvironmentalConsequences2.pdf

Other key issues to address

7

7.1 Economics of a Severn barrage

7.1.1 A brief synopsis of the economics of a barrage can be categorised in three parts – capital costs, output costs and annual costs. Capital costs are subject to a number of sensitivities such as variations in the capital expenditure, energy output, life expectancy of the project and in particular the discount rate (as discussed by Carr in 'The Economics of the Severn barrage'[46]). Based on a widely accepted discount rate of 8%, the 8640MW Cardiff-Weston barrage is estimated at £15 billion. Recent unfavourable comparisons with offshore wind, the only other large-scale renewable, would appear to be out of date. Shell has recently pulled out of the proposed Thames Array project of 341 turbines with a nameplate capacity of 1GW, reportedly because costs have doubled from the £2.4 billion originally envisaged (from £1.3 million per installed MW to between £2.4 and £3 million). That figure is now estimated to be above £2.4 million per installed MW and will reach £4 million in the latest German phase of offshore wind in 2010.[47]

7.1.2 By comparison, the widely accepted £15 billion estimate for a Severn barrage, including grid connection, calculates as £1.7 million per MW installed. It is not possible to build the equivalent installed capacity using wind for less, even with a combination of onshore and offshore. A significantly higher cost for the barrage, such as that reported recently, would not much alter this differential.

7.1.3 The 2007 Sustainable Energy Commission report 'Turning the Tide' gives a generation cost of 9.24p/kWh (at a discount rate of 8% for the Cardiff-Weston barrage) and the 2004 Royal Academy of Engineering report 'The Cost of Generating Electricity' gives a cost of 7.2p/kWh with standby generation for offshore wind (in the light of experience of building and operating offshore wind farms this seems likely to be an underestimate).

7.1.4 Attention is also drawn to indirect costs. Since most renewables are variable, some uncontrollably so, the introduction of these generators imposes a management cost on the system. These costs arise from grid expansion, short-term reserve costs (balancing), and the costs of running a slightly reduced conventional fleet at lower load factor and under more demanding operating schedules (and thus with higher generation fixed costs). It follows, therefore, that the scale of renewables to be introduced should not impose system costs which exceed the value of the fuel saved from conventional plant. Determining this in relation to any renewable energy technology is not a trivial exercise, but there is reason to think that a Severn barrage might offer lower integration costs than other technologies.

7.1.5 Annual costs have not been updated since 2001, but as a guideline, operations and maintenance are estimated at £64 million per year and off-barrage costs (eg transmission) at £48 million per year. However, there are no fuel costs to be added, unlike gas where fuel accounts for 60% of costs, hence the vulnerability to recent volatile price hikes.

[46] Carr, J.G (1990) cited in "Developments in tidal energy" Institution of Civil Engineers, Thomas Telford, London
[47] Sun and Wind Energy (March 2008) pp 217

7.2 Financing

7.2.1 In the privatised but heavily regulated UK Energy Market it is unlikely that the private sector will provide a Severn barrage spontaneously. Financial incentives will be needed to restore investor confidence after the policy vacillation and injudicious market intervention of recent years. The sharp fall in electricity prices, instigated by the regulator in a vain attempt to address fuel poverty, led to the near collapse of British Energy, and since it is now widely recognised that similar events must be prevented in the future, there may have to be a minimum floor price for such generation projects. While we are aware from the Renewable Energy Strategy consultation document that the present Government is minded to extend the Renewables Obligation, rather than introduce a feed-in tariff, we believe that a possible model to stimulate the construction of a Severn barrage would be for the electricity price to be guaranteed by letting a 50-year contract (or concession), at a fixed price (with escalators), for electricity supply, then inviting appropriate consortia to bid for the contract. Theoretically, clear long-term carbon-price signals might be an adequate substitute, but we doubt that such certainty will be forthcoming.

7.2.2 Other models of ownership, such as variations on public and private-sector partnerships are being examined by PricewaterhouseCoopers as part of the BERR Severn Tidal Power Feasibility Study.

7.3 Legislation

7.3.1 What follows here is a guideline to the probable legalisation, but more in-depth clarification is recommended. The main environmental legislation relevant to the Severn Tidal Power proposals is listed at 7.3.4.

7.3.2 Because of the scale and nature of the development, it is probable that either barrage option would need to be promoted through an Act of Parliament. Such an act could incorporate the requirements of certain national environmental legislation (for example, the Water Resources Act 1991 and Food & Environment Protection Act 1985) such that separate consent under these acts might not be required. However, the proposal would still be likely to require separate regulatory approval in relation to the requirements of European directives (such as the EC Birds Directive (79/409/EEC), EC Habitats Directive (92/43/EC) and EC Environmental Impact Assessment Directive (85/337/EEC), for example).[48]

7.3.3 The usual practice of such development proposals going to a public inquiry is under question as the details of the new Planning Bill are coming forth. Likewise, there is concern that the forthcoming Marine Bill may compromise the country's energy needs. What is clear is that the plethora of energy-related policies, including climate-change adaption strategies and future environmental legalisation, must integrate with UK Energy Policy to avoid counterproductive and costly conflict.

[48] SDC (2007) Research Report 3 – Severn Barrage Proposals for "Turning the Tide – Tidal Power in the UK

7.3.4 Main environmental legislation relevant to the Severn barrage Proposal

EC Birds Directive (79/409/EEC) and EC Habitats Directive (92/43/EC) as implemented through the Conservation (Natural Habitats & c.)Regulations 1994 (as amended) – in relation to potential impacts on internationally designated nature conservation sites (Special Protection Areas designated under the Birds Directive, Special Areas of Conservation designated under the Habitats Directive and, as a matter of Government policy, Ramsar sites designated under the Ramsar Convention).

EC Water Framework Directive (2000/60/EC) as implemented by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (the Water Framework Regulations) – in relation to potential impacts of the development on Water Framework Directive objectives.

EC Strategic Environmental Assessment Directive (2001/42/EC) as implemented by Environmental Assessment of Plans and Programmes Regulations 2004. It is anticipated that any proposal to take forward either Severn barrage option would need to be considered in the wider context of UK/national energy policies andprogrammes, which would be subject to the requirements of the SEA Directive (on the basis that it is unlikely that such a large project could be successfully promoted in the absence of a robust supporting strategic context).

EC Environmental Impact Assessment Directive (85/337/EEC) as amended by 97/11/EC) as implemented through sectoral EIA Regulations. Any development application for a barrage would need to be supported by a detailed environmental impact assessment (the Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000 are likely to be the most relevant Regulations for environmental impact assessment for a barrage proposal).

Wildlife & Countryside Act 1981 (as amended by the Countryside & Rights of Way Act 2000) – in relation to potential impacts on nationally designated nature conservation sites.

Food & Environment Protection Act 1985 – in relation to the environmental impact of construction works or the disposal of dredged material below mean highwater mark of spring tides (MHWS)).

Water Resources Act 1991 – in relation to any requirement for consented discharges and approval of works affecting flood defences.

Source: Sustainable Development Commission Research Report 3, Severn barrage Proposals in ‘Turning the Tide – Tidal Power for the UK’, 2007

8 Public opinion

8.1 A comprehensive programme of public and stakeholder events was held by the SDC to engage public opinion for the 2007 'Turning the Tide study'. The SDC found that the majority of people, around 90%, were in favour of a barrage. Steve Webb, Liberal Democrat MP for Northavon, asked 2000 of his constituents, "Do you support, in principle, the idea of a barrage across the Severn in order to generate electricity?" The result was an overwhelming (85%) yes. The previous year in 2006, the Bristol Evening Post led a straw poll and 71% of the readers supported the proposal.

9 Conclusion

Given political will, construction of a Severn barrage could start in 2012, with the structure complete and generation starting by the end of 2018. Full operation would be reached a year or two later, in compliance with the 2020 target.

Nonetheless, building a Severn barrage is enormously complex. It will be expensive. It will have both positive and negative economic, social and environmental impacts that need addressing. EU directives on the environment and procurement may have to be challenged. However, in the context of failing power plants, the threat of dependency on unstable imports, and demonstratively challenging and legally binding targets, we find there is a compelling argument to urgently invest in the UK's tidal resources.

With a barrage, we will have insurance against rising fuel prices, a significant contribution to security of supply and flood protection, and a CO_2 saving of around 500,000 tonnes every month. Without a barrage, the Severn Estuary ecosystem will continue to adapt to environmental changes and face increased flooding. Yet more deferral would leave the issue unresolved, with many impacts on businesses in the area. Likewise, the political temptation to take advantage of the provision in the EU Renewables Directive that allows projects begun before 2020 to be counted towards the target will merely illustrate a please-all indecisiveness. This should be avoided at all costs.

What is clear is that the decision not to proceed with a barrage cannot be made without the decision on how renewable energy and CO_2 targets can be met another way. A decision either way certainly will have far-reaching consequences on a cohesive energy policy, and thus must be determined with the utmost urgency in conjunction with our recommended strategy outlined in "A Pragmatic Energy Policy for the UK".

Glossary

Capacity credit means the amount of base load capacity which can be displaced by an intermittent source such as wind.

GW means gigawatt.
One gigawatt equals 1000 megawatts **(MW)**.
One megawatt equals 1000 kilowatts **(kW)**.
A terawatt **(TW)** is 1000 gigawatts

Integrated gasification combined cycle (IGCC) is where coal is gasified, using oxygen, to form syngas which is then burnt in a gas turbine to generate electricity. The heat from the gas turbine's exhaust is used to raise steam for use in a steam turbine to generate more electricity. This gives a high fuel-to-electricity efficiency of over 50%, compared with 35% or less from conventional plant. If the unit is fired by natural gas rather than going through the coal gasification process (called a **combined cycle gas turbine**), plant efficiencies of 56% can be achieved.

Load factor means average power output as a percentage of nameplate capacity.

Nameplate capacity means the maximum design output under optimum conditions.

Nuclear fission is the process whereby a uranium 235 atom splits to cause a chain reaction and releases heat which is then used to generate electricity. When used in such a thermal reactor, 1Kg of natural uranium releases as much energy as 20,000 tonnes of coal.

Nuclear fusion is the process in which an atom of deuterium and an atom of tritium (both isotopes of hydrogen) are squeezed together at 100 million°Celsius for 10 seconds in a plasma. They fuse together to form one atom of helium. The process becomes self-sustaining and releases enormous amounts of heat.

A **nuclear breeder or fast reactor** uses uranium 60 times more effectively than a typical thermal reactor by converting the inactive uranium 238 atoms (99% of uranium) to plutonium which, in the form of plutonium oxide, is a good reactor fuel akin to uranium 235.

Renewable obligation certificates (ROCs) awarded to suppliers generating electricity from eligible renewable sources under the Renewables Obligation. Suppliers are obliged to generate an increasing proportion, on an annual basis, of their electricity sales from eligible renewable sources. For each unit of electricity generated from eligible sources, a tradeable certificate, known as a renewable obligation certificate (ROC), is awarded. Suppliers can meet their obligation through presenting ROCs and paying a defined buyout price which increases each year in line with retail price index, or a combination of the two.

Super critical steam is steam at or above the critical point for water, above which there is no phase change between water to steam. Electricity generating plant using the supercritical steam cycle can have efficiencies in the low to mid 40 percentages whilst older subcritical steam cycle plant typically have efficiencies in the mid to high 30 percentages.