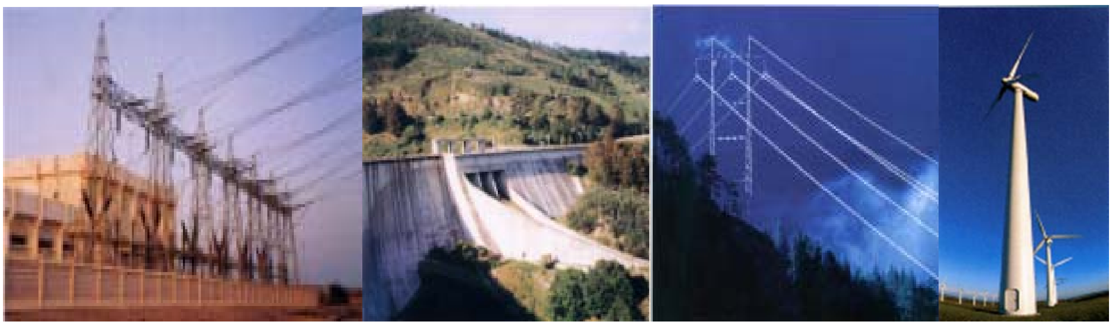
Final Report



Alternative Solutions to the Lewis Wind Power Wind Farm Proposal

to

RSPB

January 2007

IPA Energy + Water Consulting

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EXECUTIVE SUMMARY

IPA Energy + Water Consulting (IPA) has been asked by the RSPB to provide a report assessing potential alternatives to developing the Lewis Windfarm Proposal (LWP). The Lewis Windfarm Proposal (LWP) is a 651.6MW windfarm proposal which will generate some 2,000GWh per year, if built on Lewis.

Our findings are summarised below:

- **Critique of alternatives considered in the LWP Environmental Statements**

  In considering alternatives the developer confines itself to looking only at projects within the Western Isles that could deliver (either combined or separately) over 600MW of renewable energy generation.

  The developer examines 11 areas in the Western Isles and reasons that only 6 sites (all on Lewis) would be capable of supporting a large scheme. They conclude that at best a total of 609MW is potentially available and as a result no combination of projects could meet the project objectives of the LWP proposal.

  In addition to the LWP there are currently two other wind farm proposals of significant size. The Pairc windfarm (250MW) and the Muaitheabhal/Eisken windfarm (159MW) both of which are situated on Lewis. Unlike the LWP, approximately 328MW of this capacity would be outside SPA (and NSA) areas. In addition, there are also a number of other smaller proposed wind sites (5), varying in size from 2.5MW to 12MW.

  Using the developers own criteria for screening sites there is significant other potential to develop windfarms of a similar or greater capacity than the LWP on Lewis alone. Including the Pairc and Eisken windfarms around 600MW, of this potential capacity would be outside SPA areas.

  This does not take into account other areas on the Western Isles, such as South Uist which is considered to have significant potential for onshore windpower and would not encroach on SPA areas. However, other issues such as radar and air defence issues may limit its development for wind farms.

  Therefore, based on the developer's project objectives the criteria for a single site producing 652MW would unlikely be met if SPA areas are excluded, but the sum of two alternative proposal sites could provide around 330MW and more capacity could likely be built in the same timeframe and scale as the LWP outside SPA and NSA areas, if additional sites were also developed.

- **Extent to which renewable energy generated from LWP is required to meet existing policy objectives**

  The LWP is a large scheme and, if developed, would provide a significant contribution to both the GB and Scottish renewable energy targets. However, on the basis of current progress towards Scottish renewable energy targets, our analysis suggests that there appears to be no clear need for a contribution from LWP in order to meet them. While the 2015 GB target appears more challenging (based on the current knowledge of planned and proposed renewable capacity) it is likely that further schemes will come forward over the coming years, increasing the probability that the target will be met without a contribution from LWP. The need for meeting energy policy targets therefore, appears not to provide an overriding and imperative justification to build LWP.

While national energy policy promotes onshore wind power (and other renewables), it does not provide justification for building within an SPA to meet renewable energy targets. There is considerable policy guidance requiring developers and planners to take account of nature conservation issues, indicating that developments should only be permitted where they are not adversely impacting the nation's natural heritage.

- **Technical and commercial viability of alternative technologies to onshore wind**

Onshore wind technology is currently the most mature and widespread form of renewable generation. The main technical obstacles to its development appear to be planning and land use constraints and limits to the capacity of power grids to support it. The latter is an issue that will need to be addressed for the widespread development of all renewable generation.

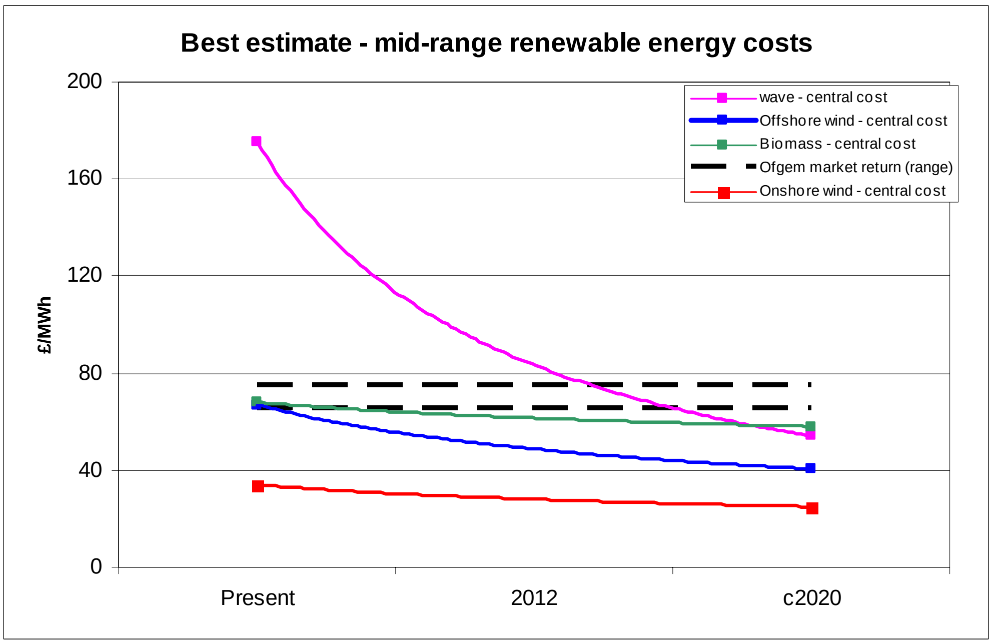
The development of offshore wind technology is likely to increase significantly over the period to 2020. Although there is currently limited experience of installing and maintaining such structures offshore, with more potential to gain economies of scale than onshore wind technology and less planning restrictions, it is widely predicted to experience very rapid development in the next few years.

The technological development of wave power has not progressed to the point where it is capable of being commercially applied, but it rivals offshore windpower, in its potential to deliver large amounts of power to the UK grid.

Biomass is currently limited to smaller commercial applications and co-firing in conventional power stations. Dedicated biomass plants are likely to remain relatively small in scale because of the costs of transporting the fuel.

The following figure compares the mid-range of the 'Best Estimate' cost for these renewable technologies.

Figure: Current and expected mid-range of renewable costs set against market entry prices



Onshore wind is likely to remain the most economic renewable in the short to medium term, although offshore wind and then later wave are likely to become more commercially attractive over the period.

It is also important to note that as these are 'generic' central estimates of the cost of these technologies they do not reflect likely costs at the best sites for these resources. Lewis and Uist, for example, have some of the best offshore resources in Europe.

- **Credible and feasible alternative Solutions for generating 652MW of renewable energy**

The Western Isles has significant renewable energy potential (both wind and wave). Based on a review of the state of the renewable technologies most able to utilise these resources, it was assessed that a mix of technologies, including onshore wind and offshore wind and wave could easily match the capacity of the LWP in the medium term.

Up to 600MW of alternative onshore capacity on the Western Isles has also been proposed and could be viable in the same timescales as the LWP. While this would not match the size of LWP, additional onshore wind developments could potentially also be developed in other areas of the Western Isles, which would not impact upon environmentally sensitive areas.

Looking to the mainland of Scotland, a significant area of land has been earmarked for onshore wind farm development by several Scottish Planning Authorities. The Scottish Natural Heritage has also identified a significant area of land that would be suitable for onshore wind developments. As the LWP covers some 225km^2, there would appear to be opportunities for alternative sites, however, given the size of this proposal, a development of this magnitude would be expected to generate significant planning problems. Whilst the number of locations for similar large-scale single developments might be limited the total number of developments in the pipeline suggests that there are many locations where smaller developments could be located and collectively generate the same output (and significantly greater) as the LWP.

The size of alternative renewable resources available for development in Scotland is very large. Garrad Hassan identified over 10GW of offshore wind resources alone that they predicted could be economically developed. Similarly, it indicated that Scotland has over 5GW of offshore wave potential that could be commercially viable. The bulk of the identified wave resources and a significant portion of the offshore wind potential lies off the coast of the Western Isles. It is therefore highly likely that this area will become a prime site for the development of these resources. Lacking the planning and land use constraints found onshore, construction of very large 652MW arrays of generators is also much more feasible offshore.

In the context of the UK, where over 10GW of onshore and almost 10GW of offshore windfarms are currently planned, LWP at 0.652GW, while significant as a single project, is not overly significant when considered against other proposed renewable developments. There are clearly other locations around the UK that can accommodate a significant amount of renewables capacity, some of which (particularly offshore) could support schemes in excess of the size of the LWP proposal. Given the need for a reason of overwhelming national importance to overturn the protection accorded by an SPA, it would not appear that LWP is 'vital' in a national context given other proposed renewable developments.

- **Options for the construction and funding of an electrical grid-interconnector from the Western Isles to the mainland**

  The LWP would provide justification for the construction of an upgraded link to the mainland, but there are other developments that would also require the upgrade. Although there are no offshore wind or wave projects of any size currently proposed for Lewis, there are two smaller proposed onshore windfarms which would also require a new connection to the mainland.

  Using current Ofgem guidelines, a renewable project of around 216MW could economically justify building a new connection of 600MW. The Pairc windfarm proposal alone, at 250MW would therefore justify a new link.

  A representative of SSE's Transmission Division (SHETL) said that they they were now beginning preparatory works (detailed planning of the interconnection) to lay a transmission link to the Western Isles of some 900MW capacity (3 300MW cables) on the back of commitments made to them by the developers on the Western Isles. Nearly 600MW of renewable generation developments have now signed contracts for the design and connection to the transmission system. This does not include the LWP. The decision to lay 3 cables would allow for additional capacity on the line as a whole and for the failure of one of the cables.

  Thus the actuality of developments 'on the ground' on Lewis, confirms the view that LWP is not required to prompt investment in a new transmission link to the Western Isles.

- **Review of Alternative Means to Meet Climate Change Targets**

  The emissions savings from the Lewis wind farm arise from the fact that it would displace electricity generated by other sources, elsewhere. However, the magnitude of these savings depends on a number of factors such as transmission losses associated with the Lewis wind farm which could range from 3-16% depending on the route and technology used for the interconnector, the profile of the wind output over time compared with the marginal electricity generators producing electricity at those times and emissions associated with generation required to be maintained on standby in case of unexpected reduction in the output from the Lewis wind farm.

  In addition, the manufacture of wind turbine components, as well as construction and decommissioning of the wind farm, are activities that produce greenhouse gas emissions. The most important factor affecting the life cycle emissions of the Lewis Wind Farm is, however, associated with the fact that the wind farm will be built almost entirely on peat soils. Disturbance to the natural environment attributes around 70% of the life cycle emissions from the Lewis wind farm.

  In the near term the main alternatives to providing 600+ MW of new renewable energy supply are likely to be other onshore wind sites and offshore wind. Other onshore wind sites on the mainland would have lower transmission losses, and might also have lower life cycle emissions (if not located on peat). This would improve their overall contribution to emission reduction targets. However, the wind resource in the Western Isles is likely to be better than most alternative sites, which could favour the Lewis Wind Farm over alternatives. Whether a specific alternative would make a greater or lesser contribution would depend on site-specific factors.

  Offshore wind farms are likely to have greater life cycle emissions than the equivalent onshore turbines, mainly due to their increased concrete and steel consumption.

However, this would be offset by higher capacity factors and lower requirements for standby generation, due to the more consistent wind profile offshore. There would also be no issues with peat or forest clearance. Therefore the overall contribution to emission reduction targets from offshore wind farms would generally be higher (particularly if they are located close to centres of demand, such as in south-east England).

1. INTRODUCTION & BACKGROUND

The Lewis Windfarm Proposal (LWP) is a 651.6MW (652MW) windfarm proposal which will generate some 2,000GWh per year[1], if built on Lewis. It could produce approximately 13% of the Scottish Executive's 2020 renewable target and supply some 6%[2] of Scottish electricity demand.

The stated objectives of the LWP are:

- To deliver a commercially viable wind farm
- To provide justification for the investment in a large efficient grid interconnector to the Western isles with spare capacity for other renewable projects
- To make a major contribution to Scottish and UK renewable energy targets
- To make a major contribution to the economy of the Western Isles

The proposed development would take place on land within the internationally protected Lewis Peatlands Special Protection Area (SPA) and could have an adverse impact on its integrity. As such consent can only be given to the project if the competent authority in Scotland (in the case of section 36 planning applications, the Scottish Executive) can be persuaded that there are no alternative solutions and that there are imperative reasons of over-riding public interest to build it.

IPA Energy + Water Consulting (IPA) has been asked to provide a report assessing potential alternatives to developing the LWP. This report identifies and evaluates alternative solutions to the LWP wind farm application.

The report is structured as follows:

- **Section 2**: Provides the context for reviewing alternative solutions to the LWP.
- **Section 3:** Provides a critique of alternatives considered in the Lewis Wind Power Environmental Statements.
- **Section 4**: Investigates the extent to which renewable energy generated from the Lewis Windfarm proposal is required to meet existing policy objectives.
- **Section 5**: Identifies and discusses the technical and commercial viability of alternative technologies to onshore wind.
- **Section 6**: Investigates credible and feasible alternative solutions for generating 652MW of renewable energy.
- **Section 7:** Considers options for the construction and funding of an electrical grid-interconnector from the Western Isles to the mainland.
- **Section 8:** Undertakes a review of alternative means to meet climate change targets.

[1] Using a 35% load factor as set out in the 2004 LWP Environment Statement
[2] Scottish Renewables Forum, 2006, Delivering the New Generation of Electricity.

2. CONTEXT FOR REVIEWING ALTERNATIVE SOLUTIONS TO THE LEWIS WINDFARM PROPOSAL

In November 2004 the Lewis Windfarm Proposal was submitted to the Scottish Executive. Following on from additional submissions in 2005 and 2006, the joint proposal, by Amec and British Energy, is for the construction of a 181 turbine, 652MW wind farm, (and associated structures) on the northern end of the Isle of Lewis. The proposal falls within an area designated as the Lewis Peatlands SPA. This area was classified as an SPA by a European Council Directive on the Conservation of Wild Birds (79/409/EEC) and this Directive was enshrined in UK law by the 1994 Conservation (Natural Habitats &c) Regulations.

Because this development will affect a European site, the Scottish Executive are required to consider a series of legal tests before consent can be issued.

The first test is whether the proposal alone, or in combination with other plans or projects is likely to have a significant effect on a European site. If this is deemed so, then the next stage is to undertake an appropriate assessment to determine whether or not the project will adversely affect the integrity of the site. If it cannot be shown that it will not affect site integrity then it must be determined whether there are alternative *solutions* to it.

It is important to point out at this stage, that if Scottish Ministers conclude that there are no alternative solutions the development may be granted consent for imperative reasons of overriding public interest.

Based on guidance from the Secretary of State (SoS)[3], in cases where a development would have a significant effect upon the integrity of designated sites '…*consideration of alternatives must concern alternative ways of avoiding impacts on the designated sites'*.

A consideration of alternative solutions would need to consider all of the following –

- Other locations (Guidance from SoS –'*The Secretary of State considers that such alternatives would not be confined to alternative local sites for the project*'[4]);
- Different technologies; (Guidance from SoS –'....*a competent authority should not limit consideration of alternative solutions to those suggested by a project's proponents*[5]);
- Different forms, layouts or sizes, which would have a lesser impact on the SPA.

This is confirmed by EU Commission guidance on this subject which states that when looking at alternative solutions '*It should be stressed that the reference parameters for such comparisons deal with aspects concerning the conservation and the maintenance of the integrity of the site and of its ecological functions. In this phase, therefore, other assessment criteria, such as economic criteria, cannot be seen as overruling ecological criteria*[6].

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[3] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
[4] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
[5] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
[6] European Commission (April 2000) 'Managing Natura 2000 Sites: The Provisions of Article 6 of the Habitats Directive 92/43/EEC', European Commission

Although not reflecting planning guidance on this issue, it is useful to put an examination of 'alternative solutions' in the context of the views of the Lewis windfarm developers. In the LWP 2004 Environment Statement (ES)[7] – the developer states that *'To fulfil the LWP proposal objectives, the alternative would have to be a large-scale renewable energy project on the Western Isles that could be developed in the timeframe of the LWP proposal'*.

The developer places great emphasis on the term proposal or project objectives. In the 2006 Addendum to the Environmental Statement[8] it emphases that in considering *alternatives,* only projects on the Western Isles which can deliver on all four of the project objectives can be considered. This is based on their own assessment of the EU/UK guidance, ECJ/UK case law and previous consenting decisions, as there are no definitive definitions of "alternative solutions" or the scope of the alternatives test.

Clearly, objectives directly relating to the Western Isles such as the contribution to the economy and justification of an interconnector to the mainland should be taken in the context of the Western Isles. However, when considering the third objective (contribution to renewable energy targets) this is likely to be more contentious as energy targets are not set at a regional level, but nationally. As a result, in contributing to national renewable energy targets it would be likely to be more pragmatic to investigate alternatives in the national context rather than just locally.

Additionally, as the development impinges on land within the internationally protected Lewis Peatlands SPA, which is considered of national and international importance, it would be pragmatic to consider alternative solutions to the LWP on at least a national basis.

However, the final decision on the assessment of alternative solutions lies with the Scottish Ministers and their interpretation of the relevant guidance. The remainder of this report investigates alternative solutions on the basis of guidance from the Secretary of State described above.

In terms of scale, the LWP is a 652MW windfarm that will generate ~2,000GWh a year. Although the developer does not define the project's 'timeframe', this is inextricably tied to the successful reinforcement of local grid connections, because the development's output would be many times larger than the demand of the Western Isles. It would therefore need to export power to the mainland to be viable. The existing links to the mainland are inadequate for this purpose and consist of two separate 33kV lines running from Harris and Uist, respectively, to Skye.

A study is currently being carried out by Scottish Hydro Electric Transmission Ltd (SHETL) on the possible development of a new high voltage electricity transmission line capable of accommodating power from renewable energy developments on the Western Isles. This line, however, is contingent on the successful completion of reinforcement of the mainland's Beauly-Denny line (work on this will be delayed by a Public Inquiry, which is expected to report by the end of 2007) because the Lewis line will be a spur off this upgraded line. This line would be used to transfer power from the LWP to the centres of demand further south. The earliest completion date for the Beauly line reinforcements was previously 2008, but given the ongoing planning delay 2012 is now considered the earliest possibility. On this basis, the very earliest LWP could start operation is assumed to be 2012, for the purposes of this review (however, this start date is considered to be optimistic).

[7] Section 8.2 of The Lewis Windfarm Proposal's Environment Statement, 2004.
[8] Section 3 Report to Inform the Alternatives Test, 2006 Addendum to the Environmental Statement.

3. CRITIQUE OF ALTERNATIVES CONSIDERED IN THE LEWIS WIND POWER ENVIRONMENTAL STATEMENT

This section provides a critique of the assumptions in the 'Alternatives' chapter (chapter 8) of the developer's 2004 Environment Statement (ES) and Section 3 'report to Inform the Alternatives Test,' of the Addendum to the Environmental Statement 2006 (AES) for the LWP.

3.1. Alternative Windfarm Sites on the Western Isles

Both the developer and guidance from the SoS, highlighted in the previous section, are in agreement that an examination of alternative locations for the proposal, on the Western Isles, is required as part of the planning process.

The 'Alternatives' chapter of the LWP ES lists a series of sites on the Western Isles, which are then discounted in favour of the LWP site. The sites listed were identified from preliminary desk studies and include areas earmarked by other developers.

In confining their analysis of alternatives to '*..a large-scale renewable energy project on the Western Isles*' the developers are implying that the only alternative should be a very large single project (on the Western Isles), although in section 3 of the 2006 AES the developer considers alternative technologies either separately or in combination that could deliver over 600MW of renewable energy generation in the Western Isles.

It is worth noting that LWP is only one of three on shore wind farm proposals of this magnitude (>500MW) in Scotland (and the UK), although Lewis is the biggest. In Scotland there are over 150 windfarms[9] currently in either the initial stages of development or the planning process.

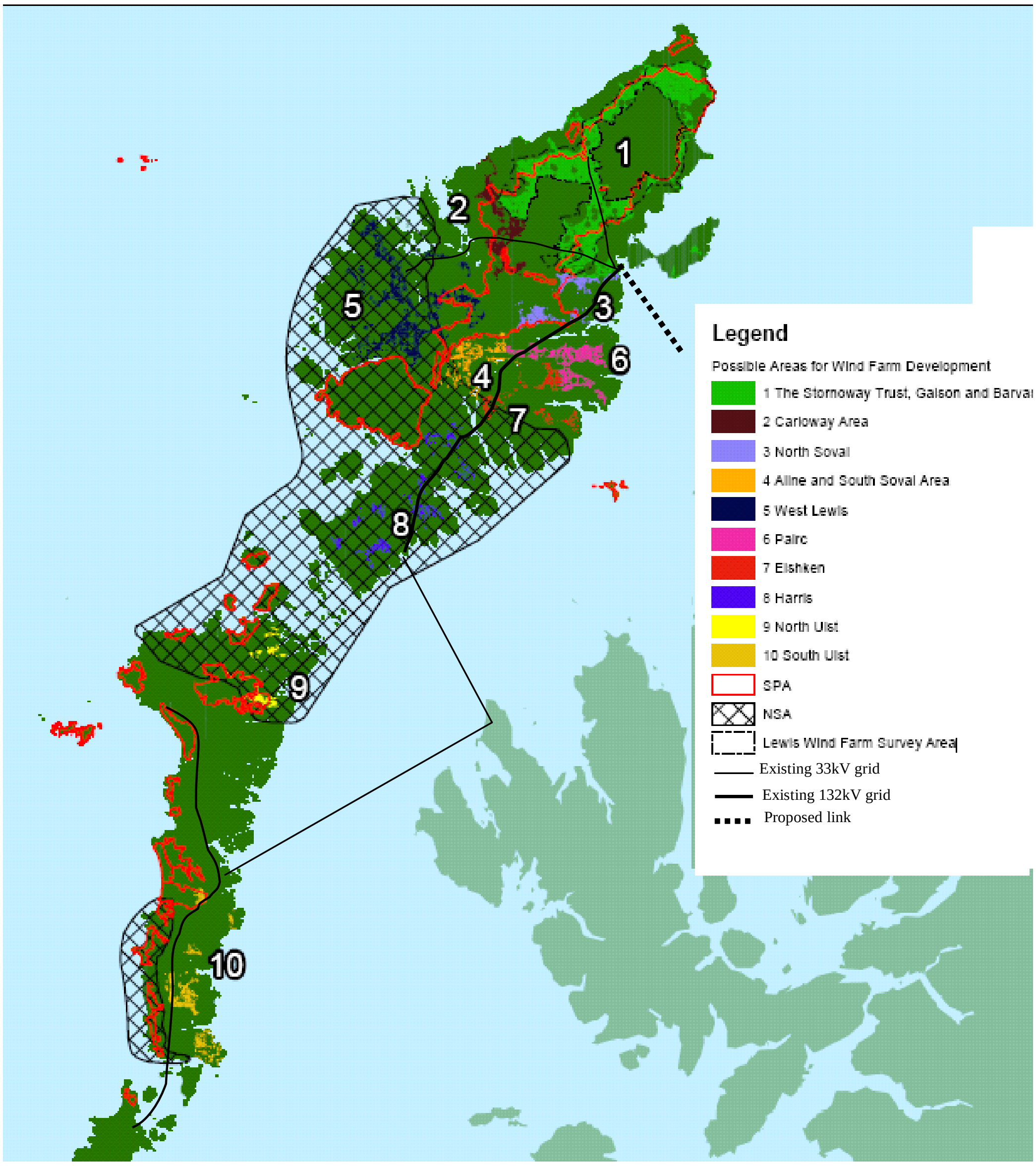
In the 2006 AES 11 areas are examined, although in the 2004 ES only 10 sites are investigated. Two of these locations have been chosen by other developers with plans for significant wind development. They and the other sites considered in the Environmental Statements are shown in Figure 1 below.

Area 9 through to 11 are not shown on the overview map in the 2006 AES and so we use the 2004 ES to show the alternative locations for a wind farm development on the Western Isles. Area 11, which is an addition to the earlier map, is around the region of Benbecula (between areas 9 and 10 on figure 1)

The proposed development sites are the Lewis windfarm (652MW) – site 1 - which is being proposed by the British Energy/AMEC consortium, the Pairc windfarm (250MW) – site 6 -, which is being proposed by Scottish and Southern Energy and Muaitheabhal/Eisken windfarm (159MW) – site 7 - which is being proposed by Beinn Mhor Power.

[9] Platts Power UK Power Station Tracker and IPA Analysis, September 2006

Figure 1: Location of proposed onshore windfarms on Western Isles



Source: British Energy/AMEC, 2004, The Lewis Windfarm Proposal Environment Statement

It is worth reviewing all these sites against the broad environmental criteria of whether they impinge on SPAs and National Scenic Areas (NSAs)[10].

Five (including site 11) of the 11 sites fall outside SPA and NSA designated areas and 2 partly enter them. The LWP site falls entirely within an SPA area. Muaitheabhal/Eisken (site 7) does not enter an SPA but partially intrudes into the Western Isles NSA (27 of the 53 3MW turbines intrude[11]); and the Pairc site (site 6) does not intrude on any SPA, or NSA areas.

[10] National Scenic Areas are Scotland's only national landscape designation. They are those areas of land considered of national significance on the basis of their outstanding scenic interest which must be conserved as part of the country's natural heritage. They have been selected for their characteristic features of scenery comprising a mixture of richly diverse landscapes including prominent landforms, coastline, sea and freshwater lochs, rivers, woodlands and moorlands (Scottish Natural Heritage)

[11] Letter to the Scottish Executive Energy Policy Unit, David MacLennan, Area Manager Western Isles, 12th October 2006

On two of the currently proposed alternative project sites (sites 6 and 7) it would be possible to build 328MW (i.e. 250MW at Pairc and 78MW at Muaitheabhal/Eisken) outside SPA (and NSA) areas. Additional sites on Lewis and Uist should also present opportunities for onshore windfarm development.

In addition to the above there are also a number of smaller proposed wind farm sites (5) in the Western Isles, varying in size from 2.5MW to 12MW[12].

The LWP developer uses constraints as part of a geographical screening process, to identify the areas (11) potentially developable for an onshore wind farm. These constraints cover issues like proximity to dwellings, slope of ground, military practice and regulated airspace. These sites are then further refined as a result of a "theoretical" GIS process to leave areas within Lewis and North Harris (areas 2-7) as potential alternative sites. Analysis was then undertaken on these sites to determine whether individually or combined these sites could deliver the capacity of the LWP. Their analysis concluded that no combination of projects could meet the project objectives of the LWP.

In their first elimination of sites, of the potential 11 areas for development, sites 8-11 were discounted as they were considered too small, spread over a large area and that linking these areas together would not be practical or economic. However, they do not rule out these areas in the future for discrete developments and so clearly these sites could be viable for smaller scale onshore wind developments. Whilst they are not considered to be practical for a single or "combined" large scale wind development of the size of the LWP, they could be suitable for smaller individual developments.

Most of Uist (including site 10) is discounted by the developer in the 2004 Environmental statement because of air defence related issues. While this is not unreasonable, in the UK, civil aviation and defence interests have been working since 2001 to tackle issues associated with the impact of wind turbines on radar. The British Wind Energy Association (BWEA) also states that the MOD is currently developing radar technology to mitigate the effects of wind farms on radar, both in air traffic and air defence systems. In the light of these developments these sites could also be seen as a potential site for windfarm development. Perhaps more crucially, the two other windfarm proposals on Lewis are closer to the air defence radar site on South Clettraval, North Uist, and issues related to MOD radar do not appear to be preventing their ongoing development.

In fact, in the 2006 Addendum to the Environmental Statement, the developers say that they have consulted with representatives of the Civil Aviation Authority, Highlands and Islands Airports Limited and National Air Traffic Services (NATS) through the development of the wind farm. This has enabled them to develop the wind farm layout and propose mitigation measures without comprising the safeguarding of the airport or NATS radar infrastructure. This level of consultation and development could also be applied to the other sites on the Islands, allowing development to take place.

From their analysis, the developer concludes that only sites in areas highlighted 2-7 would be capable of supporting a large scheme. They then go on to determine the possible size (in terms of capacity in MW) that each of the areas, individually and combined, could support. They conclude that at best estimates 609MW is potentially available and as a result no combination of projects could meet the project objectives of the LWP proposal.

[12] Scottish Renewables November 2006

However, it is interesting to note that sites 6 (Pairc) and 7 (Eisken) already have proposed developments, totalling some 409MW, around 328MW of which would be outside of SPA (and NSA) areas. This would then leave sites 2-5 to contribute around 243MW to be of similar scale to the LWP. If we consider the best estimates of these areas, as shown in the report to Inform the Alternatives Test[13], then around 455MW is potentially available. If we then consider alternative sites that have been identified by the developer to be outside of SPA areas then up to 273MW could potentially be available in sites 2-5.

There is therefore significant potential to develop windfarms of a similar or greater capacity than the LWP from sites 2-7 alone. In fact, around 600MW of this capacity would be outside of SPA areas. It is also interesting to note that the developer reasoned that only up to 154MW of capacity was available at sites 6 and 7, where there are currently some 409MW being proposed.

When Garrad Hassan conducted surveys for the Scottish Executive (2001)[14] and later in 2002 for both the Scottish Executive and Comhairle Nan Eilean Siar[15], of renewable resources in Scotland, they identified the area around site 10 on South Uist as having significant potential for onshore windpower on the W Isles (smaller sites around 2 and 7 were also highlighted as having potential). However, South Uist is located within 74 km of an air defence site, and the MoD has a policy of objecting to wind farm projects within this radius[16]. Therefore, whilst there are immediate constraints to utilising this area for wind farm development, this site could be seen as a site for wind farm development as a result of advances in radar technology and consultation with the MoD, as discussed earlier.

Garrad Hassan also specifically excluded most of Lewis in the 2001 study as a wind resource because it was defined as a Tier 1 environmental constraint in their study (a Tier 1 constraint being defined in the study as an area designated as not for development by virtue of its national or international environmental or cultural value). The 2002 update report goes on to emphasise this by highlighting significant areas of Lewis for blanket bog interest and moorland bird designated areas. These two figures are shown below:

[13] Section 3 of the 2006 Addendum to the Environmental Statement
[14] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis
[15] Garrad Hassan, 2002, Western Isles Renewable Energy Study Part I Resource Investigations
[16] Garrad Hassan, 2002, Western Isles Renewable Energy Study Part II Development Considerations

Figure 2: Areas designated for blanket bog interest[17]

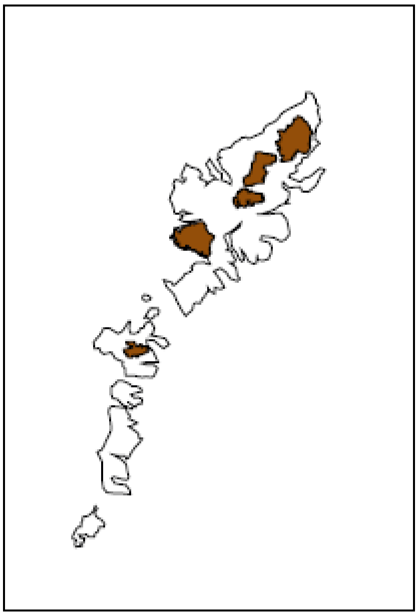
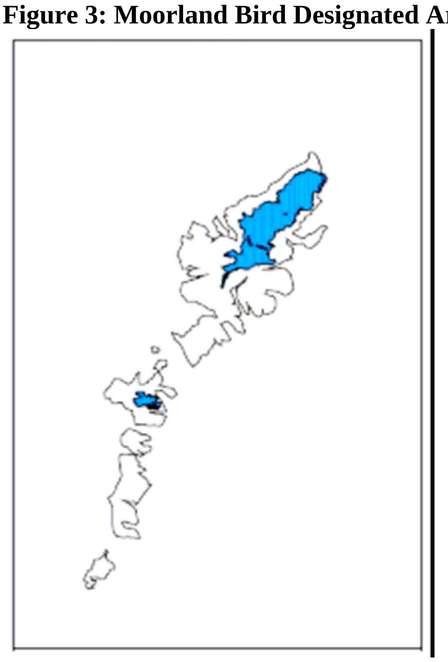


Figure 3: Moorland Bird Designated Areas[18]



Garrad Hassan scaled down the onshore wind resources in the 2001 study (11.5GW of capacity), to match an expected maximum market for onshore wind of 3GW of capacity in 2010, picking only the very low cost sites. As a result, none of the sites on the Western Isles were further considered.

It is also important to note that whilst guidance from the SoS states that alternatives would not be confined to alternative local sites… highlighting the national importance placed on SPA sites, the Environmental Statements do not consider other sites within the UK or even Scotland, it only considers alternatives on the Western Isles. SPAs are of national (and European) importance and so based on the guidance from the SoS the

[17] Garrad Hassan, 2002, Western Isles Renewable Energy Study Part II Development Considerations
[18] Garrad Hassan, 2002, Western Isles Renewable Energy Study Part II Development Considerations

Environmental Statements appears to fail in addressing and considering properly alternative solutions to the LWP wind farm proposal, although the developer argues that the alternatives must meet all of the project objectives.

3.2. Alternative Technologies

In section 8.3 of chapter 8 of the ES, the developer states that the prospects for alternative technologies, other than onshore and offshore wind (in the timeframe of the LWP) are negligible. This is reaffirmed in the 2006 Addendum to the Environmental Statement, which concludes that only offshore and onshore wind developments have the potential to meet the project objectives.

Section 5 of this report assesses the technical and commercial viability of alternative technologies to onshore windpower and Section 6 assesses credible and feasible alternatives for generating around 652MW of renewable energy in the same timescale as the LWP both on the Western Isles (and its coastal waters) and the mainland.

3.3. Environment Statement Critique Findings

Around 400MW of onshore wind could be developed outside SPA areas on Lewis using site 6 – the Pairc Windfarm site – and site 7 – the Muaitheabhal/Eisken windfarm site - (although this total drops to just under 330MW if one discounts the turbines intruding in the nearby NSA area). There are also several other sites which show potential for development near these two core sites. Considering existing proposed developments and the developers findings, up to 600 MW could potentially be generated using areas that did not fall within SPA designated areas on Lewis (sites 2-7) and which were largely contiguous.

Similarly, referencing the Garrad Hassan study, it is clear that additional resources could be developed on South Uist at site 10 subject to MOD concerns as well as the potential for developments in areas 8, 9 and 11.

It is also interesting to point out here that nearly 600MW[19] of renewable generation developments on Lewis have signed contracts for the design and development of a connection to the transmission system, indicating that there are significant other potential developments taking place.

The developer considered in its 2006 Addendum to the Environmental Statement, whether there were other onshore wind sites, either separately or in combination, on the Western Isles that could deliver over 600MW of renewable energy generation (in the light of the project objectives). In the 2004 Environmental Statement the developer stated that, ‘To fulfil the LWP proposal objectives, the alternative would have to be a large-scale renewable energy project on the Western Isles that could be developed in the timeframe of the LWP proposal.’ The criteria for a single site producing 652MW would not be met, but the sum of two alternative proposal sites could provide around 330MW outside SPA and NSA areas and more capacity could likely be built in the same timeframe and scale as the LWP, if additional sites were also developed.

[19] Scottish Hydro-Electric Transmission Limited, Proposed Western Isles Connection, Consultation Document, December 2006

4. EXTENT TO WHICH RENEWABLE ENERGY GENERATED FROM THE LEWIS WINDFARM PROPOSAL IS REQUIRED TO MEET EXISTING POLICY OBJECTIVES

Guidance from the SoS[20] assessing alternative solutions to developing within SPAs indicates that even if there are no alternative solutions, there still must be *"imperative reasons of overriding public interest"* to build within it. This section reviews whether UK energy policy provides a justification for building within the SPA in order to meet renewable energy generation targets and if the building of LWP will enable the Government to meet its targets.

4.1. Existing Energy Policy Objectives

The primary tool to stimulate the development of renewable generation within the UK is the Renewables Obligation (RO). This places an obligation on electricity suppliers to source an increasing portion of their electricity supplies from renewable sources of power (or pay a buy-out price). As renewable energy is a devolved matter each of the devolved administrations have their own Renewables Obligation. However, certificates issued under the different Renewables Obligations are fully fungible allowing the trade of certificates between different administrations. For example, electricity generated from renewable sources in Scotland can count towards an electricity suppliers obligation in England & Wales and vice versa.

In addition to this, the Scottish Executive has set its own target, or aspirations, for renewable generation. These are in excess of the RO targets, recognising the large renewable resource base in Scotland, and the contribution of its larger hydro development schemes (which are excluded from the RO). These targets are shown in the table below.

Additional support mechanisms such as the climate change levy also promote the use of renewable sources as well as capital grant schemes for the promotion of 'near-market' technologies such as dedicated biomass generation, marine generation and offshore wind.

[20] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.

Table 1: GB and Scottish RO and Scottish Executive renewable targets[21]

Year	GB Renewable Obligation (% of sales)	GB Obligation (~TWh)	Scottish Obligation (~TWh)	Scottish Executive RE targets (~TWh)
2002	3	9.4	1.0	
2003	4.3	13.7	1.4	
2004	4.9	15.9	1.6	
2005	5.5	17.6	1.8	
2006	6.7	22.3	2.2	
2007	7.9	26.6	2.7	
2008	9.1	31.0	3.1	
2009	9.1	33.5	3.3	
2010	10.4	36.4	3.6	6.6
2011	11.4	40.4	4.0	
2012	12.4	44.4	4.4	
2013	13.4	48.6	4.8	
2014	14.4	52.8	5.2	
2015	15.4	57.1	5.6	
2020	15.4	~57.1	~5.6	15.4

Sources: http://www.dti.gov.uk/files/file21123.pdf ,
Scottish Renewables Forum, June 2006, Delivering the New Generation of Electricity,
IPA GB & Scottish demand estimates

4.2. Balancing Nature Conservation and Renewable Energy Development

Support for new renewable energy projects is not unconditional as NPP6 states *"policy is based on the principle that renewable energy developments should be accommodated throughout Scotland where the technology can operate efficiently and environmental impacts can be addressed satisfactorily"*[22]. Planners are obliged to take account of issues like sustainable development and adverse local impacts when considering projects, as these issues are mentioned in policy guidelines. This also includes the Habitats Regulations (Regulations 3(2)) which states '*The Secretary of State, the Minister of Agriculture, Fisheries and Food and the nature conservation bodies shall exercise their functions under the enactments relating to nature conservation so as to secure compliance with the requirements of the Habitats Directive.'*[23].

Other key policy guidelines relating to nature conservation and renewable energy development include:

[21] In 2007, the GB Renewables Obligation is to be changed so that from 2015/16 to 2020 there will be a maximum target of 20%.
[22] National Planning Policy Guidelines number 6 section 19
[23] Reg 3(2) of the Habitats Regulations which can be found at the Office of Public Sector Information website at http://www.opsi.gov.uk/si/si1994/Uksi_19942716_en_2.htm#end

- *'Our aim is to develop a policy that takes full advantage of Scotland's massive renewables potential at an affordable cost to consumers and whilst safeguarding our natural heritage. (*Scottish Executive*)* [24]
- *'renewable energy projects should only be permitted where it can be demonstrated that the objectives of designation and the overall integrity of the area will not be compromised or any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by social and economic benefits of national importance.' (*Planning Policy Guideline NPPG 6 (Renewables*))*[25].
- *'the most sensitive landscapes may have little or no capacity to accept new development. Some of Scotland's remoter mountain and coastal areas possess an elemental quality from which many people derive psychological and spiritual benefits. Such areas are very sensitive to any form of development or intrusive human activity and planning authorities should take great care to safeguard their wild land character. This care should extend to the assessment of proposals for development outwith these areas which might adversely affect their wild land character. (NPPG 14 (*Natural Heritage*))'*[26]
- *'maximise the opportunities for renewable and alternative energy production' but also 'respect the special qualities of the Western Isles, maximise the potential of its natural resources and provide good stewardship of the natural and built environment (*Western Isles Structure Plan*)'*[27]
- *Development proposals for hydro, wave, tidal and wind (on-shore and off-shore) energy schemes and associated infrastructure will be viewed positively. Proposals will be subject to satisfactory assessment of all of the following: the impact on local communities and any other existing or proposed land uses and interests; the impact on natural and built heritage resources; (contd) (*Western Isles Structure Plan*)*[28].

Any new renewable developments should therefore be taken in the context of the above guidelines.

4.3. Lewis Windfarm in the Context of National Renewable Energy Targets

In order to place LWP within the context of national renewable energy policy targets, the following figures show the capacity of renewable generation projects (at various stages of development as of September 2006) and Scottish and GB Renewable Obligation targets for 2010 and 2015 and the 2020 Scottish Executive targets.

From

[24] Scottish Executive Report, March 2003, Securing a Renewable Future: Scotland's Renewable Energy,
[25] Scottish Executive, November 2000, National Planning Policy Guidance Note 6 (Renewables)
[26] Scottish Executive, January 1999, National Planning Policy Guidance Note 14 (Natural Heritage)
[27] Comhairle nan Eilean Siar, December 2003, Western Isles Structure Plan
[28] As above

Figure 4 it can be seen that the Scottish Executive targets for 2010 will be met by projects currently operating or given planning approval. This was confirmed by the Scottish Renewable Forum recently stating that Scotland is set to meet the 2010 Executive target by the end of 2007[29], that is to say, 3 years early. It is also highly likely that the 2020 Scottish Executive targets will be met, given the number of projects given planning approval, or which have applied for planning approval. Only around 31% of capacity applying for planning permission would have to be approved for the 2020 target to be met (without the LWP). The BWEA suggest that approximately 60% of all wind farm planning applications are approved (based on UK approved/refused statistics for 2005)[30]. Clearly, looking out to 2020, it is likely that additional projects that are not currently in the planning system (including projects involving "near market" technologies such as wave and tidal) will also be developed thereby contributing further towards the Scottish renewable targets.

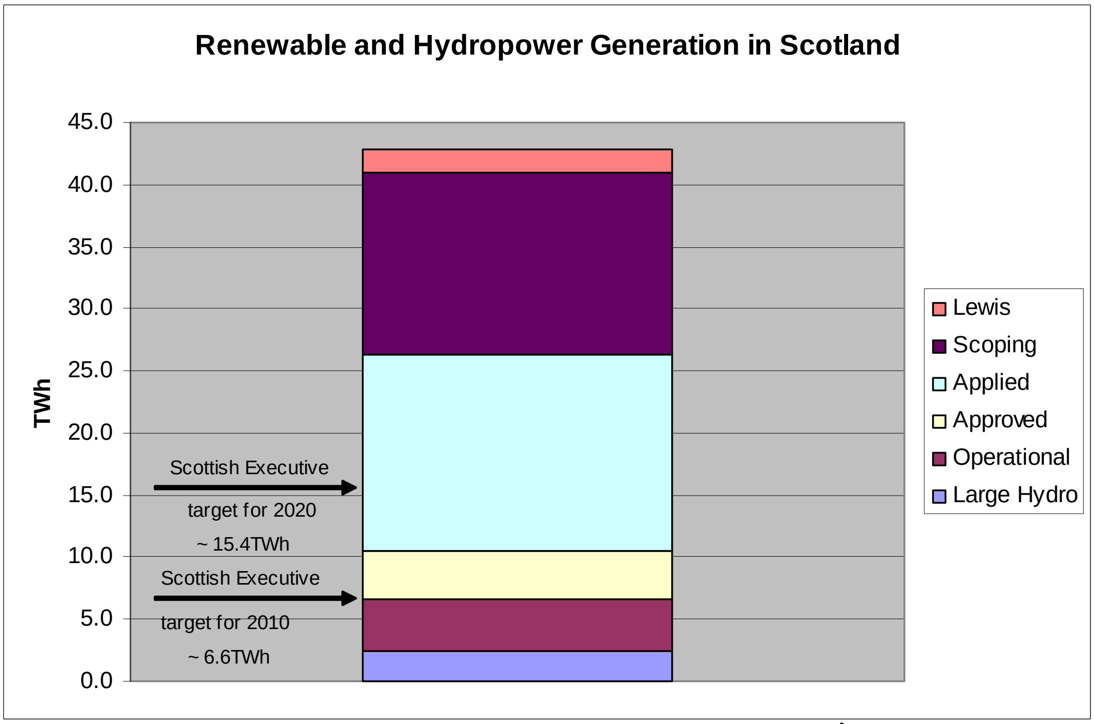
Figure 5 shows the Scottish RO targets in 2010 and 2015 could also be easily met without the Lewis windfarm, based only on renewable projects already with planning approval.

[29] Scottish Renewables Forum website article 'Renewables are delivering - Executive recognition in 'no nuclear aim', 27/06/2006, http://www.scottishrenewables.com/newsitem.asp?id=113
[30] BWEA, 2006.

Figure 6 shows that the GB 2010 RO target is likely to be met if around 47% of currently planned projects are given planning approval (providing they can also be built before that date). The 2015 target is more onerous and would be unlikely to be met (without Lewis) unless all of the projects currently in planning and around 32% of those at the scoping stage were developed, based on existing schemes in the pipeline. If planning approvals stayed at the current 60% rate there would be a ~3TWh shortfall by 2015, which would be too large to be closed by Lewis alone (~2TWh)[31]. However, as highlighted above this assessment only takes account of currently planned developments, taking no account of further schemes that could be developed across the whole of the GB over the intervening years.

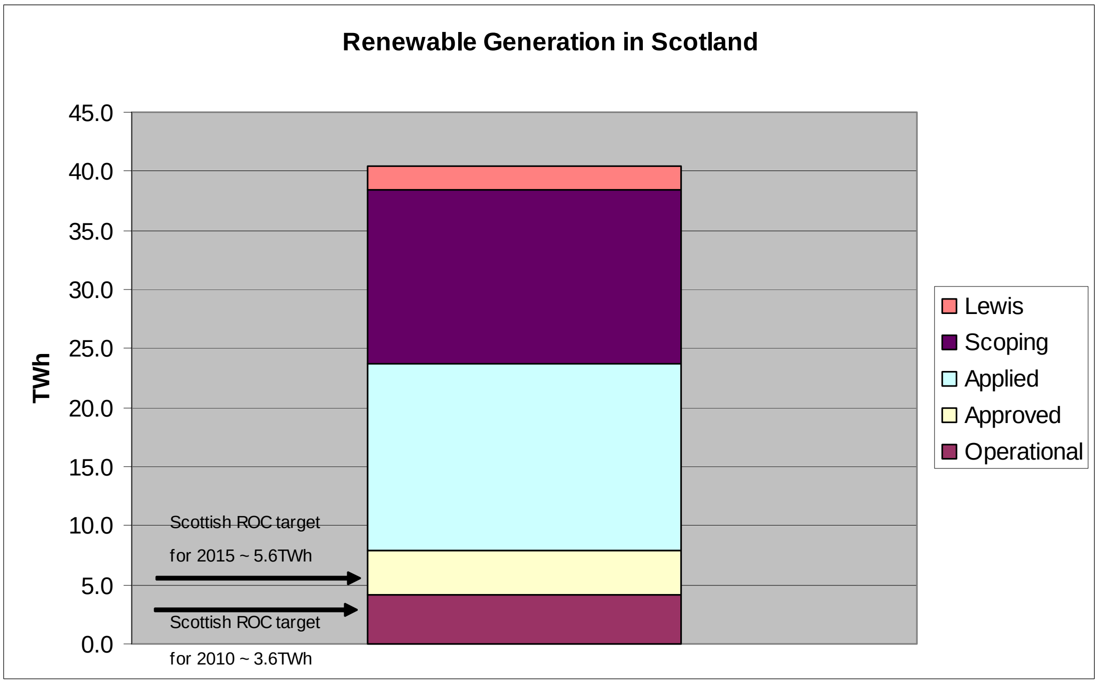
[31] Assuming a 35% load factor, as depicted in the 2004 Non Technical Summary of the Environmental Statement.

Figure 4: Renewable and hydro generation projects in Scotland and Scottish Executive Targets



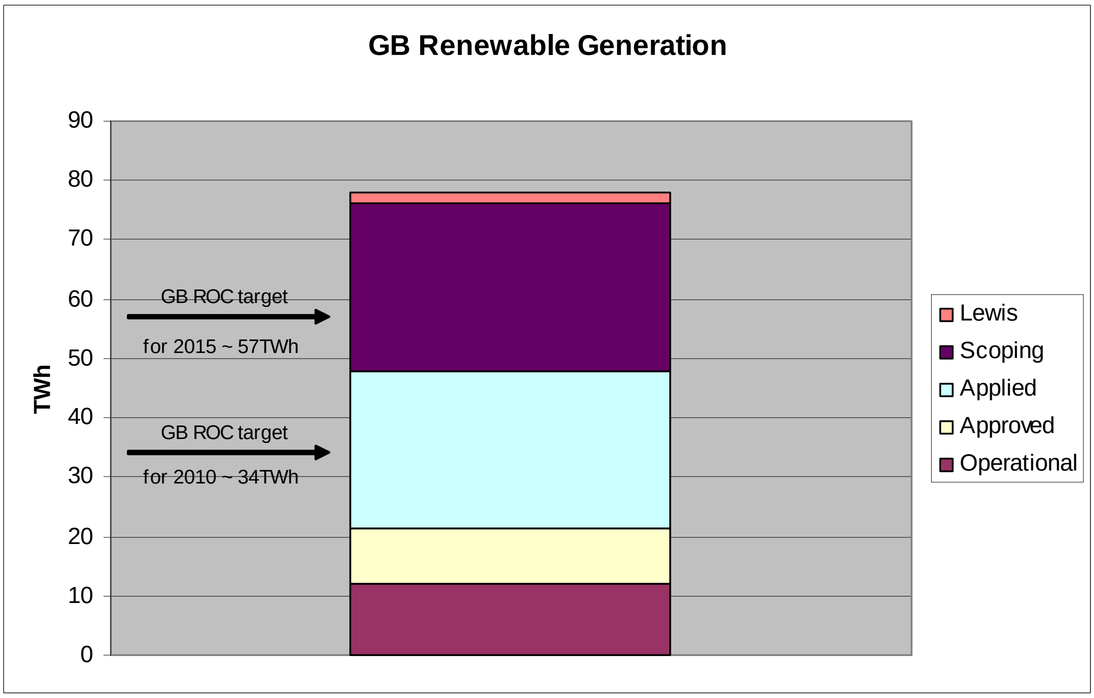
Source: Source: Platts Power UK Power Station Tracker Power Station Tracker September 2006, Ofgem list of Accredited Generator Stations September 2006.
Note: Definitions – ‘Approved’ means given planning permission, ‘Applied’ means has applied for permission, ‘Scoping’ means project has not applied for consent.

Figure 5: Renewable generation projects in Scotland and Scottish RO Targets



Source: Source: Platts Power UK Power Station Tracker Power Station Tracker September 2006, Ofgem list of Accredited Generator Stations September 2006.

Figure 6: Renewable generation projects in GB and GB RO Targets



Source: Source: Platts Power UK Power Station Tracker September 2006, Ofgem list of Accredited Generator Stations September 2006.

4.4. Conclusions on the Requirement for LWP to Meet National Policy Targets

The LWP would provide a significant contribution to both the GB and Scottish renewable energy targets. However, on the basis of current progress towards Scottish renewable energy targets, our analysis suggests that there appears to be no clear need for a contribution from LWP to meet them. While the 2015 GB target appears more challenging (based on the current knowledge of planned and proposed renewable capacity) it is likely that further schemes will come forward over the coming years, increasing the probability that the target will be met without a contribution from LWP. The need for meeting energy policy targets[32] therefore, appears not to provide an overriding and imperative justification to build LWP.

While national energy policy promotes onshore wind power (and other renewables), it does not provide justification for building within an SPA to meet renewable energy targets. There is considerable policy guidance requiring developers and planners to take account of nature conservation issues, as highlighted earlier, indicating that developments should only be permitted where they are not adversely impacting the nation’s natural heritage.

[32] It is important to note, however, that the government is currently consulting on changes to the Renewables Obligation. One such change is to introduce a guaranteed “headroom” of 1%. This will ensure that the RO targets are always above the level of supply (i.e. number of ROCs circulating in the market). If implemented, this is unlikely to be in place before 2015/16.

5. TECHNICAL AND COMMERCIAL VIABILITY OF ALTERNATIVE TECHNOLOGIES TO ONSHORE WIND

Guidance from the SoS[33], indicates that a review of alternative solutions to development within an SPA should also assess other technological solutions. This section examines the prospects for alternative technologies to onshore wind, set against the scale and timeframe of the LWP proposal. It examines likely geographical locations for these alternatives, focussing particularly on sites on, or around, the Western Isles.

A key determinant of a renewable technologies' viability is the local resource available for generating energy. This study focuses on renewable resources which are specific to the Western Isles and are likely to be available in the same timescale as the LWP.

As renewable technologies are developing rapidly and there are a number of alternatives available, a broad-brush analysis of the current and future state of the most promising provides useful insight into their prospects on the Western Isles.

A renewable technology's 'technical potential' refers to the amount of power that might reasonably be accessed from an area, taking into account various technical and physical limiting factors such as the stage of development of the technology, competing land (and ocean) uses and other limitations, such as electricity grid constraints.

Its 'economic potential' refers to the amount of accessible potential that is economically viable, given current technology, or expected with future advances. Economic potential depends upon a technology's own costs (including available grants and subsidies), the cost of alternative/competing energy sources, and the achievable market price. Costs are likely to drop, as renewables are either achieving, or are likely to achieve, rapid market growth and most industrial products exhibit 'learning rates' of between 15% and 30% — that is each doubling of cumulative production results in a 15–30% cost reduction.

While there is considerable information about the current and mid-term commercial viability of renewable technologies, information on their prospects in the longer term is very limited. Accordingly this research focuses on the prospects for technology out to 2020, although the LWP scheme would be expected to operate for 20 years[34].

5.1. Discounted Technologies

Several renewable technologies were not considered in this report because they were not considered viable on the Western Isles in the timeframe of the LWP. Technologies were discounted where the resources available were considered sub-optimal for commercial development, based on the findings by Garrad Hassan in their seminal 2001 'Scotland's renewable resource' study.

Tidal resources in Scotland are centred in the Pentland Firth and off Orkney, while PV resources are limited by low levels of insolation and micro-hydro by the mostly flat relief of the Western Isles. The low productivity of the isles' farmland and its low population density also preclude commercial development of many bioenergy resources. Co-firing biomass in conventional power plants (such as coal) currently offers the most low cost and viable option for generating bioelectricity, but there is no

[33] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
[34] Non Technical Summary, 2006 Addendum to the Environmental Statement.

plant on the Western Isles suitable for co-firing and there is unlikely one to be developed.

Hydrogen based technologies could also be considered an opportunity for the Western Isles, but primary energy will still be required to produce the hydrogen. This therefore, has also been discounted.

In its 2006 Addendum to the Environmental Statement, the developer discounts all technologies with the exception of on and offshore wind. When assessing the potential capacity of these technologies it considers a report undertaken by Halcrow in 2003[35] for the Highlands and Islands Enterprise. A minor observation is that there appears to be an inconsistency with the data in the Halcrow report and that presented in Table 2 of the Report to Inform the Alternatives Test. The Halcrow report specifies that 150MW of Offshore wind could be potential available over the period 2013-2020, whereas the developers statement only states that 100MW could be available.

Additionally, the developer then goes on to discount offshore wind as a potential alternative technology. It states that whilst offshore wind may become economically viable for the Western Isles in the longer term, for the short to medium term offshore wind around the Western Isles is not a reasonable, practical or available alternative technology capable of fulfilling the project objectives.

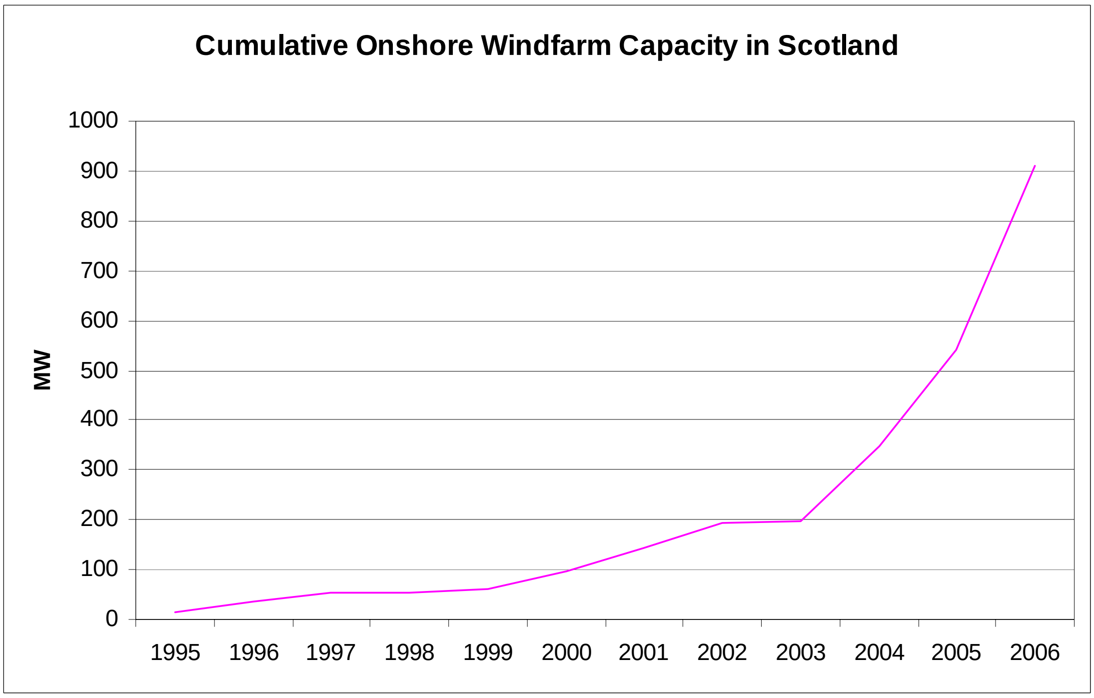
5.2. Onshore Wind Technology

The costs and prospects of onshore wind technology provide a benchmark for comparison with the alternatives. Onshore wind technology has the highest level of technological maturity and currently has the lowest costs relative to the other options.

On the back of the Renewables Obligation, onshore wind has made rapid market entry throughout the UK. Some 930MW[36] of capacity is currently operating in Scotland (and over 1,600MW operates in the UK). It makes up over 60% of the existing Scottish renewable (as defined by eligibility for Renewable Obligation Certificates – i.e. not including large scale hydro) capacity (the rest largely being small scale hydropower). Significant additional volumes are being planned or proposed and grid operators are currently seeking to upgrade their networks to support 3GW of onshore capacity on the Scottish mainland. About half of the onshore development in Scotland has been south of the M8, although the most recently built (in May 2006), was a 92MW windfarm at Farr in the Highlands. The largest wind farm built to date (in March 2006) was Hadyard Hill, with 120MW of capacity, in Ayrshire.

[35] Economic and Social Impact of Renewable Energy Projects in the Western Isles, November 2003.
[36] BWEA, November 2006

Figure 7: Cumulative Scottish onshore wind build



Source BWEA – operational onshore windfarms - January 2007

5.2.1. The Technical Viability of Onshore Wind Technology

Wind turbines have become cheaper to produce, more efficient and more reliable. As the industry has matured, learning has reduced design, planning and installation costs, and market growth has brought economies of scale. The perceived risk of investment in wind power has also decreased, leading to a lower cost of financial capital and longer amortisation periods.

Progressively larger machines have brought significant economies of scale, in terms of cost per unit of installed capacity. However, the pace of further cost cuts is likely to reduce as onshore turbines run up against the feasible size limits for onshore devices (given their local impact).

The main technical obstacles to the development of onshore wind appear to be institutional planning and land use constraints and limits to the capacity of the high and low voltage grid to support such projects. These constraints, however, are not just an issue for wind farm developments but for other renewables as well, particularly grid constraints.

5.2.2. The Economics of Onshore Wind Technology

Several sources put current and future onshore wind costs within the range shown in table below.

Table 2: Onshore wind power costs

Source	Current Costs (£/MWh)	Future[37] (c2020) Costs (£/MWh)
Garrad Hassan, 2001[38]		18-28
Gross, 2004[39]	31-52	
Gross & Bauen, 2005[40]		13-28
SDC, 2005[41]	30-36	
NFFO-5, 1998[42]	36	
RAE, 2004[43]	38	33
PIU, 2001[44]		17-28
Best estimate	**30-38**	**17-33**

Unlike the other technologies considered, onshore wind appears to be close to commercial viability without support from Government, and if costs continued to fall to £17/MWh by 2020, it would be highly competitive against conventional technologies (combined cycle gas fired stations having a levelised cost of around £35/MWh[45], at today's gas prices of around 40p/therm[46]). A gas price of around 5p/therm would be required to achieve a cost of around £17/MWh. This shows that even at current costs onshore wind is competitive.

5.3. Offshore Wind Technology

This is a maturing technology and there are several commercially operating schemes off the coast of Western Europe. A very large resource is available off the Scottish coast. However, initial development in the UK has been off England, where conditions are more favourable.

The first large scale offshore wind farm in the UK, North Hoyle (60MW), was commissioned in December 2003 and there are currently 4 other operating offshore windfarms in the UK, with a combined capacity of ~ 300MW (BWEA).

In the UK, some 9.6GW[47] of offshore capacity is being planned or has been approved to be built, most of it in the strategic areas identified by the Crown Estates as

[37] For the purpose of this analysis, it is assumed that future costs are circa 2020. The range from the references varies between 2010 and 2025.
[38] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis - 2010 cost estimates
[39] Robert Gross, Energy Policy 32, 2004, Technologies and innovation for system change in the UK: status, prospects and system requirements of some leading renewable energy options,
[40] Gross, R. & Bauen, A. (2005) Alternative fuels for transport and low carbon electricity generation: A technical note
[41] Sustainable Development Commission, 2005, Wind Power in the UK - A guide to the key issues surrounding onshore wind power development in the UK
[42] NFFO-5 1998
[43] Royal Academy of Engineering (RAE), 2004, The costs of generating electricity
[44] HMG Policy and Innovation Unit, 2001, Technical and economic potential of renewable energy generating technologies: Potentials and cost reductions to 2020
[45] IPA Analysis
[46] Spectrometer, November 2006, 2007 Gas Prices.
[47] Platts Power UK Power Station Tracker September 2006.

appropriate for offshore development. These strategic areas are the Thames Estuary, the Greater Wash and off the North West of England. No other areas have been proposed for development, to date. However, in Scotland an offshore windfarm in the Solway Firth (Robin Rigg, 180 MW[48]) is expected to start construction early in 2007 and there are two 5MW pilot turbines being constructed near the Beatrice oil platform by Talisman and SSE[49]. In addition there is a proposal for a 115MW development off Aberdeen (Aberdeen Harbour Offshore windfarm – AMEC and Aberdeen Renewable Energy Group)[50] and a scoping for a 1GW development in the North sea by Talisman and SSE.

5.3.1. The Technical Viability of Offshore Wind Technology

Offshore turbine designs are effectively the same as onshore turbines (adapted for the harsher environment) but costs are currently double onshore costs. The higher costs reflect additional transmission and offshore installation costs and higher operation and maintenance costs implicit in operating in a marine environment.

Turbine sizes tend to be larger than most of the capacity installed onshore — typically 2 or 3MW - in the most recent developments, with larger turbines being developed and widely expected to come to the market in the near future. If the design of offshore turbines diverges from onshore ones it would allow larger machines to be built at sea. With more potential to gain economies of scale than onshore wind technology, offshore wind is widely predicted to experience very rapid development in the next few years.

All offshore wind farm developments in the UK require a lease from the Crown Estate. Leases have to date been released in 2 tranches (Round 1 in 2001 and Round 2 in 2003) to developers. Intended as a pilot phase, Round 1 sites were limited to a maximum of 30 turbines. 17 sites were awarded leases and approximately 1GW+ of capacity is expected to be built on 12 of these sites. In the second round, the rights to develop 15 sites, able to produce 5-7 GW, were awarded.

Offshore wind developments are currently focused in relatively shallow waters because it is cheaper and easier to build there (5–20 metres water depth is typical, although depths up to about 50m, have been used (for example the two 5MW turbines being installed near the Talisman/Beatrice platform will be in water 40m deep) although using deeper water, or floating structures, is more problematic. There are significant areas of seabed that are in 30m (or less) of water off the UK coast and a small proportion of UK coastal waters could produce substantial amounts of power.

The development of offshore windfarms has been slower than initially expected. These delays have been attributed to the lack of clarity in the connection regime, although the current high costs of turbines and experience of constructing windfarms offshore may also be a limiting factor.

[48] http://www.eon.com/en/unternehmen/11273.jsp
[49] BWEA website section 'Wind farms currently under construction' at http://www.bwea.com/ukwed/construction.asp
[50] Scottish Renewables November 2006

In March 2006 the then Energy Minister announced[51] that the existing principles of onshore electricity transmission are to be extended to offshore. This will result in offshore wind farms paying for the costs of a 'shallow connection', and an annual transmission charge. The responsibility for developing the offshore transmission network will be shared by the System Operator and the Transmission Asset Owners. This decision should give developers certainty and speed up the development of the offshore capacity.

Although prospects for technological improvement and cost reduction appear promising, offshore wind still faces a number of challenges as there is, at present, limited experience installing and most importantly maintaining such structures offshore.

5.3.2. The Economics of Offshore Wind Technology

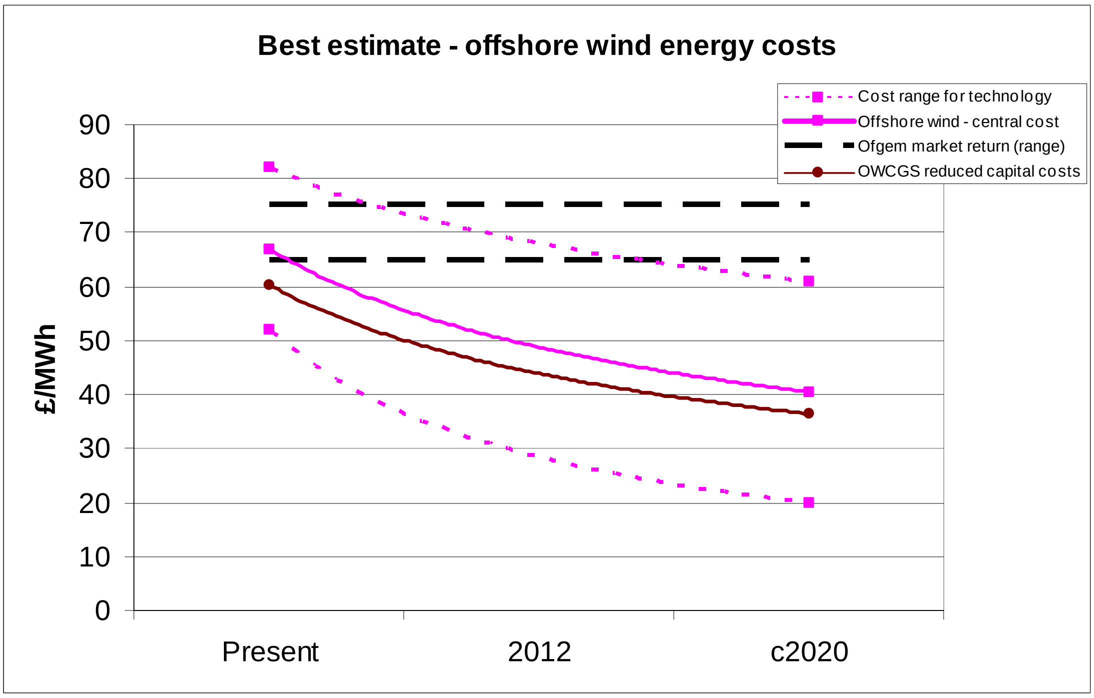
Nearly all approved offshore schemes in the UK have benefited from an Offshore Wind Capital Grant Scheme and the BWEA argue that in the absence of a new support programme, the economic gap between capital costs, expected operational costs and revenue for most projects could remain too large for substantial industry commitment. In Round 1, 11 of the applications were awarded capital grants roughly equivalent to 10% of their capital costs (£107m was provided to support 1100MW). There are no capital grants for Round Two[52], although the DTI is currently analysing the case for further funding of offshore wind developments.

A range of offshore wind power costs are shown in Annex A. The figure below captures the range and mid point of these costs and assumes a learning curve to estimate cost reduction trends between the present and the estimated 2020 costs of generation

The figure compares these costs with a £65-75/MWh expected market return from renewables (based on revenue from ROCs and electricity) used by Ofgem as a benchmark for investment in Grid reinforcement for new renewables projects[53].

[51] 30th March 2006
http://www.gnn.gov.uk/environment/detail.asp?ReleaseID=193600&NewsAreaID=2&NavigatedFromDepartment=True
[52] Offshore Wind: At a crossroads. A report prepared for BWEA and Renewables East by BVG Associates and Douglas Westwood, April 2006.
[53] Ofgem, 2004, Transmission Investment for Renewable Generation

Figure 8: Predicted offshore wind costs



Based on this it can be seen that the mid-range cost of new build offshore wind should, by 2012, be below this market entry price, with the provision of capital grants from an Offshore Wind Capital Grant Scheme (OWCGS) further cutting costs (it is assumed any future scheme would be the same as the present one for this illustration).

5.4. Offshore Wave Technology

There are numerous types of wave harnessing technology, including shoreline, near-shore and offshore devices (in water more than 40m deep). In assessing the resources around Scotland, Garrad Hassan focussed on offshore devices (and in the context of the LWP, this means these devices would have no impact on the SPA).

Offshore devices exploit the more powerful wave regimes available in deep water before energy dissipation mechanisms have had a significant effect. In order to extract the maximum amount of energy from the waves, these devices need to be at or near the surface (i.e. floating) and so they usually require flexible moorings and electrical transmission cables.

Garrad Hassan point out that 'Scotland has a world class resource and industrial capability, which if exploited offers the potential for Scotland to become a world-leading industrial base for wave energy (and other marine technologies)[54]. Garrad Hassan (2001) estimated the theoretical potential of offshore wave technology in Scotland at up to 13.8 GW in 2010, capable of generating around 45 TWh/year.

5.4.1. The Technical Viability of Offshore Wave Technology

A large number of alternative technological approaches are still being developed to extract energy from the waves, most of which are only beginning to be tested

[54] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 2

outside of laboratory conditions. The UK has several testing facilities, the most renown being in Orkney.

In August 2004, the first offshore wave energy was exported into the UK electricity system from the European Marine Energy Centre (EMEC) at Orkney. Three of these 0.75MW devices (the Pelamis) have now been exported to Portugal.

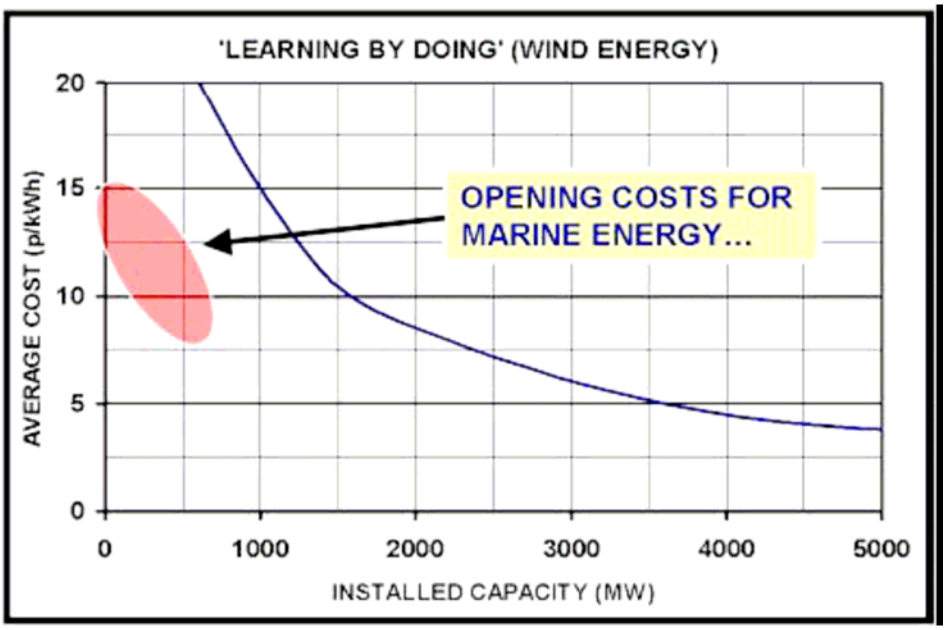
Although wave energy devices under development in the UK have been subject to rigorous and independent assessments of probable capital and generation costs, as none have yet been deployed on a commercial scale, the potential role and likely costs of commercial wave technology remain uncertain. For estimates of costs and technical feasibility to improve a great deal more commercial scale experimentation and testing will be needed.

The main technological constraint to wave technology thus appears to be its early stage of development.

The UK Government provided a Marine Renewables Deployment Fund in January 2005 to promote development. This £50 million fund gives revenue support of £100/MWh to wave generated power projects and capital grant's equivalent to 25% of their costs (up to a maximum of £5M per project). the Scottish Executive is also considering giving further support through the RO mechanism by awarding additional ROCs to wave & tidal technologies.

The Scottish Forum for renewable energy development (FREDS) suggest that wave energy costs are likely to mirror the drop off wind energy costs as the technology matures and the size of the generators increases.

Figure 9: Wave energy costs in context of onshore wind energy cost reduction curve



Source: FREDS, 2004, Marine Energy Group (MEG) Report

5.4.2. The Economics of Offshore Wave Technology

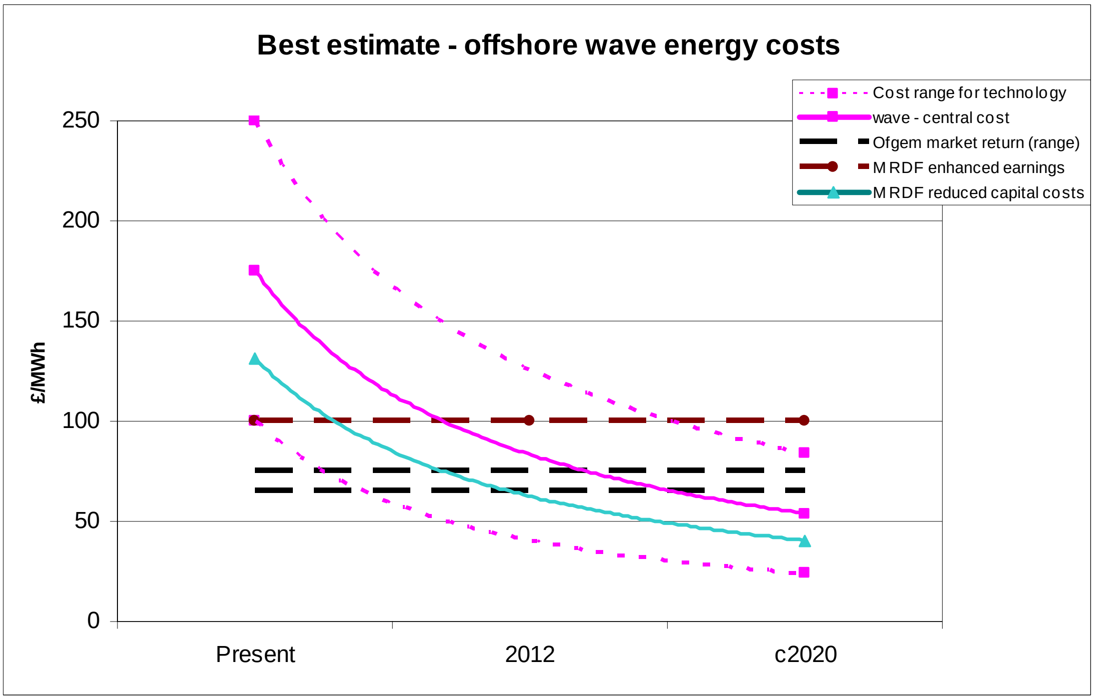
A range of offshore wind power costs are shown in Annex A. The figure below captures the range and mid point of these costs and compares them with a £65-

75/MWh expected market return from renewables and the £100/MWh enhanced earnings available from the Marine Renewables Deployment Fund (MRDF).

Without the capital grants and the enhanced earnings, the projected mid-range of new build costs in 2012 would not be viable (although the lowest range of expected costs is predicted to be able to enter the market without assistance from the MRDF).

Assuming an equivalent grant was available in 2012 and the 'gap' between mid-range costs and required revenue is £15/MWh (£85MWh vs £70/MWh), this £50m Fund would be able to support the entry of ~950MW of wave energy capacity in 2012 (assuming a 40% load factor).

Figure 10: Predicted offshore wave costs



5.5. Bioenergy Resources

There are many types of biomass energy conversion technologies, for example, anaerobic digestion, gasification, pyrolysis (all of which convert the biomass into a useable fuel) and conventional generation, as well as many different fuels (such as wood, energy crops, agricultural residues etc).

Biomass can be used to generate electricity (and/or heat) either by co-firing with fossil fuels in conventional power plant (primarily to produce electricity), or by a number of different conversion processes in dedicated biomass plant (which may be electricity-only, heat-only, or combined heat and power (CHP).

At present there is only 1 biomass burning plant (with a capacity of 12MWe) currently operating in Scotland, 2 are currently under construction (~45MWe) and a further 13 are at different stages of the development process (~185MWe)[55].

[55] Scottish Renewables November 2006.

5.5.1. The Technical Viability of Bioenergy

Advanced conversion technologies such as gasification and pyrolysis, are still some way from being fully commercial and require financial support (in addition to ROC revenues) to operate. Currently restricted to niche markets and to specific feedstocks (e.g. small scale gasifiers treating specific waste streams) their continued development and scale-up should result in more efficient and cleaner use of biomass for electricity production in the future.

Most burnt biomass is currently either used in co-firing plant or in small scale dedicated biomass plants such as the chicken manure plant in Ely. Co-firing biomass with coal and/or other additives is by far the cheapest method of burning biomass, but for this review will not be examined in detail as this is not likely to be an option on the Western Isles.

The availability of a cheap feedstock is a crucial element in enabling the establishment of dedicated biomass plant. A fundamental economic (and environmental) size limiting factor is imposed by the relatively low energy density of biomass fuels (compared to fossil fuels), which implies high transport costs (and associated transport emissions). The maximum economic size of a dedicated biomass plant fuelled by energy crops was estimated by the RCEP[56] as 30 MW (from collecting energy crops from within a 40km radius). However, recent proposals for biomass plants have been over 50MW in size, reflecting improvements in technology and fuel supply chains.

5.5.2. The Economics of Bioenergy Resources

Several sources put current and future biomass costs within the range shown in table below.

Table 3: Final energy costs – energy crops for electricity generation

Source	Current Costs (£/MWh)	Future[57] (c2020) Costs (£/MWh)
Electricity-only		
Gross & Bauen, 2005	34-102	34-61
PIU, 2001	87	18-57 (central range 28-45)
CHP		
Gross & Bauen, 2005	41-102	34-82
Best estimate	**34-102**	**34-82**

The government has provided a Bio-Energy Capital Grants Scheme to support dedicated biomass burning projects, which to date has supported 10 biomass power projects (providing £61m for 150MW of capacity). This scheme has

[56] Royal Commission on Environmental Pollution (RCEP), 2004, Biomass as a renewable energy source

[57] For the purpose of this analysis, it is assumed that future costs are circa 2020. The range from the references varies between 2010 and 2025.

ended, although the government is currently reviewing its support for further biomass schemes.

5.6. Findings on the Technical and Commercial Viability of Alternative Renewable Technologies

Onshore wind technology is currently the most mature and widespread form of renewable generation. The main technical obstacles to its development appear to be planning and land use constraints and limits to the capacity of power grids to support it. The latter is an issue needing to be addressed for the widespread development of all renewable generation, as power grid's have not been designed for embedded distributed generators.

The development of offshore wind technology, based on onshore technology, is likely to increase significantly to 2020. Although there is currently limited experience installing and maintaining such structures offshore, with more potential to gain economies of scale than onshore wind technology and less planning restrictions, it is widely predicted to experience very rapid development in the next few years.

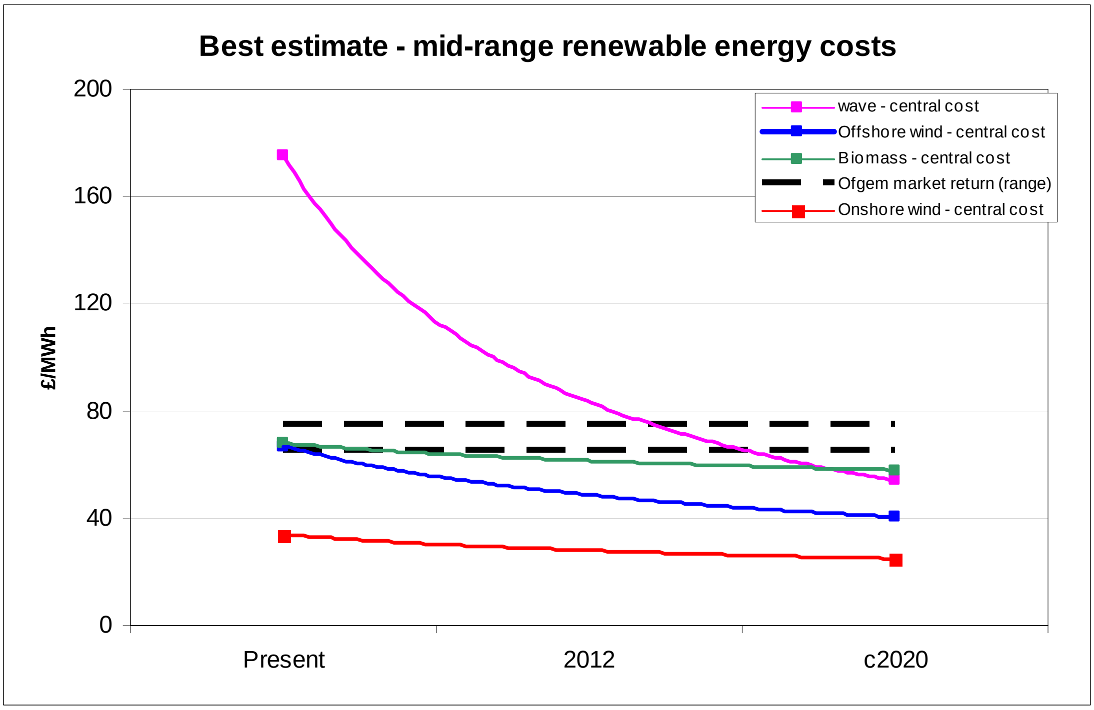
The technological development of wave power has not progressed to the point where it is capable of being commercially applied, but it rivals offshore windpower, in its potential to deliver large amounts of power to the UK grid.

Advanced biomass energy conversion technologies are still at the early stages of development. Biomass, using more conventional technologies, is currently limited to smaller commercial applications and co-firing in conventional power stations. Dedicated biomass plants are likely to remain relatively small in scale because of the costs of transporting the fuel and is therefore unlikely to provide a significant opportunity for development on or around the Western Isles.

Based on the review of the expected future costs of alternative renewables, it is possible to compare the economic prospects of these renewable technologies.

The figure below, uses the mid-range of the 'Best Estimate' cost figures discussed above for the four alternatives sources that are seen as promising alternatives to the LWP and compares them with the cost of onshore wind and a £65-75/MWh expected market return from renewable energy sales.

Figure 11: Current and expected mid-range of renewable costs set against market entry prices



In terms of cost, onshore wind is likely to be the most commercially viable technology out to 2020, however, the mid-range of estimated offshore wind and biomass costs fall below the Ofgem market entry benchmark by around 2012. Wave technology would require additional assistance to enter the market in 2012, but sees the most rapid fall in costs over this period. With capital grant support, mid-range wave power plant could be commercially viable by 2012. By 2020 wave would be expected to fall below the Ofgem market entry benchmark.

As these are 'generic' central estimates of the cost of these technologies they do not reflect likely costs at the best sites for these resources. Lewis and Uist have some of the best offshore resources in Europe and Garrad Hassan have identified significant economic offshore wind and wave resources. This is discussed further in the following section.

6. CREDIBLE AND FEASIBLE ALTERNATIVE SOLUTIONS FOR GENERATING 652MW OF RENEWABLE ENERGY

This section focuses on alternative renewable resources that would not impinge the Lewis Peatland SPA, are available in abundance on the Western Isles and are likely to be available in a similar timescale as the LWP, namely onshore wind, offshore wind and wave power. While focussing on the Western Isles, this section also considers alternative solutions elsewhere in Scotland and the UK as a result of the guidance provided by the SoS[58] when investigating alternative solutions:

- Other locations (Guidance from SoS –'*The Secretary of State considers that such alternatives would not be confined to alternative local sites for the project'*[59]);

Lewis has good onshore wind resources, but on the basis of environmental constraints they were largely discounted by Garrad Hassan in their wide-ranging studies of renewable capacity in Scotland, for the Scottish Executive. The RSPB has previously objected to the Lewis windfarm because of its likely impact on the Lewis Peatland SPA, the Ness and Barvas SPA and the Lewis Peatlands Special Area of Conservation (SAC). If developing alternative technologies had a similar adverse effect, they would also need to be discounted as a result of their impact upon environmentally sensitive areas.

As stated earlier, the developer only considers that onshore wind, on the Western Isles, can be considered as an alternative to the LWP development.

6.1. Credible and Feasible Proposals Within the Western Isles

6.1.1. Onshore Windfarms

As discussed in the review of the developer's Environment Statements, while there does not appear to be a single alternative site available for generating ~652MW on the Isles, there are smaller alternative sites for onshore wind development available, which do not impact SPA sites and which could potentially collectively match this size of development.

Two sites currently being proposed by other developers for onshore windfarms at Pairc and Muaitheabhal/Eisken, could generate some 400MW outside SPA areas (~330MW if one discounts turbines falling within local NSA areas) and there are several other possible windfarm sites on Lewis.

The timescale for the development of Pairc and Muaitheabhal/Eisken could be expected to match that of LWP which, like all large developments on the island is tied to the building of an upgraded mainland grid link.

Clearly, there are reasonable limits to the capacity of the Western Isles for onshore windfarms given environmental constraints. However, given current proposals for windfarms on the Western Isles (which also include several smaller scale schemes) and the potential for developing on less environmentally sensitive

[58] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
[59] Dibden Bay Decision Letter, Secretary of State, 20 April 2004.

sites it is likely that the 652MW being proposed by the LWP could be met from other schemes on the islands. However, it is important to note, as with the LWP project, schemes would also be subject to other constraints such as cumulative impacts and civil aviation and MoD interests all of which may affect the viability of different schemes.

On cumulative impacts it is interesting to note that the 2006 Addendum to the Environmental Statement states that "…..*the cumulative effects of the Lewis and Muaitheabhal scheme are broadly no greater than those from the Lewis proposal as a stand-alone scheme*".

This clearly emphasises that the scale of the LWP is exceptional with the addition of an extra 159MW (53 turbines), which is a significant development in its own right, having a very little effect on the overall cumulative impacts on the proposed developments.

6.1.2. Technological Alternatives to the Lewis Windfarm within the Western Isles

In their assessment of renewables in Scotland, Garrad Hassan identified the technical potential of several resources (by Planning Authority) in Scotland likely to be available in 2010 and in 2025 and then focussed on those resources with economic potential. Resources were assumed 'economic' if they cost under £50/MWh (and so were assumed to be able to be profitably sold under the Renewable Obligation Scheme, or some equivalent, after 2015). Garrad Hassan costed developing these resources at discount rates of 8% and 15%, respectively. This IPA study focuses on the resources available at the more commercial 15% rate, as the LWP and other projects are going to be privately developed. This cut off of £50/MWh is lower than an equivalent Ofgem benchmark[60] for assessing the economic potential of renewables - of £65-75/MWh - but no detailed breakdown of renewable energy costs for this higher range is available in the Garrad Hassan report.

The results of the Garrad Hassan study were published in 2001 and 2002. Since then there has been a variety of developments in both the technologies and their economics. However, the Garrad Hassan study does provide a good basis on which to assess the technological alternatives to the LWP. In the following analysis we therefore discuss technologies in terms of the economic potential or commercial viability (i.e. resources under £50/MWh as referenced in the Garrad Hassan study), unless otherwise stated.

6.1.3. Western Isles Offshore Wind Resources

Offshore of Uist and Harris, the waters are relatively shallow - the territorial shelf being between 5 and 30m in depth – and very similar to the conditions in the strategic areas chosen by the Crown Estates as appropriate for offshore development.

The Garrad Hassan study only examined offshore wind resources more than 5km from the shoreline and a clear advantage of such offshore developments is they would be sited well away from designated areas of high environmental value on the Western Isles.

[60] Ofgem, 2004, Transmission Investment for Renewable Generation – Final Proposals

Garrad Hassan identified some 1,592MW[61] of offshore wind resources likely to be economically available by 2010 in the Highland Planning Authority (without including grid constraints). A conservative visual estimate of this resource indicates that approximately 20% of it - or 318MW – was available off the Western Isles. Using a higher market cut off price, as recommended by Ofgem, would mean this figure is likely to be conservative.

A technical issue that could affect development on the Atlantic side of Uist, is the potential impact of such a development on the MOD radar facility at Benbecula, and its associated training grounds. Developers have tended to avoid areas that could conflict with the MOD, however, as the BWEA has indicated, the MOD is currently developing radar technology to address these issues.

As there are no currently known plans to develop these resources and no indication that the Crown Estate is looking at designating this area as suitable for development, it is questionable as to how much of this resource could be commercially developed by 2012. However, it is not unreasonable to assume that in the medium term (2015-2020) it could be developed.

Looking beyond this point, the Garrad Hassan study indicated a more than doubling (a ~2.1 times growth) of economic Scottish offshore wind resources by 2025, as the technology matures. Areas off the Western Isles are well suited to such development and assuming a pro-rata increase in the availability of these resources would equate to some 670MW of economic capacity off the Western Isles. Given the ten year gap between this forecast and the expected build of 300MW, it would not be unreasonable to assume this could be built by 2025.

6.1.4. Western Isles Offshore Wave Resources

Garrad Hassan's studies[62] show that Lewis is one of the best Scottish locations for offshore wave resources, both immediately along the SW shoreline of Lewis and further offshore, beyond local shipping lanes. The Garrad Hassan study says '*the resource off the Western Isles is notable for its size and proximity to the islands*'. As wave technology matures these areas could clearly support significant generating capacity.

The offshore wave resources assessed by Garrad Hassan for their 2001 study were all located well away from the shoreline in water over 40m in depth, minimising their potential environmental impact.

Garrad Hassan identified 4,200MW of potential economic wave resources seaward of the local shipping lanes off areas under the then Highlands Planning Authority jurisdiction likely to be available by 2010 (without considering grid constraints). A significant proportion of this lowest cost offshore wind resource is located immediately off Lewis and Uist[63] and if we assumed that 50% is deployed then this would be equivalent to ~ 2,100MW.

Garrad Hassan also identified 1,460MW of economic wave resources landward of the shipping lanes (but in more than 40m of water) off areas under the then

[61] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis
[62] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis
[63] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis

Highlands Planning Authority jurisdiction as likely to be available by 2010 (without consideration of grid constraints). A significant proportion of this lowest cost offshore wave resource is located immediately off Lewis and Uist and if we assumed that 50% is deployed then this would be equivalent to ~ 730MW.

Therefore, the total estimated economic potential wave resource off Lewis and Uist, expected by Garrad Hassan in 2010, amounts to some 2,830MW**.** Assuming a higher economic potential cut off, as recommended by Ofgem, would mean this capacity figure is likely to be conservative.

Garrad Hassan did not examine the shoreline or near shore potential of wave energy in their 2001 report. However, in their updated 2002 report analysis was undertaken and an estimate of around 30MW was determined. Recently, a 'shoreline' wave power project at Siadar on the north west coast of Lewis, which could cost around £9m, has been reported[64]. Thirty generating units, giving a maximum total output of 3MW are being proposed to be built into a new harbour wall structure.

Although the Garrad Hassan study strongly suggests that significant economic wave resources are likely to be available by 2010, the technological development of wave power has not progressed to the point where it is capable of being commercially applied. Only one generator has to date exported power from a wave generator to the mainland in the UK (from the EMEC test bed in Orkney).

Given this situation and the fact that there are no known plans to develop any Western Isle offshore wave resources, it is questionable as to how much of this resource could actually be developed by 2012. However in the medium term 2015-2020) it would not be unreasonable to assume that these resources (which are amongst the best in the UK) could be developed commercially. Therefore an assumption could reasonably be made that a portion of the 2,830MW of capacity could be developed in the medium term, say 20% (equivalent to around 560MW) although this could appear to be a fairly aggressive assumption given the timescales involved and the current status of the technologies. However, a recent statement by Dr Richard Yemm, Chairman of Scottish Renewables, said that "…2007 will see the start of development of the first commercial marine projects"[65].

Looking beyond this point, the Garrad Hassan study indicated a doubling (a ~2.3 times increase) of the availability of economic offshore wave resources by 2025 in Scotland. As the Western Isles have some of the best wave resources in the UK, it would be reasonable to assume an equivalent pro-rata increase in development there and that a significant portion of the potential of offshore wave capacity could be developed by 2025 (subject to development constraints).

6.1.5. W. Isles Biomass Resources

Garrad Hassan[66] listed the Western Isles as an unsuitable location for most biomass resources, on technical grounds. The Western Isles are considered seriously disadvantaged by the EU in terms of land productivity, (most farmed

64 Stornoway Gazette, Fri, 16 Jun 2006
65 Scottish Renewables, Review, Issue 33.
66 Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 2

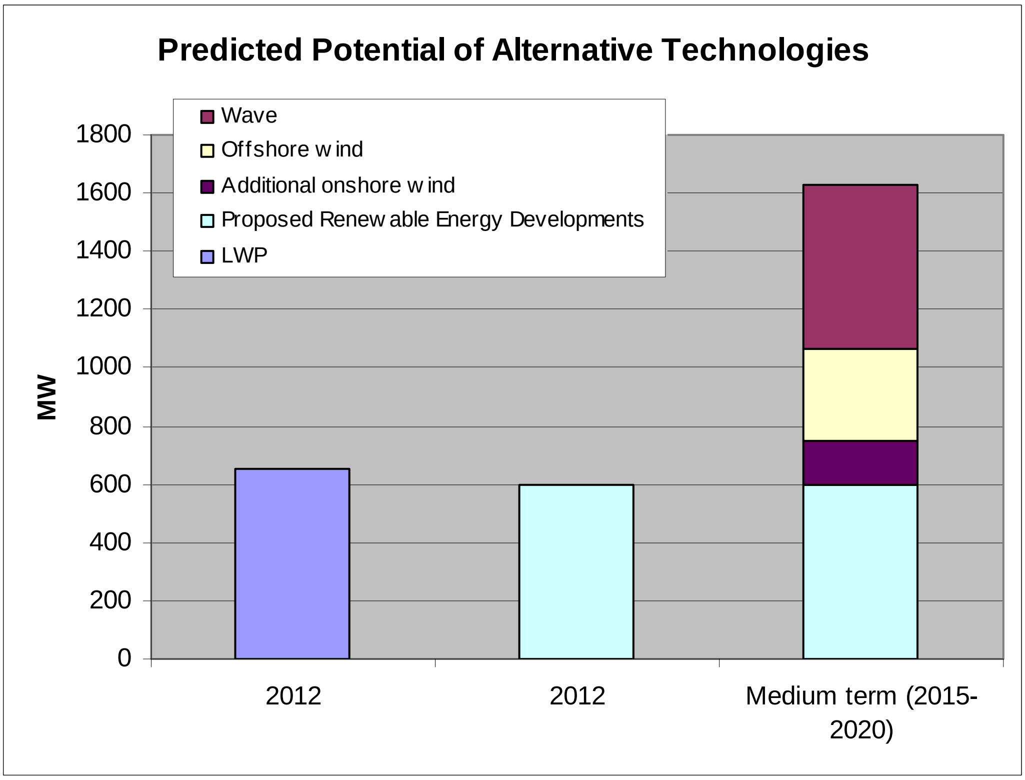
land being used for rough grazing) and it also lacks woodland cover, so resources are limited. This does not mean small scale biomass development is not feasible, but does mean that commercial development on a scale comparable to the LWP proposal is very unlikely on any timescale.

6.1.6. Western Isle Alternative Resource Summary

The diagram below shows the summed capacity of alternative renewable resources expected to be available in a similar timescale to the LWP. It consists of a mixture of onshore and offshore wind and wave power. The following section summarises how this diagram was derived.

Excluding the LWP, at present nearly 600MW of renewable generation developments on the Western Isles have signed contracts with SHETL for the design and connection to the transmission system. It is likely that these could be developed in a similar timeframe to that of the LWP.

Figure 12 : Predicted capacity of local renewable alternatives to the Lewis Windfarm proposal



Note: This diagram assumes LWP and alternatives could be developed by 2012 at the earliest. All development would be tied to the construction of a mainland grid link required for exporting power

Like the LWP, the onshore windfarm proposals (which make up the majority of the proposed renewable energy developments above) could, conceivably, be operating by 2012 (the earliest possible date for LWP and a connection to the mainland to be functioning). Whilst these do not match the 652MW of the LWP, it is feasible that other developments could be proposed that would take the cumulative capacity above that of the LWP. We estimate that another 150MW of onshore capacity (representing the areas 8-11 shown in Figure 1 previously), and which do not impinge on SPA areas, (additional onshore wind) could be delivered from these extra sites by 2015-2020.

While theoretically economic, the current state of offshore wind and wave technology means it is not expected that anything other than pilot projects would be operating off the Western Isles by 2012. However, in the medium term 2015-2020, it could be expected that technological progress would have made it viable to build such projects, in order to utilise the nationally significant offshore resources available there. By 2015-2020, some ~318MW of offshore wind and ~560MW of offshore wave could potentially be developed, using the Garrad Hassan study as a benchmark for likely capacities.

By 2025 these offshore renewable energy resources could be expected to be further developed. Assuming similar predictions as Garrad Hassan on the likely rate of development of these resources, the utilisation of offshore wand and wave capacity would, plausibly, at least double by 2025.

6.2. Credible and Feasible Alternative Proposals to Generate c652MW in Scotland

6.2.1. Review of Other Locations in Scotland for Onshore Windfarms

SoS guidance[67] on the consideration of new developments in SPAs indicates a review of alternative sites should not be restricted to the locality of the proposal.

Looking off island there are significant alternative sites throughout Scotland that have been designated as preferred search areas for new windfarms by local authorities.

Based on these ‘prospective search’ areas alone (the development of these designations for other Scottish Planning Authorities is still proceeding) over 7,000km^2 of land would potentially be available for windfarms, although some of this area could already be earmarked for other developments (this is not the case for the Highland PA search areas which were specifically identified as being undeveloped in their 2006 study).

Table 4: Designated ‘prospective search’ area for new windfarms on the Scottish mainland

Area	km^2
Highlands Planning Authority[68]	~5,419
Perth and Kinross[69]	~900
Glasgow and Clyde Valley[70]	~675
Ayrshire[71]	~600
Total	**~7,594**

In addition, in 2002, SNH published its *Strategic Locational Guidance for Onshore Wind Farms in respect of the natural heritage*[72]. The policy statement

67 Dibden Bay Decision Letter, Secretary of State, 20 April 2004.
68 Aquatera, 2005, Highland Area Renewable Resource Assessment. after Table 3.2
69 Perth and Kinross Council, 2005, Wind Energy Policy: Preferred Areas, after Diagram 1
70 Joint Council paper, 2006, Glasgow and Clyde Valley Joint Structure Plan, after Diagram 22
71 Joint Council paper, 2006, Ayrshire Joint Structure Plan, after p53 diagram
72 SNH, Strategic Locational Guidance for Onshore Wind Farms in respect of the natural heritage, 2002 & May 2005.

sets out a number of principles that should guide the location of onshore wind farm projects so as to minimise effects on the natural heritage. The guidance takes account of landscape and nature conservation designations at international, national and local levels, wild land issues, and also bird species and habitats whish are sensitive to wind farm development.

The guidance divides Scotland into 3 zones:

- Zone 1: identifies land with least natural heritage sensitivity and the greatest opportunity for wind farm development.
- Zone 2: identifies where there are natural heritage sensitivities but there could be scope for development of an appropriate scale.
- Zone 3: identifies areas where there is a high natural heritage sensitivity and in general most proposals are unlikely to be acceptable in natural heritage terms.

The map is shown in Annex B and shows the categorisation of the different zones of natural heritage sensitivity. Zone 1 areas are likely to be considered suitable for wind farm developments and cover some 26% of Scotland (~ 20,000 km^2). Clearly, not all of this area would be suitable for wind farm development. Other issues would also need to be taken into account such as military and civil aviation interests, visual impacts, wind speed, topography etc, but it does show that there is a considerable amount of land available within Scotland for wind farm development that would not impact upon natural heritage interests.

It is also interesting to note from this that the area of the LWP is considered a Zone 3 – high sensitivity area.

Scotland is recognised as having one of the best wind resources in Western Europe, extending right across the country. Garrad Hassan, in their survey of Scottish renewable resources in 2001, identified a maximum potential of over 11GW of onshore wind capacity in Scotland. The size of this resource would require just under 2% of Scotland's land area[73].

An illustrative onshore wind power density of $10MW/km^2$ [74], shows that a significant amount of capacity could potentially be developed on areas highlighted as being potentially suitable for wind farm development, although technical and economic constraints would reduce this.

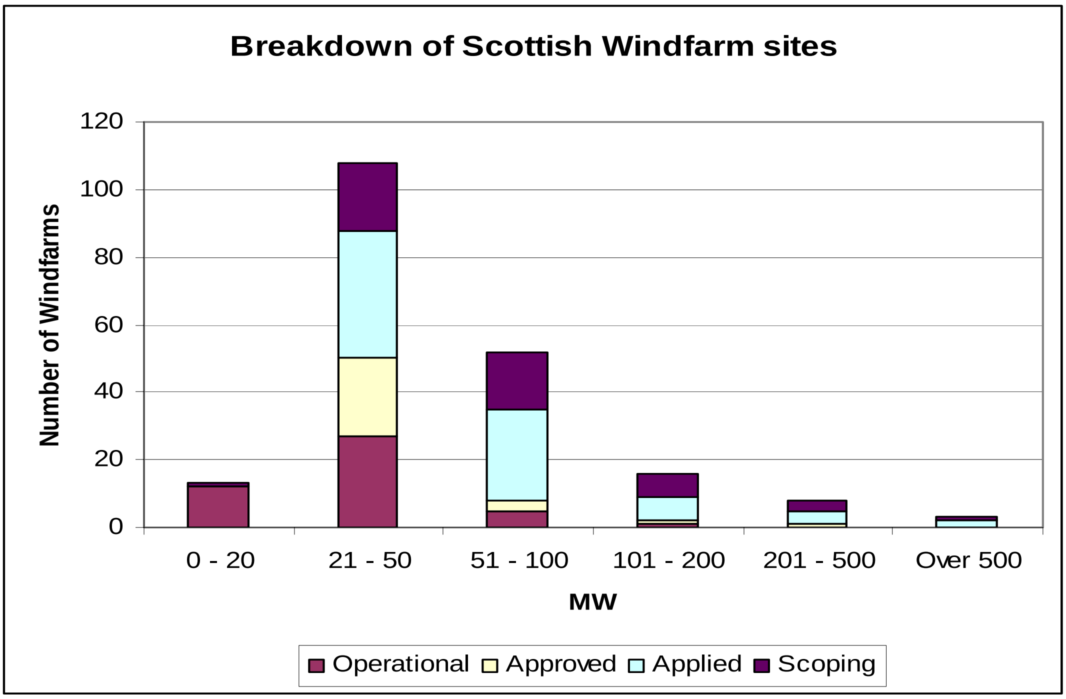
There are clearly significant areas available on the Scottish mainland which have been earmarked for onshore windfarm development by the local authorities. As the LWP covers an area of approximately $225km^2$, there would appear to be reasonable grounds for assuming alternative sites could be acquired for it.

However, the extreme size of LWP would be expected to generate objections, at any location, which makes gaining planning approval less likely. Such a large project would probably also need extensive grid reinforcement. Thus it is more conceivable this capacity could be met through a combination of several smaller alternative projects. The figures below show that the vast majority of operating

[73] SNH, Policy Statement, Strategic Locational Guidance for Onshore Wind Farms in respect of the Natural Heritage ,May 2005.
[74] Garrad Hassan, 2002, Western isles Renewable Energy Study Part I: Resource Investigations (Note, this figure is also used by the developer in the 2006 Addendum to the Environmental Statement)

windfarms are 20MW or less and the bulk of new proposals being proposed by other developers are under 100MW.

Figure 13: Number of currently operating and planned onshore wind farms in Scotland (including LWP)



Source: Platts Power UK Power Station Tracker September 2006, BWEA, Ofgem list of Accredited Generator Stations September 2006.
Note: Figure above does not include wind turbines of less than 50kWe.
Note: Definitions – 'Approved' means given planning permission, 'Applied' means has applied for permission, 'Scoping' means project has not applied for consent.

Only 3 windfarms over 500MW are proposed in Scotland (and the UK). They are the Clyde windfarm, the Muckla Moor windfarm and Lewis itself (which is the largest proposal of all). This shows that the LWP is exceptional, in terms of scale, when compared to most of the onshore wind farm projects currently being explored.

6.2.2. Scottish Onshore Wind Resources

In terms of the overall timescale and size of opportunities for onshore wind developments, it has been shown that there is a significant amount of onshore wind schemes in the development pipeline that could be developed by 2012. There is currently around 900MW[75] of capacity already operational and a further 800MW[76] under construction in Scotland alone, all of which are likely to be operational by 2012.

The Scottish Executive renewable target of 15.4TWh by 2020 provides a possible guide for opportunities beyond 2010. Taking off the hydropower component of this target (about 2.5TWh p.a) would mean that some 12.9TWh would have to be supplied from other renewables by 2020. Assuming a load factor of between 20% and 30%, this would equate to between 5-7GW of

[75] Ofgem list of Accredited Generator Stations September 2006
[76] Scottish Renewables, November 2006.

renewable capacity. A considerable portion of this could be expected to be onshore wind, given its technological maturity, its relatively low cost and the considerable number of proposals being planned (at present around 7GW[77] of onshore capacity is in the planning phases of development, either approved or applied, (not including LWP) in Scotland).

6.2.3. Scottish Offshore Wind Resources

Scotland has considerable offshore wind resources. Garrad Hassan identified ~26GW of potential offshore wind capacity in Scottish waters less than 30m deep (excluding considerations about grid restrictions).

The prime locations for this resource are (in order of size), off the Western Isles, in the Solway Firth, off Tiree, Jura and Islay, Fife and Lossiemouth.

Narrowing this down to the resources likely to be commercially viable (at a 15% discount rate) by 2010, Garrad Hassan identified ~10.5GW of resources. Using a higher market cut off price, as recommended by Ofgem, would mean this figure is likely to be conservative.

As yet only a small fraction of this resource is being developed, as highlighted earlier (section 5.3). As there are no other known plans, it could be expected that by 2012 only this capacity (305MW) would be commercially developed. However, as there are considerable resources available and the technology is maturing rapidly one would expect a larger portion of this resource to be developed in the medium term (2015-2020). A reasonable estimate might be 1,000MW.

The Garrad Hassan study indicated that by 2025 all of the offshore wind capacity they identified off Scotland would be economic, effectively more than doubling (a ~*2.1 growth) the expected economic capacity. Based on an estimate of 1,000MW being built by 2015 and assuming a pro-rata growth this would equate to 2,100MW by 2025.

Lacking the planning and land use constraints affecting onshore developments, offshore windfarms have generally tended to be larger (which allows more economies of scale), so a 652MW offshore windfarm is much less likely to raise environmental concerns than a 652MW onshore windfarm.

6.2.4. Scottish Offshore Wave Resources

Garrad Hassan identified 4,200MW of economic wave resources as potentially being available by 2010 seaward of the shipping lanes around Scotland and 1,460MW landward (but in more than 40m of water) of these lanes. The total economic wave resources off Scotland expected to be available by 2010 is thus estimated at some 5,660MW in the study**.** Assuming a higher economic potential cut off, as recommended by Ofgem, would mean this figure is likely to be conservative. Additionally, there may be further potential from shoreline or near shore wave energy, but the number of suitable sites and hence capacity is likely to be limited.

The bulk of the 2010 resource is immediately offshore of the Western Isles.

[77] Platts Power UK Power Station Tracker September 2006

The commercial utilisation of this resource has not yet begun and predicting the likely timescale for its development is difficult. Based on a review of the current state of technological progress of wave technology it is likely that within the next 5-10 years commercial scale utilisation will have begun.

The Garrad Hassan study indicated that by 2025 the economic wave capacity seaward of shipping lanes should have more than doubled. While there is no information on landward wave capacity cost changes in their study, as the technology and sea conditions are similar for both (all the assessed wave areas are in water over 40m deep), it would be reasonable to assume its economic capacity increased similarly.

Assuming this, the total available economic capacity of wave power in Scotland would be some 13,000MW by 2025. This is a huge amount of potential energy (more than the UK's current nuclear capacity) and would be able to produce about 20% of the UK's electricity needs. Clearly, there are likely to be numerous constraints to developing this scale of capacity, particularly if the developments are concentrated in one area such as the Western Isles. However, it does illustrate the significant potential of wave power in Scotland.

It could be conceived, however, as outlined earlier, that given the resource some 2,830MW could be built in the medium term (2015-2020) and further developments approaching 5,660MW of capacity could be built in Scotland by 2025.

As with offshore windfarms, without the planning and land use constraints of onshore developments, a single 652MW capacity development could be feasible offshore.

6.2.5. Scottish Biomass Resources

The Garrad Hassan 2001 Scotland renewable resource study surveyed several bioenergy resources, including forestry residues, energy crops and agricultural wastes available in 2010. They did not publish the expected size of these resources beyond this date. The total economic resource available from these is tabled below.

Table 5: Predicted potential capacity of domestically produced biomass by 2010 in Scotland[78]

Biomass Type	Maximum potential, MW
Forestry residues	57
Energy crops	1,083
Agricultural wastes	441
Total	1,581

Relative to the offshore resources identified, the total biomass energy potential is quite small and this is further reduced by the application of Garrad Hassan's economic cut-off - only 2 areas (Strathclyde and Dumfries and Galloway) are modelled as having economic potential (although the vast majority of this

[78] Garrad Hassan, 2001, Scotland's Renewable Resource 2001 - Volume 1: The Analysis

resource is predicted to be available at a cost of around £65/MWh, which is within the market entry range used by Ofgem when assessing renewable market entry potential).

There are nearly 210MW[79] of biomass projects in 12 proposals, at various stages of the development chain in Scotland (45.5MW of this is currently under construction).

Given the general trends for renewable energy production costs to drop and the current relatively low cost of these biomass resources, it would not be unreasonable to assume that all 1,581MW of the Garrad Hassan identified biomass resources could be commercially viable by 2025.

6.3. Credible and Feasible Alternative Proposals to Generate c652MW in the UK

This study has focussed thus far on those resources likely to be feasibly developed on the Western Isles and Scotland in a similar timescale to the LWP and has drawn extensively on Garrad Hassan's 2001 (and 2002) study of Scottish renewable resources, which estimated the technical and economic potential of these resource in the years 2010 and 2025.

It is also worth examining the LWP in the context of UK-wide alternatives to building within the Lewis SPA. SPAs are strictly protected sites classified in accordance with Article 4 of the EC Directive on the conservation of wild birds (79/409/EEC), also known as the Birds Directive, which came into force in April 1979. They are classified for rare and vulnerable birds, listed in Annex I to the Birds Directive, and for regularly occurring migratory species.

Guidance on the DEFRA website[80] suggests that there are only a few cases where the integrity of an SPA could be overturned '*The Government considers that the following guiding principles will be relevant to deciding whether imperative reasons of overriding public interest are demonstrated:*

1 *A need to address a serious risk to human health and public safety;*

2 *The interests of national security and defence;*

3 *The provision of a clear and demonstrable direct environmental benefit on a national or international scale;*

4 *A vital contribution to strategic economic development or regeneration;*

5 *Where failure to proceed would have unacceptable social and/or economic consequences.'*

If we consider point 3 above, and the guidance from SoS highlighted earlier[81], it is worth assessing the scale and suggested timing of completion of LWP in the context of alternatives available within the UK

[79] Scottish Renewables, November 2006.
[80] DEFRA website guidance on SPAs at – http://www.defra.gov.uk/wildlife-countryside/ewd/ewd09.htm
[81] *The Secretary of State considers that such alternatives would not be confined to alternative local sites for the project*

To estimate the UK potential of these resources requires utilising non Garrad Hassan data. While every effort has been made to ensure consistency with that study, it has not been possible to acquire data which exactly matches the criteria that produced Garrad Hassan's results, namely a resource estimate (in 2010 and 2025), using a 15% discount rate for capital expenditure and a £50/MWh market entry price.

It is worth starting by bounding the maximum expected UK renewable capacity in these years. Although all renewable costs are falling, most technologies are likely to still require support from the Renewables Obligation over the forecast horizon considered here. This provides an initial boundary for the maximum expected capacity. In 2012, for example, the maximum market size for renewables could be expected to be ~44TWh. Although the renewables obligation at present only runs to 2015, it could be reasonably assumed that it would be extended by 1 percentage point each year from 2015. This would create an equivalent bounding for renewables in 2025 of around 96TWh.

The LWP is expected to generate just over 2TWh pa and while it is a large scheme, in the context of these targets, its significance drops from around over 4.5% in 2012 to 2% by 2025.

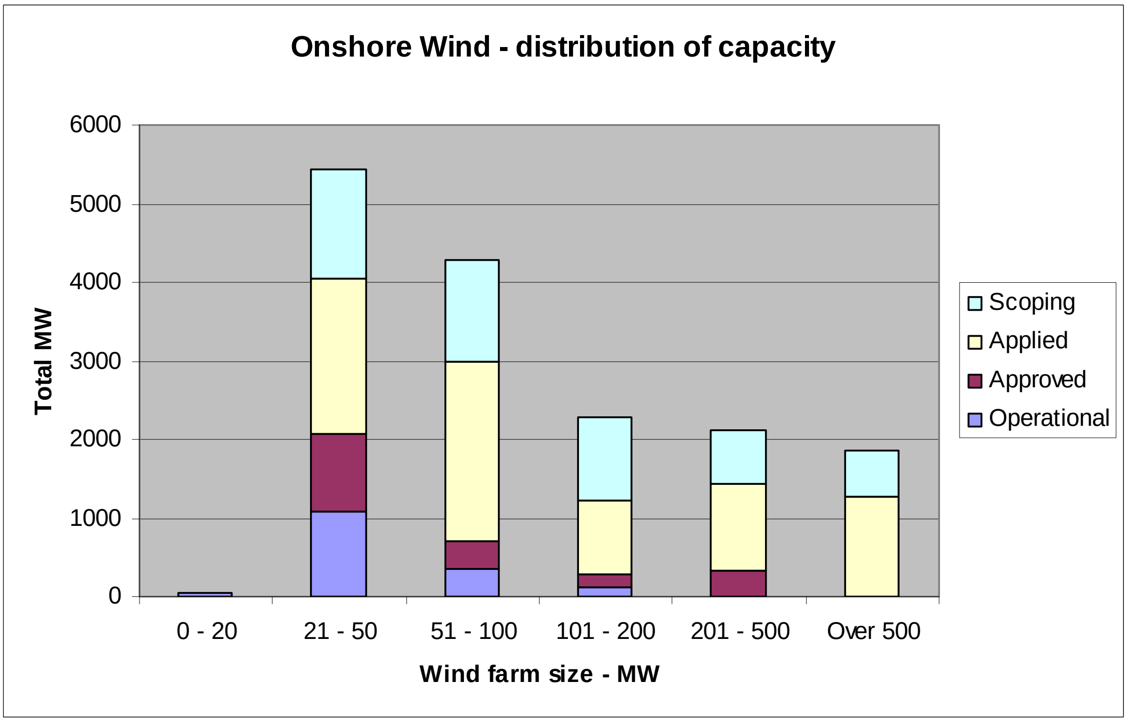
6.3.1. UK Onshore Wind Resources

Around 1.7GW of onshore wind capacity is currently operating in the UK and in total some 10.7GW of new capacity[82] is at various stages of development. In terms of the overall timescale and size of opportunities for onshore wind developments, there are around 640MW currently under construction and a further 1.5GW consented all of which could be constructed by 2012.

There are no known proposals as large as LWP being planned in the UK, and the average size of new projects is generally under 100MW. While the development of a single site generating 652MW is feasible and offers economies of scale, there will be a number of issues, such as grid connection, environmental and planning issues that will be associated with it which, because of its size, become more difficult to overcome. The table below shows the size distribution of known operating and planned wind farm projects for the UK as a whole. Most proposals are under 100MW.

[82] BWEA, 20/12/06, website UKWED Statistics at http://www.bwea.com/statistics/

Figure 14 Capacity of currently operating and planned onshore windfarms in the UK (including LWP)



Source: Platts Power UK Power Station Tracker September 2006, BWEA, Ofgem list of Accredited Generator Stations September 2006.
Note: Figure above does not include wind turbines of less than 50kWe.

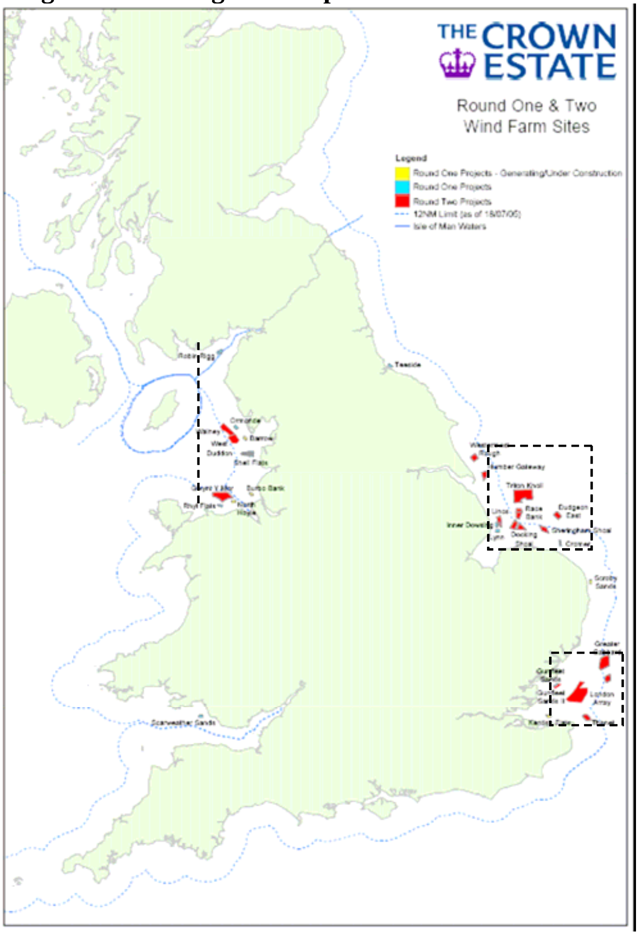
6.3.2. UK Offshore Wind Resources

In the UK, three strategic areas have been earmarked for offshore windfarm development by the Crown Estates, namely the Thames Estuary (some 2,000km^2 in size), the Greater Wash (3,000km^2) and off the North West of England (5,000km^2). The total area for development is extremely large when one puts it in the context of the expected size of a 1GW offshore wind farm (~165km^2)[83] and as

[83] DTI, 2006, http://www.og.dti.gov.uk/offshore-wind-sea/process/regions.htm

Figure 15 shows, these areas still offer significant new development opportunities.

Figure 15: Strategic development areas for offshore windfarms



Source: http://www.thecrownestate.co.uk/34_round_1and2_project_map2.pdf

As the 3 strategic areas are off English coastal waters, it is here that the bulk of development is expected to take place, at least over the next 5-10 years. There is around 2GW[84] of offshore capacity that has been approved, around 300MW currently operating, around 2.9GW (which also includes the recently consented (December 2006) London Array of 1GW) that has applied for consent and a further 4.7GW in the scoping stages of development. There are therefore almost 10GW of offshore windfarms that are either operational or in various stages of development, the majority of which are located in the strategic areas.

There is currently one proposal that is of similar magnitude to LWP, at Gwynt y Mor (750MW) off North Wales and a much larger one at Triton Knoll (1,200MW) in the Greater Wash. Offshore windfarm developments are generally larger than onshore ones (the average size for onshore sites being under 40MW compared to around 275MW for offshore ones), because there are less constraints on developers and there is an expectation that offshore arrays and turbines will become larger.

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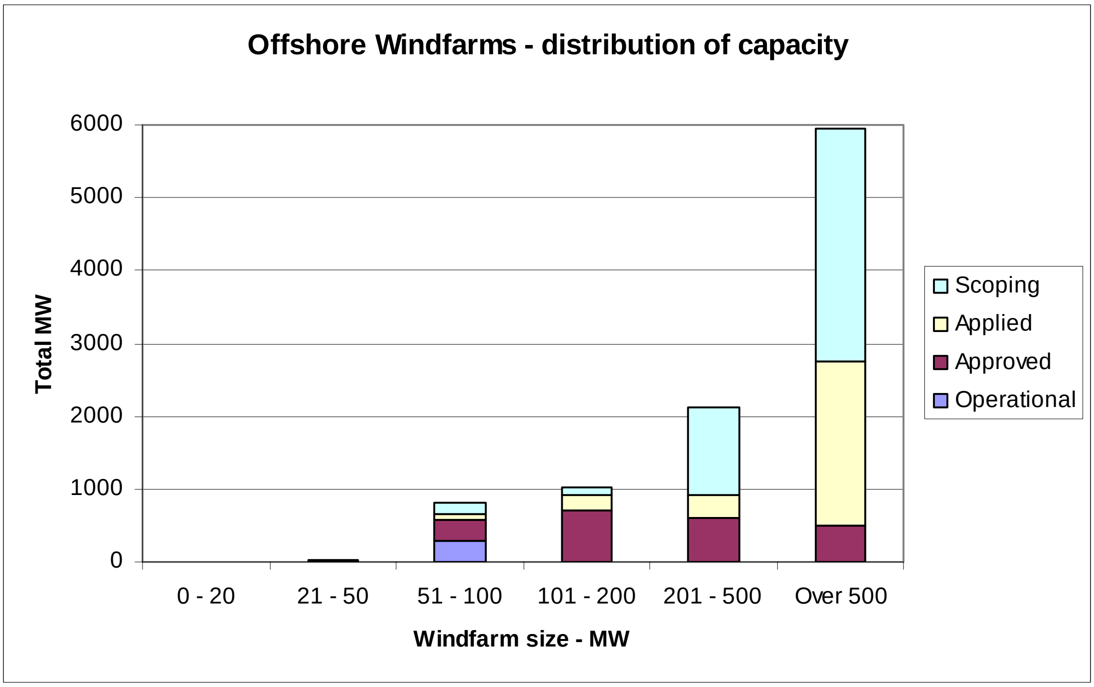
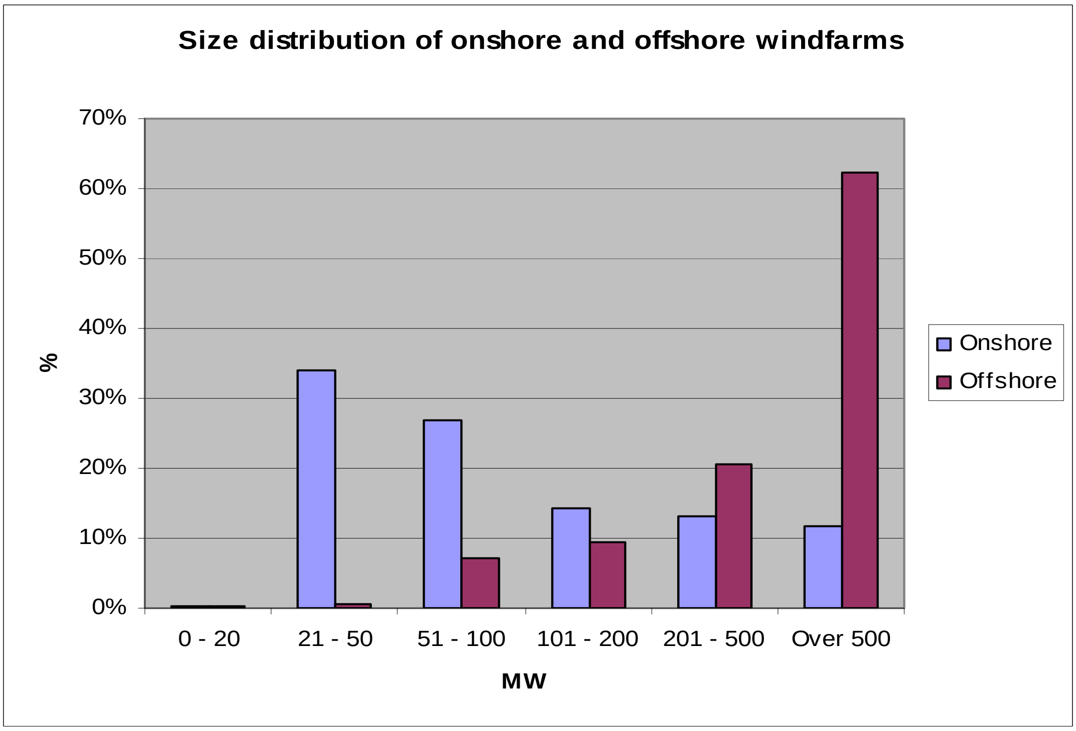
84 Platts Power UK Power Station Tracker September 2006

Figure 16: Capacity of currently operating and planned offshore in GB



Source: Platts Power UK Power Station Tracker September 2006, BWEA, Ofgem list of Accredited Generator Stations September 2006.

Figure 17: Relative size of onshore and offshore UK windfarms (including LWP)



Source: Platts Power UK Power Station Tracker September 2006, BWEA, Ofgem list of Accredited Generator Stations September 2006.

6.3.3. UK Biomass Resources

There is around 170MW[85] of biomass capacity accredited for ROC eligibility operating in the UK. Of this total, 90% is situated in England & Wales.

Over the past year there have been several announcements about new dedicated biomass projects and there is currently some 1.6GW[86] of biomass capacity (at various stages of planning) being planned for development.

The average size of these proposals is 74MW and given the technical size limits of biomass plant, construction of a single large 652MW plant is not considered feasible. Based on current plans, the capacity of new biomass plants entering the system (excluding co-firing) is likely to be relatively small (when compared to offshore wind, for example) by 2012.

6.4. Findings on Alternatives to the Lewis Windfarm Proposal Within the Western Isles and Elsewhere in the UK

The Western Isles has significant renewable energy potential (both wind and wave). Based on a review of the state of the renewable technologies most able to utilise these resources and an assessment of their prospects for developing within the timescale of the LWP, it was assessed that a mix of technologies, including onshore wind and offshore wind and wave could easily match the capacity of the LWP in the medium term.

Up to 600MW of alternative onshore capacity on the Western Isles has also been proposed and could be viable by 2012. While this would not match the size of LWP, additional onshore wind developments could potentially also be developed in other areas of the Western Isles, which would not impact the Lewis Peatland SPA or the Lewis NSA.

Looking to the mainland of Scotland, a significant area of land has been earmarked for onshore wind farm development by several Scottish Planning Authorities. Scottish Natural Heritage has also identified a significant area of land that would be suitable for onshore wind developments. As the LWP covers some 225km^2, there would appear to be opportunities for alternative sites, however, given the size of this proposal, a development of this magnitude would be expected to generate significant planning problems. Whilst the number of locations for similar large-scale single developments might be limited the total number of developments in the pipeline suggests that there are many locations where smaller developments could be located which collectively could generate the same (or greater) output as the LWP.

The size of alternative renewable resources available for development in Scotland is very large. Garrad Hassan identified over 10GW of offshore wind resources and 5GW of offshore wave capacity that they predicted could be economically developed by 2010. Similarly, this study indicated Scotland has over 5GW of offshore wave potential that could be viable by 2010. The bulk of the identified wave resources and a significant portion of the offshore wind potential lies off the coast of the Western Isles. It is therefore highly likely that this area will become a prime site for the development of these resources. Lacking the planning and land use constraints found onshore,

[85] Platts Power UK Power Station Tracker September 2006
[86] Platts Power UK Power Station Tracker September 2006

construction of very large 652MW arrays of generators is also much more feasible offshore.

In the context of the UK, where over 10GW of onshore and almost 10GW of offshore windfarms are currently planned, LWP at 0.652GW, while significant as a single project, is not overly significant when considered against other proposed renewable developments. There are clearly other locations around the UK that can accommodate a significant amount of renewables capacity, and some (particularly offshore) which could develop projects in excess of the size of the LWP proposal. Given the need for a reason of overwhelming national importance to overturn the protection accorded by an SPA, it would not appear that LWP is ‘vital’ in a national context given other proposed renewable developments.

7. OPTIONS FOR THE CONSTRUCTION AND FUNDING OF AN ELECTRICAL GRID-INTERCONNECTOR FROM THE WESTERN ISLES TO THE MAINLAND

This section examines the options for the construction and funding of a grid interconnector to the mainland. The LWP developers argue that their project will play a vital role in justifying such a link.

Upgrades to electricity networks in Scotland are largely being driven by new renewable capacity. In its role as the energy regulator, Ofgem has been developing techniques for assessing the economics of reinforcement proposals to support renewables. Ofgem is seeking to ensure customers do not pay for either, unnecessary reinforcement, or for losses from constrained generating capacity. A tranmission investment is considered to be justified if the annualised cost of building the reinforcement matches the cost of constraints avoided.

A methodology for assessing investments to address renewable energy related transmission constraints has been developed by Ofgem. In its document 'Transmission investment for renewable generation – Final proposals'[87] Ofgem states that such investment is justified if the annualised cost of building extra transmission capacity matches the 'cost' (lost revenue) of constrained renewable generation. Ofgem suggest a constraint cost of £65-75/MWh should be used as the estimated constrained cost for renewables from sales of energy and Renewable Obligation Certificates (ROC). In subsequent documentation, released in mid-2006[88] Ofgem states that there has been no new information or arguments to change this assessment methodology.

A number of studies have been undertaken on the costs of connecting the Western Isles to the UK mainland, research by Sinclair Knight Merz (SKM)[89] estimated the costs of engineering works for a Western Island Connector as ~£400m[90] to lay a ~1000MW capacity undersea cable to the mainland and then build a link on to the Beauly-Denny line. A more recent and detailed study undertaken for Scottish Hydro-Electric Transmission Ltd (SHETL) by PCS Limited[91] estimated that £373 million was required to provide 600MW of capacity with an indicative incremental cost estimate of around £193 million to increase the link to 1,000MW (lowest cost solution).

This information and the Ofgem investment guidelines[92] enables an estimate of the size of renewable capacity required to justify building a new link to the Western Isles.

Annually capitalising the cost of the connector (using the greater SHETL estimate), using Ofgem investment guidelines (a 20 year asset life and an 6.5% pre-tax rate of return)[93] and assuming a 4 year construction period with an equal capital drawdown each year, equates to an annual charge of some £60m. Dividing this by a £70/MWh renewable constraint cost (the mid-point for the Ofgem suggested range of £65-75/MWh for expected earnings for

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87 Ofgem, 2004, Transmission Investment for Renewable Generation – Final Proposals
88 Ofgem, 2006, Transmission Price Control Review: Initial proposals
89 Sinclair Knight Merz, 2004, A Technical Evaluation of Transmission Network Reinforcement Proposals.
90 Includes cost of submarine cable and associated onshore transmission
91 Western Isles HVDC Connection Options, 17 March 2006.
92 Ofgem, 2004, Transmission Investment for Renewable Generation – Final Proposals
93 Ofgem, 2006 Transmission Price Control Review: Final Proposals

renewables) produces a matching constrained annual generation output of 861GWh. At a 35% load factor[94] this would equate to some 281MW of installed capacity. Assuming a more conservative load factor of 30%, would equate to 328MW of installed capacity to justify a link of 1,000MW. To justify a link of 600MW, with a load factor of 30%, would equate to ~216MW of installed capacity.

However, applying the above criteria to new transmission investment is not such a straight forward exercise, specifically to the Scottish islands. Ofgem specifically says that uncertainty surrounding the development of new Scottish island links is so great that a meaningful investment methodology will have to be assessed for them separately. Two approaches have been highlighted[95]:

- Re-open the price control of Grid Owner (in this case Scottish Hydro-Electric Transmission Ltd - SHETL) when further information is available; and
- Open up the transmission links to alternative providers (a competitive approach could potentially bring quicker delivery, drive down costs, encourage innovation, give more certainty to ex ante costs, and reveal cost information).

However, in the absence of any methodology specifically for assessing new links to the Scottish islands, the existing Ofgem guidance provides some basis to assess the view of the LWP developers that *'in the absence of this investment, the existing connector would not be sufficient to enable the renewables sector to develop much beyond the point where it was meeting the Western Isles' own internal needs'* [96]. What the methodology indicates is that a much lower level of capacity that the LWP would be expected to trigger a decision to build a link to Lewis.

7.1. Evaluating Whether the Lewis Windfarm Proposal is Necessary in Order to Secure the Construction of an Interconnector

The LWP would provide justification for the construction of the upgraded link to the main land, but there are other developments that will also require the upgrade. Although there are no offshore wind or wave projects of any size currently proposed for Lewis, there are two smaller onshore windfarms which would require a new connection to the mainland.

Using current Ofgem guidelines, a renewable project of around 216MW could economically justify building a new connection of 600MW. The Pairc windfarm proposal, at 250MW would therefore justify a new link.

A representative of SSE's Transmission Division (SHETL) indicated in mid-November 2006 to IPA[97] that SSE were now beginning preparatory works (detailed planning of the interconnection) to lay a transmission link to the Western Isles of some 900MW capacity (3 300MW cables) on the back of commitments made to them by the developers on the Western Isles. Nearly 600MW[98] of renewable generation developments have now signed contracts for the design and connection to the transmission system. This does not include the LWP. The decision to lay 3 cables

[94] Using a 35% load factor as depicted in the 2004 LWP Environment Statement
[95] Ofgem, 2006 Transmission Price Control Review: Final Proposals
[96] Chapter 9, The Lewis Windfarm Proposal Environmental statement 2004

[97] Phone call with David Molly of SSE Transmission Division on 9/11/06
[98] Scottish Hydro-Electric Transmission Limited, Proposed Western Isles Connection, Consultation Document, December 2006.

would allow for additional capacity on the line as a whole and for the failure of one of the cables.

Additionally, in their proposed Western Isles Connection consultation document, SHETL state that[99]:

"As few of the renewable generation schemes on the Western Isles have received consent, the final power transmission capability of the reinforcement cannot be confirmed at this stage. Options are also being studied to allow the connection capacity to increase in stages. The minimum economic size of increment is likely to be around 300MW."

Thus the actuality of developments 'on the ground' on Lewis, confirms the view that LWP is not required to prompt investment in a new transmission link to the Western Isles.

[99] Scottish Hydro-Electric Transmission Limited, Proposed Western Isles Connection, Consultation Document, December 2006.

8. REVIEW OF ALTERNATIVE MEANS TO MEET CLIMATE CHANGE TARGETS

8.1. UK and Scottish Climate Change Targets

In the negotiation of the Kyoto Protocol in late 1997, the European Community (then consisting of 15 Member States) adopted a target to reduce aggregate emissions of a 'basket' of six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride, each assigned a 'Global Warming Equivalent' value terms of tonnes of carbon dioxide equivalent or CO_2-e) by 8% from 1990 levels, over the period 2008-2012.

The European Union later conducted further internal negotiations to divide up this aggregate target between Member States. As a result, some Member States adopted targets that were higher or lower than 8%.

Under this 'Burden Sharing Agreement' (decision of the EU Environment Council 16 June 1998, reaffirmed by joint ratification of the Kyoto Protocol on 31 May 2002) the UK agreed to a target reduction of 12.5%.[100] The Kyoto Protocol came into force on 16 February 2005 and this target is therefore now legally binding.

The UK also has a domestic goal (non-legally binding target) to reduce emissions of carbon dioxide (not including the other greenhouse gases) by 20% by 2010. The UK Climate Change Programme (CCP), published in 2000, set out a package of policies and measures designed to meet the 12.5% Kyoto target and 'move towards' the 20% domestic goal. A review of the UK Climate Change Programme was launched in September 2004 and continued throughout 2005. One finding of this review was that the UK was no longer on course to meet its 20% goal (on the basis of the existing policies and measures). Additional policies and measures were announced in March 2006 with the publication of *Climate Change: The UK Programme 2006*. The new policies and measures, combined with existing policies and measures, are projected to reduce the UK's carbon dioxide emissions by 15-18% by 2010 (in other words, current policies and measures are projected to fall short of delivering the 20% goal). Nevertheless, *overall* greenhouse gas emissions are projected to be 23-25% below 1990 levels in 2010 (going beyond the 12.5% Kyoto target). This is because greater reductions are projected for non-CO_2 greenhouse gases, than are currently projected for carbon dioxide.

The Scottish Executive published a complementary package of policies and measures, the Scottish Climate Change Programme, in November 2000. This was also reviewed during 2005. One of the key questions in the review was whether Scotland should have its own climate change target. Respondents to the consultation exercise were strongly in favour of introducing a Scottish target, and accordingly, in March 2006 the Executive published Changing Our Ways: Scotland's Climate Change Programme, which specified the 'Scottish share' of the total UK emission reductions set out under the UK CCP (1.7 million tonnes of carbon, or MtC, equivalent to 6.23 MtCO2), and also a 'Scottish target' (being to exceed the Scottish Share by 1 million tonnes of carbon, equivalent to 3.67 MtCO2, in 2010). The Scottish Share was derived from the estimated Scottish proportion of the UK population in 2010 (8.3%) multiplied by the

[100] The base year against which reductions will be measured is 1990 for carbon dioxide, methane and nitrous oxide, but 1995 for the other gases (due to improved data availability for 1995). The aggregate 12.5% reduction must be made over the period 2008-2012.

estimated carbon savings from 'devolved' policies and measures in the UK CCCP (20.7 MtC).

In the Energy White Paper published in February 2003, the UK Government announced a longer term goal to put the UK on a path to reduce carbon dioxide emissions by 60% by 2050, thereby adopting a recommendation made by the Royal Commission on Environmental Pollution (RCEP) in their 22nd report, Energy: The Changing Climate, in June 2000. The 60% reduction target was recommended by the RCEP as a level likely to avoid 'dangerous' levels of interference with the global climate, envisaged at the time as requiring a limitation of carbon dioxide levels to approximately twice pre-industrial levels.

In November 2005, the Prime Minister announced a further review of the UK's energy policy framework, with the result being The Energy Challenge: Energy Review Report 2006, published in July 2006. In his foreword to this report, the Prime Minister identified energy security of supply and climate change as two key challenges facing the UK. The report notes that renewable energy can help address both of these challenges states, "It is clear that we must significantly increase investment in, and support for, renewable energy so that it plays a larger role in our energy needs." On the other hand, the report also notes that no single solution to these challenges exists, and a balanced approached, driven by technological advances and increased efficiency, is required. One of the technologies singled out for new support is nuclear energy, which previously was considered an unattractive option in the 2003 Energy White Paper, primarily due to its high costs and issues of waste disposal.

With regard to renewables, the Energy Review proposed to ensure that the Renewables Obligation remains above the level of renewables actually installed, up to a maximum of 20% of the UK's energy demand. However, it also proposed to 'band' the Obligation to reduce support for certain relatively mature technologies, such as landfill gas and onshore wind, while simultaneously increasing support for emerging technologies such as wave or tidal power. A consultation paper on these proposals was released by the DTI in late 2006. In this consultation paper, it is made clear that these changes would only be introduced by 2009 at the earliest, and that they would not apply retrospectively, but only to new plant commissioned after the 'banding' levels have been established.

8.2. Life Cycle Emissions of the Lewis Wind Farm Project

Once a wind farm is operational, there are minimal emissions associated with generating the electricity. Therefore, on the one hand, a wind farm project can be considered to displace the emissions associated with alternative forms of electricity generation, thus making a contribution to greenhouse gas emission reduction targets.

However, the manufacture of wind turbine components, as well as construction and decommissioning of the wind farm, are activities that produce greenhouse gas emissions. Different options for reducing greenhouse gas emissions are therefore best compared on a full life cycle basis. The full life cycle includes the following stages:

- Resource extraction, transportation and processing;
- Component manufacture and transportation;
- Turbine construction and transportation;
- Wind farm construction (including roads, electrical connection and deforestation and peat removal due to construction activities);

- Wind farm operation;
- Decommissioning; and
- Product disposal.

Appendix 18A of the 2006 Addendum provides an estimate of the carbon emissions associated with the felling of 746.9 ha of trees, as part of the proposed Habitat Management Plan. The direct loss of carbon from the felled trees is estimated at 148,000 tC (542,250 tCO2). This is then compared with the estimated carbon savings.

The methodology employed in Appendix 18A is based on a guide to the evaluation of carbon savings from wind farms, published by Scottish Natural Heritage.[101] However, the guidance has been interpreted in an overly prescriptive manner. For example, the capacity factor used in the SNH example (40%) has been used uncritically, as it conflicts with the capacity factor assumed elsewhere in the Environmental Statement of 35%.[102] If a capacity factor of 35% is assumed, then the carbon savings from the wind farm would be 12.5% less: i.e. 1,558,288 tCO2/year if displacing coal-fired generation instead of the quoted 1,781,00 tCO2/year; or 859,056 tCO2/year instead of 982,000 tCO2/year if displacing the average grid mix (keeping all other assumptions constant). This in turn would mean that the wind farm would take 4.2 months (instead of 3.7) to save the amount of carbon released by the felling of 746.9 ha of trees, assuming displacement of coal-fired generation; or 7.6 months (instead of 6.7), assuming displacement of the average grid mix. Nevertheless, the conclusion remains valid: the emissions from the deforestation alone are not significant in the context of the assumed 20-year lifespan of the project.

Appendix 18B of the 2006 Addendum provides a 'first order' life cycle analysis of the (revised) proposed project. It concludes that the CO2 emissions associated with the manufacture, construction, operation and decommissioning of the project will be around 1,059,190 tCO2, compared with savings of 1,718,113 CO2/year. In other words, the wind farm will 'pay' for itself (in terms of carbon dioxide) within 7.4 months of operation.

Another way of expressing this would be to say that, over a 20 year lifespan for 651.6 MW operating at an average capacity factor of 35%, the full life cycle emissions would be around 26.5 kgCO2/MWh. Around 70% of these emissions are attributed to disturbance of the natural environment (peat and forest clearance). Therefore the life cycle emissions excluding those associated with peat and forest disturbance are estimated to be around 7.95 kgCO2/MWh.

This estimate appears to be in line with the available literature. A review in 1994 of a number of published studies of the full life cycle emissions associated with wind farms found that estimates ranged from 7-74 kgCO2/MWh.[103] However, as wind turbine technology has improved significantly since the mid-1990s, the current range would be lower.

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101 Referenced in the EIS as SNH (2000), although the correct citation is SNH (2003) Windfarms and Carbon Savings. Technical Guidance Note. Redgorton: Scottish Natural Heritage. www.snh.org.uk/pdfs/polstat/caf.pdf

102 E.g. at www.lewiswind.com/projectcentre/stats.php - note at bottom of page; likewise Annex 18B, page 6, paragraph 35.

103 J. F. van de Vate (1994) Comparative Assessment of Full-Energy-Chain Associated Emissions of Greenhouse Gases from Different Energy Sources: A Tentative Analysis. Renewable Energy 5: 2359-61.

A full life cycle analysis was undertaken in 1998 of what was then the UK's largest wind farm – Penrhyddlan and Llidiartywaun in Wales, with 103 turbines, each rated at 300 kW.[104] This found that the dominant stages of the life cycle (in terms of emissions) were the processing of the main energy intensive materials (steel, copper, glass and cement) and the subsequent engineering process. The study concluded that each 300 kW turbine could be associated with life cycle emissions of 190 tCO2, or 9.1 kgCO2/MWh.

The 3.6 MW turbines assumed to be used in the Lewis Wind Farm have 12 times the rated capacity of the turbines examined in the 1998 study, yet they are only around 3 times the physical size (e.g. 86.5m towers as opposed to 30m towers for the 300kW turbines). If the dominant life cycle impact is related to the physical quantities of resources used in construction, this would suggest that the impact per kWh of the corresponding aspects of the Lewis Wind Farm would be considerably lower. The assumed load factor in the 1998 study (31%) is also lower than the assumed load factor for the Lewis Wind Farm (35%), which would also reduce the impact per kWh output for the Lewis Wind Farm.

A more up-to-date comparison can be made with a life cycle assessment published by Vestas of its V90-3.0 MW turbine.[105] Vestas point out that the 3 MW turbine has been significantly optimised in relation to the V90-2.0 MW turbine. The larger diameter rotor in the 3 MW model weighs around the same (together with the nacelle), and the tower weighs relatively less, than in the 2 MW model. Vestas estimate life cycle emissions associated with an onshore V90-3.0 MW turbine at 4.64 kgCO2/MWh. The key assumptions used in the study are set out below and compared with the characteristics of the Lewis Wind Farm.

Table 6: Comparison of LWP with Vesta LCA study

Characteristic	Vestas LCA study	Lewis Wind Farm
Number of turbines	100	181
Rated capacity	3.0 MW	3.6 MW
Total capacity	300 MW	651.6 MW
Assumed load factor	30.02%	35%
Assumed output (turbine)	7,890 MWh/year	11,038 MWh/year
Tower height	90m	86.5m
Tower weight	275t	316t[106]
Foundations (size)	15x15x2m (475 m^3)	22x22x2m (968 m^3)
Foundations (weight)	1,200 tonnes	2420 tonnes[107]
Electrical cabling (total/per turbine)	140/1.4 km	?
Assumed lifetime	20 years	20 years

Sensitivity analysis undertaken in the Vestas study found that the length of electrical cabling did not have a significant impact on the overall life cycle impacts. The assumed lifetime had a significant (proportional) impact, and the assumed output also has a directly proportional impact. On the basis of the increased output of 11,038 MWh/year

104 Berry, J.E. et al (1998) Power Generation and the Environment – a UK Perspective. AEA Technology Environment 3776.
105 Vestas (2005) Life cycle assessment of offshore and onshore sited wind power plants based on Vestas V90-3.0 MW turbines. www.vestas.com/uk/environment/2005/life_cycle_assessment/life_cycle_assessment.asp
106 Siemens 3.6 MW turbine (weight of 250t quoted for 80m tower and scaled up in proportion), www.powergeneration.siemens.com
107 Estimated on basis of 2.5 tonnes/m3.

per turbine instead of 7,890 MWh/year, the Lewis Wind Farm *could* be expected to have only around 71% of the Vestas life cycle emissions per unit output, or around 3.32 $kgCO_2$/MWh.

However, a number of factors would increase the Lewis Wind Farm life cycle emissions, relative to the Vestas example:

- The fact that the turbine foundations will be twice as large (by volume) as those in the Vestas analysis would increase the life cycle emissions, due to the larger volumes of concrete and steel consumption. It should also be noted that there is no guarantee that the foundations will be of the predicted size: the 2006 Addendum notes, "The exact dimensions of the foundation would vary depending on the final choice of wind turbine and the ground conditions at the wind turbine location."[108] Foundations of up to 3m depth are common elsewhere in Scotland, even for smaller wind turbines than the proposed 3.6 MW machines.[109]
- The Vestas analysis assumed that the towers would be constructed by Vestas in Norway, using 69% CO_2-neutral electricity, and that transport of 900 km/year by car per turbine would be required for maintenance. The turbines that will actually be used in the Lewis Wind Farm are likely to be manufactured in Denmark or Germany and assembled in the UK, which have much higher grid electricity emission factors (it is difficult to ascertain exactly what emission factor has been assumed in the Vestas analysis, but UK, Denmark and German emission factors are likely to be at least 3 times higher). Some maintenance activities might have to be carried out by specialised engineers who would have to be flown in to the Western Isles, thereby increasing the transport-related costs.

In addition, the Vestas analysis uses electricity delivered to the grid as the denominator in the gCO_2/kWh calculation, which excludes transmission losses (i.e. the 'effective' output of the wind farm is equal to the electricity delivered to the grid, less transmission losses between the point of generation and the point of consumption). As losses in transmission from the Western Isles to centres of demand in the UK grid are likely to be significant, this under-states the life cycle emissions per unit of effective output. The transmission losses will depend on the final decision on the route and technology used for the interconnector, but could range from 3-16%.[110] Although for the lowest cost solution (connection to Beauly using a HVDC link with VSC (voltage source converter) technology) would be at the lower end of this range. Based on this range this would translate into an increase in the life cycle emissions per unit of effective output of 3-19%.

By comparison, losses for the 280 km Basslink interconnector between Tasmania and Victoria have been estimated at 4-6% (this includes only the losses for the undersea portion of the interconnector, which consists of a high voltage direct current line with metallic return, capable of 630 MW peak power flow from Tasmania to the mainland – further losses are associated with the onshore overhead lines at either end).

However, the most important factor affecting the life cycle emissions of the Lewis Wind Farm is associated with the fact that the wind farm will be built almost entirely on peat soils. The life cycle analysis at Appendix 18B attributes around 70% of the life cycle emissions (740,922 tCO_2) to disturbance of the natural environment.

[108] LWP (2006) Addendum Section 1, chapter 7, page 5.
[109] Wind turbine foundation specialist engineer, pers. comm. 2007.
[110] See Table 18 in PCS (2006) Western Isles HVDC Connection Options: Report. East Kilbride: Power Systems Consultancy Services Ltd.

An estimated 3.84 million m^3 of peat will be excavated during the construction of the wind farm, according to the Environmental Statement (Addendum section 1, chapter 7.11). Of this, 2.98 million m^3 will be re-used during the construction phase. The remainder (quoted in two separate places as 866,500 or 879,000 m^3) will be used to restore former peat cuttings. Therefore there should be no carbon emissions resulting from deliberate destruction (e.g. burning) of peat. Nevertheless, peat bogs are an important store of carbon, and disruption leading to dewatering and erosion could release significant amounts of carbon to the atmosphere.

A report by an independent expert[111] suggested that the impacts on peat soils were severely under-estimated in the 2004 Environmental Statement, comparing the 2004 Environmental Statement estimate of active bog affected by the development (189.8 ha, Table 11.7) with the expert's estimate of up to 6,255 ha. The 2006 Addendum concludes that 901 ha of peat bog will be affected, as no significant change in hydrology or surface vegetation is likely to occur more than 10 metres away from any new construction.

The 2006 Addendum estimates that the carbon content of the maximum amount of peat that could possibly be disturbed is 1,041,000 tC (3,815,735 tCO_2), assuming an average peat depth of 2.1m over 901 ha and an average carbon content of 55kg/m^3 fresh peat. In the worst-case scenario (all of the carbon in this potentially disturbed peat is released) this would require 2.2 years of generation to compensate for the carbon losses, if the wind farm output is assumed to displace coal-fired generation only, or 3.9 years of generation, if displacing the average grid mix. In a more realistic scenario (5% of the carbon in the affected peat is lost to the atmosphere), the 'pay back' period would be 1.3 months (if displacing coal-fired generation) or 2.4 months (if displacing the current grid mix). If these assumptions are correct, then the impacts from peat disturbance will be small relative to the total carbon savings from the operation of the wind farm.

However, the overall assessment hinges very much on whether or not the wind farm will cause any disruption across a wider area of peatland, for example through inducing changes in hydrology. The total potential zone of impact (defined as the area within 50m of new construction) is estimated at 1,671 ha. If 5% of the carbon is lost across this entire area, that would amount to 1,930,000 tC (7,076,685 tCO_2). Whether this or any other alternative is more realistic would require the opinion of a specialised peatland carbon modelling expert.

In summary, in the best-case scenario, a new onshore wind farm using 3.6 MW turbines operating in a similar wind regime to the Lewis Wind Farm *could* have full life cycle emissions as low as around 3.32 $kgCO_2$/MWh, if the assumptions in the Vestas analysis otherwise held true. This compares favourably with emission reductions due to displacement of fossil fuels, even if these may be lower than the figures used in the Environmental Statement (see section 8.3 below).

The Lewis Wind Farm development, however, is likely to have significantly higher emissions than this, primarily due to the fact that the turbines will be situated on peat bog, necessitating much larger foundations and involving possibly major losses of soil carbon. The estimate at Appendix 18B equates to 26.5 $kgCO_2$/MWh. It may still be on the low side due to the assumption of a very low emission factor for concrete: 0.2585 tCO_2/tonne concrete (emission factors for concrete depend on the type of concrete used and the production method, but typically vary between 0.75 and 1.25 tCO_2/tonne

[111] Lindsay, R. (2005) Lewis Wind Farm Proposals: observations on the official Environmental Impact Statement. RSPB.

concrete). However, even correcting for this would add only around 10% to the total estimate. The only factor with the capability to seriously impair the positive emission reductions of the project is the disruption to peat bog.

8.3. Emissions Savings from the Lewis Wind Farm Project

The emissions savings from the Lewis Wind Farm arise from the fact that it would displace electricity generated by other sources, elsewhere.

The actual emissions of the electricity displaced depend on a number of factors, including:

- The profile of wind output over time (daily/seasonal variation), compared with the marginal electricity generators producing electricity at those times;
- The carbon emissions per unit output of those marginal generators;
- The transmission losses associated with the electricity generated by the Lewis Wind Farm, relative to the transmission losses associated with the marginal generators; and
- The emissions associated with generation required to be maintained on standby in case of an unexpected reduction in output from the Lewis Wind Farm.

Data on the profile of wind output at the Lewis Wind Farm site are not available, and hence detailed modelling of the above factors is not practicable. Nevertheless, the following observations can be made:

- The 2006 Addendum estimates carbon savings based on an assumed 40% capacity factor, whereas 35% is assumed elsewhere in the report. Small changes in the overall capacity factor would have a major impact on the overall output of the wind farm. The likely variability in capacity factor from year to year would more than outweigh any variation in emission reductions due to, for example, displacement of different marginal generators at different times of the year (due to it being windier at different times of the year, in different years).
- The range of possible emission factors (0.78 tCO_2/MWh if displacing coal-fired generation and 0.43 tCO_2/MWh if displacing the average grid mix) under-estimates the future average grid emission factor, and hence the lower end of the scale of possible emission reductions. Over the lifetime of the Lewis Wind Farm (in fact, from around 2013 onwards), the average grid emission factor is likely to decline to around 0.30 tCO_2/MWh.[112] This is largely due to mandatory closures of coal plant due to European legislation. Additionally, whilst the emission factors are derived from SNH[113] they are higher than more recent figures used by the DTI. DTI Emission factors for coal fired generation for example are 0.32tCO_2/MWh[114]. The stated emissions savings from the LWP are therefore over estimated as a result of using the 2000 SNH report.
- Transmission losses are likely to be in the range of 3-16%.
- Emissions associated with providing additional flexibility at the system level (to cope with uncertainty in wind output) are highly variable, depending on the

[112] See Figure 17 in IPA (2005) Implications of the EU Emissions Trading Scheme for the UK Power Generation Sector. Report for the Department of Trade and Industry.

[113] SNH 2000. Windfarms and Carbon Savings: technical guidance note. Information note series. Battleby, Scottish Natural Heritage.

[114] http://www.dti.gov.uk/files/file33302.xls

behaviour of all generation and demand on the system. There is no agreement in the available literature on likely emission levels per unit of wind output, but in a worst case scenario, with high levels of wind on the system requiring relatively high levels of additional reserve, the emission reductions due to wind power operation could be reduced by up to 25%.[115]

The impact of these factors on the estimated emission reductions is summarised in the table below. In each case, the estimated emission reductions have been compared with the estimated life cycle emissions of 1,059,190tCO_2 as calculated in Appendix 18B and the 'pay back' period is shown in brackets.

Table 7: Estimated Emission Reductions

Estimated emission reductions (tCO_2/year)	**If displacing coal ('pay back' in months)**	**If displacing average grid mix ('pay back' in months)**
Appendix 18A (40% capacity factor)	1,781,000 (7.1)	982,000 (12.9)
Appendix 18B and project statistics web page[116]	1,718,113 (7.4)	N/A
Assuming 35% capacity factor	1,558,288 (8.2)	859,056 (14.8)
Assuming 35% capacity factor and 0.30 tCO_2/MWh average grid emission factor	1,558,288 (8.2)	599,342 (21.2)
Assuming 35% capacity factor, 0.30 tCO_2/MWh average grid emission factor and 3% transmission losses	1,511,540 (8.4)	581,361 (21.9)
Assuming 35% capacity factor, 0.30 tCO_2/MWh average grid emission factor and 16% transmission losses	1,308,962 (9.7)	503,447 (25.2)
Assuming 35% capacity factor, 0.30 tCO_2/MWh average grid emission factor, 16% transmission losses and 25% 'penalty' for wind uncertainty	981,722 (12.9)	377,585 (33.7)
Assuming 35% capacity factor and 0.32tCO_2/MWh emission factor for coal.	639,298 (19.9)	N/A

Therefore, in the worst case, assuming the estimated life cycle emissions are correct, the 'pay-back' period in the worst case could extend to nearly 3 years. The preceding analysis has shown that the estimated life cycle emissions appear reasonable, although assuming a higher emission factor for concrete would add around 10% to the total figure. However, if the 'worst case' for release of carbon from the peat identified in the 2006 Addendum as being potentially disturbed were realised (i.e. release of 1,041,000 tC or 3,815,735 tCO_2), combined with the worst case for emission reductions shown above, the 'pay-back' period could be as high as 10 years.

[115] See for example Milborrow, D. (2004) Assimilation of wind energy into the Irish electricity network. Dublin: Sustainable Energy Ireland.

[116] Assumes displacement of coal-fired generation initially, but with slight reduction over the project lifetime as wind increasingly displaces gas-fired generation.

8.4. Alternative Options to Reduce Emissions

The analysis of alternatives to the proposed project, presented in section 3 of the 2006 Addendum, rules out any project on the mainland, on the grounds that the project's objectives include making a major contribution to the economy of the Western Isles and justifying the investment in a large, efficient interconnector.

It could be argued that the project's objectives have been selected with a particular project in mind and hence it is illogical to use these objectives to limit the consideration of alternatives. Certainly, when considering options to reduce emissions of greenhouse gases, a project could be located anywhere in the UK – or indeed the world – and have an identical effect on the global atmosphere.

If only projects in the Western Isles are to be considered, then it is clear that the only alternatives that could possibly deliver a similar size renewable energy project are other onshore wind sites, offshore wind and wave power (as identified in the report in section 5). Of these, wave power, while having excellent potential resources in the Western Isles, are not yet at a stage of technological development where a 600+ MW installation is feasible. Offshore wind is at a more advanced stage of development, with a 1,000 MW wind farm recently consented in south-east England, but the Western Isles is not a priority area for offshore wind development within the UK, due to the lack of shallow, protected waters although in the medium term this resource could be developed. Alternative locations for onshore wind exist in the Western Isles, but the LWP proposal is probably the only option that provides such a large single project, involving a relatively small number of landowners.

If projects anywhere in the UK are to be considered, then the main alternatives to providing 600+ MW of new renewable energy supply are likely to be other onshore wind sites and offshore wind. Other onshore wind sites on the mainland would have lower transmission losses, and might also have lower life cycle emissions (if not located on peat). This would improve their overall contribution to emission reduction targets. However, the wind resource in the Western Isles is likely to be higher than most alternative sites, which could favour the Lewis Wind Farm over alternatives. Whether a specific alternative would make a greater or lesser contribution would depend on site-specific factors.

According to Vestas (2005), offshore wind farms using V90-3.0 MW turbines would have life cycle emissions of around 5.25 $kgCO_2/MWh$, or around 13% more than the equivalent onshore turbines (mainly due to increased concrete and steel consumption). However, this would be offset by higher capacity factors and lower requirements for standby generation, due to the more consistent wind profile offshore. There would be no issues with peat or forest clearance. Therefore the overall contribution to emission reduction targets from offshore wind farms would generally be higher (particularly if they are located close to centres of demand, such as in south-east England). The potential for offshore wind in Scottish waters has been estimated at 25.6 GW.[117] However, the cost is currently up to 25% above economically feasible levels.[118] In other words, further offshore development is dependent either on continued additional subsidies (beyond the Renewables Obligation as it currently stands), or substantial cost reductions, for example through the 'learning effect' as more capacity is installed over time.

[117] Garrad Hassan (2001) Scotland's Renewable Resource 2001. Executive Summary and two volumes. Report to the Scottish Executive.
[118] BWEA submission to the UK Government Energy Review, April 2006, Appendix B.

Therefore the main feasible alternatives to the Lewis Wind Farm, in terms of renewable energy supply options in the UK in the near term, appear to be either other onshore wind farms on the UK mainland, or offshore wind farms.

ANNEX A RENEWABLE ENERGY COSTS

Table: Offshore wind power costs

	Current Costs (£/MWh)	**Future[119] (c2020) Costs (£/MWh)**
Garrad Hassan, 2001		40-60
Gross, 2004	52-63	
Gross & Bauen, 2005	61-82	20-54
DTI, 2002[120]	56	27-38
PIU, 2001		22-34
SDC, 2005[121]	50-71	
New Energy 5, 2005[122]	76	
FES, 2003[123]		42-61[1] 33[2]
RAE, 2004	58	50
Best estimate	**52-82**	**20-61**

[119] For the purpose of this analysis, it is assumed that future costs are circa 2020. The range from the references varies between 2010 and 2025.
[120] DTI, 2002, Future offshore: A strategic framework for the offshore wind industry. DTI URN 02/1327
[121] Sustainable Development Commission (SDC), 2005, Wind power in the UK
[122] New Energy 5: October 2005 (€110/MWh)
[123] Future Energy Solutions (FES), 2003, Options for a low carbon future – Phase 2. [1] With 15% discount rate and amortisation over 15 years) [2] For cheapest sites, with 10% discount rate and amortisation over plant life

Table: Offshore wave power costs

Source	**Current Costs (£/MWh)**	**Future[124] (c2020) Costs (£/MWh)**
Carbon Trust, 2006[125]	120-440 (central estimates 220-250)	25-70
Garrad Hassan, 2001		47-67
PIU, 2001	50-67	45-56
Gross, 2004	103-206	58-94
RAE, 2004	69	60
MEG, 2004[126]	105-157	42-84
Best estimate	**100-250**	**24-84**

124 For the purpose of this analysis, it is assumed that future costs are circa 2020. The range from the references varies between 2010 and 2025.

125 Carbon Trust (2006) Future Marine Energy. Results of the Marine Energy Challenge: Cost competitiveness and growth of wave and tidal stream energy

126 Marine Energy Group (MEG), 2004, Harnessing Scotland's marine energy potential. Marine Energy Group (MEG) Report 2004

ANNEX B: ZONES OF NATURAL HERITAGE SENSITIVITY