



dti

**THE TRANSMISSION ISSUES
WORKING GROUP**

Final Report

JUNE 2003

The Transmission Issues Working Group Final Report

1. Background and Objectives

The Government's target that 10% of electricity supplies within the United Kingdom should be generated from renewable sources by 2010 has potentially very significant implications for the electricity transmission system. This could require up to 10,000 MW of additional renewable energy generation. The Energy White Paper published in March 2003 has an aspiration of doubling the 2010 target by 2020. Achievement of the renewables target is likely to involve a significant change in the geographical distribution of generating capacity. Appropriate infrastructure must be in place to enable the electricity generated from renewable sources, particularly in remote regions of Great Britain, to be transmitted to centres of demand if lack of transmission capacity is not to act as a barrier to meeting the Government's 10% target.

The GB Transmission Issues Working Group (TIWG) was established by the Department of Trade and Industry (DTI) in the light of these factors. The group comprised representatives from the DTI, the devolved administrations, Ofgem, the three GB Transmission System Owners (TSOs), and a number of consultants who were conducting, or had recently conducted, relevant studies¹. The terms of reference for the group were as follows:

*"To look at the implications for the GB electricity network of the Government's renewables targets, particularly in relation to large scale renewable development, to help the parties co-ordinate, and to make recommendations"*².

¹ A full list of participants is included in appendix 1.

² Whilst the terms of reference of the TIWG refers to 'the GB electricity network' in general terms, the primary focus was on transmission issues, with specific issues arising in relation to electricity distribution networks being considered by a separate group - the Distributed Generation Working Group - that was also established by the DTI.

A previous study conducted by PB Power for DTI examined the cost of providing up to 2GW of new north-to-south GB transmission capacity by laying an offshore cable down the west coast of Britain. The report, published in February 2002, identified the need for further study of both offshore and onshore transmission issues³. An important aim of the TIWG was to provide a coherent basis for assessing alternative approaches to providing transmission capacity for renewables developments by examining the costs and timescales that would be associated with significant onshore network upgrades.

The TIWG met on six occasions between March and July 2002.

³See http://www.dti.gov.uk/energy/publications/policy/west_coast_interconnector_study.pdf

2. Key Issues Examined

The TIWG focused on three key sets of issues:

- The extent, cost levels and associated timescales of investment that might be necessary throughout the GB transmission network to accommodate various scenarios of renewable generation in Scotland and England & Wales;
- Potential regulatory issues and obstacles that might arise in relation to the provision of this investment;
- Related issues concerning the framework for offshore wind generation developments.

The consideration of these issues was informed by four studies, the results of which were presented to the group at various times.

j) The Renewable Energy Transmission (RET) Study

In order to inform the consideration of transmission issues related to the achievement of the Government's renewables objective, the DTI invited the three GB Transmission System Owners (TSOs) – Scottish and Southern Energy (SSE), Scottish Power (SP) and National Grid Transco (NGT) – to develop transmission options for accommodating significant increases in the level of renewable generation in Scotland. The Renewable Energy Transmission (RET) study modelled the impact of three possible levels of additional renewable generation in Scotland: 2000MW, 4000MW and 6000MW by 2010, identifying the reinforcements that would be required in order to accommodate these levels of new generation, and estimated the associated costs and timescales involved. The study took place against the background that the renewable energy sector, particularly wind energy, is well established in Scotland and there is considerable potential for further development, both on the mainland and on the Western Isles – indeed, significant levels of new generation capacity are already being planned. A copy of the final report of the study is provided in appendix 1, and its key results are summarized in section 3(a) below.

ii) The England and Wales Transmission Study

There is also significant potential for renewable generation offshore, particularly in shallow water off the coast of England and Wales. The DTI therefore invited NGT to develop transmission options for accommodating significant levels of renewable generation off the coast of England & Wales. The RET and England & Wales Transmission (EWT) studies are complementary and are designed to give a picture for Great Britain as a whole. The EWT study modelled the impact of accommodating up to 6000MW of wind generation (with the majority assumed to be offshore wind generation) in England and Wales and 2000MW of renewable generation in Scotland by 2010. The study identified the reinforcements that would be required in order to accommodate these levels of new generation, and estimated the associated costs and timescales involved.

The study focuses principally on the Wash, the Thames estuary and the North West. These are the three strategic areas identified in the DTI's consultation document, *Future Offshore*,⁴ as offering the best prospects for development of offshore wind farms. However strategic environmental assessment will be undertaken before these areas are offered to developers in Summer 2003 and the wind generation capacities outlined in the EWT study should be regarded as purely illustrative. A copy of the final report of the EWT study is provided in appendix 2, and the key results of the study are summarized in section 3(a) below.

iii) The Oxera Marine Generation Study

Oxera presented results to the TIWG from a multi-client study it was conducting (that was commissioned outside of the TIWG) which examined potential arrangements for the financing and infrastructure regulation of offshore wind generation. The central issues focused on in the presentations concerned potential licensing arrangements for offshore development rights, and potential regulatory arrangements concerning the development and subsequent usage of offshore transmission wires.

⁴ Available at http://www.dti.gov.uk/energy/leg_and_reg/consents/future_offshore or a hard copy can be obtained from the DTI publications orderline on 0970 1502 500 quoting reference URN 02/1327.

iv) A Study by an independent technical consultant

The DTI engaged an independent technical consultant (ITC) - Tim Keyworth - to review the studies being undertaken and, where relevant, to highlight areas where greater coordination and/or additional work may be desirable. The central focus of this work concerned an examination of regulatory factors that might mitigate against the achievement of the government's renewables target, and the highlighting of ways in which these factors, where material, could be addressed. The key regulatory issues raised by the independent technical consultant are summarised in section 3(b) below.

3. Key Results and Issues Highlighted by the TIWG

a) Transmission Reinforcement: likely requirements, costs, and timescales

As noted above, questions concerning the transmission reinforcement requirements likely to arise from a significant increase in renewable generation, and the associated costs and timescales, were directly considered in the RET study and the E&W Transmission Study. The central cost estimates generated by these studies are summarized in tables 1 and 2 below.

Table 1 provides an estimate of the cost of reinforcement associated with the connection of 2GW, 4GW and 6GW of additional renewable capacity in Scotland. The RET study notes that each of the stages (2GW, 4GW and 6GW) would require detailed preparatory work and estimates that this would take approximately two years, although it notes that the first stage could progress more quickly as fewer consents would be required. In addition to this preparatory work, it is estimated that construction of the reinforced system would take between three and five years for each stage. However, it is noted that if the stages were run concurrently, for example by overlapping the preparatory phases, the overall delivery time could be reduced to between eight and ten years. These timescales, however, do not take account of potential delays that might arise in gaining the necessary consents.

Table 1: RETS estimated costs of network reinforcement (£ millions)

	STAGE 1 2GW	STAGE 2 4GW	STAGE 3 6GW
SSE	190	+160	+70
SP	160	+155	+70
NGT	170	+400	+120
Sub-total	<u>520</u>	<u>+715</u>	<u>+260</u>
Cumulative Total	520	1,235	1,495

Source: NGT, ScottishPower, Scottish and Southern Energy: "Renewable Energy Transmission Study" for DTI Transmission Issues Working Group.

The planned work is designed to facilitate additional new renewable generation without unnecessary reinforcement. When new projects make applications to be connected to the transmission grid specific location reinforcement will be required. There is a current connection request for a project on the Western Isles. The cost for such a 1 GW project is estimated to cost £250m.

Table 2 shows the costs associated with network development that would accommodate up to 6 GW of wind generation in E&W and 2GW in Scotland by 2010. The figures shown for the 2GW case are the same as those shown in table 1 above, as this was included as part of the first stage for the E&W study. The additional reinforcement cost estimates for E&W are highly dependent on the assumed location and scale of offshore wind projects. The figure of £205m cited in the second column relates to providing transmission capacity for 0.7 GW of offshore wind in the North West. This level of reinforcement is reliant on the onshore connection from such developments being located at Heysham or further south. If the connection were further north than Heysham, then, in addition to the £205m, further upgrades to the system would be required with an estimated cost of £320m. This level of reinforcement would be consistent with that identified for the second stage of the RET study and would therefore facilitate additional generating capacity both onshore in Scotland and off the coast of northwest England. As noted above, in addition to the significant cost involved, these developments could give rise to significant issues regarding achievement of the necessary consents. By contrast, the combined estimated cost associated with providing 3GW of new generating capacity in the Wash and 1GW in the Thames Estuary is £80m. Thus, the minimum estimated cost for 4.7 GW of offshore wind in England and Wales is £285m but it could rise to £605m if the north west offshore wind connects north of Heysham.

NGT estimate that detailed preparatory work would be required that would take approximately two years. It is estimated that the construction of the reinforced system would take between five and ten years. As with the RET study, these timescales refer to preparatory and construction work, and do not include potential delays that might arise from planning consent issues.

Table 2: EWTS estimated costs of network reinforcement in England (£ millions)

	Costs for 2GW of wind in Scotland	Offshore wind reinforcement costs	Additional costs at connection point	Additional costs for Upper Northwest reinforcement
SSE	190	-	-	-
SP	160	-	-	-
NGT	<u>170</u>	<u>+205</u>	<u>+80</u>	+320
Total	520	725	805	1,125

Source: NGT: "England & Wales Transmission Study" for DTI Transmission Issues Working Group.

When comparing the two sets of cost estimates, it should be noted that, where developments are from offshore wind generation, there may be very substantial 'offshore' connection costs - which are typically considerably higher than equivalent onshore connection costs for a given distance and capacity level - that are not taken into account in the analysis. Given this, the total (ie onshore plus offshore) transmission costs associated with offshore wind developments in England & Wales can be expected to be considerably higher than those shown in table 2.

Both studies included a cost benefit analysis that considered the level of constraints that might arise, and the aggregate cost of meeting those constraints, if the additional generating capacity connected without the required reinforcement having taken place. On the basis of this analysis, in each case the transmission reinforcements considered were found to have a positive net present value.

The assumptions made to generate the results in the two studies are described in the reports (which are attached at appendix 1 and 2). These include details in respect of the assumed displacement of conventional generating plant, and the potential constraint costs if investment in additional transmission capacity to comply with security standards is not undertaken. The results have not been reviewed by Ofgem and consulted on with interested parties, although Ofgem will be consulting shortly on these issues.

Comparative costs of an offshore transmission cable

The PB Power study referred to on page 3 above examined the cost of providing up to 2 GW of new north-to-south capacity by laying an *offshore* HVDC cable from a location in Scotland down the west coast of Britain. PB Power considered various lengths of cable, including at one extreme a 700 km cable which would bypass north-to-south transmission constraints and connect to the NGT transmission network at a location where there would be sufficient capacity to accommodate the import of power without any reinforcement to the system. This option has the advantage of avoiding any potential delays in obtaining consents for the reinforcement of the onshore transmission system, particularly in regard to the second stage of the RET study where upgrading of the infrastructure in the north west of England is required. However, consents issues could arise with respect to the siting of the onshore converter stations required by the DC cable option. The main disadvantage of a sub-sea cable is that significant upfront investment would be needed and there is a danger that assets may be stranded if the capacity of the cable is not fully utilised. This issue is less significant for the onshore grid as upgrading can take place incrementally in response to demand.

Strict comparisons between the onshore and offshore cable transmission routes are difficult for a number of reasons:-

- The onshore option would enable new generation distributed throughout Scotland to be integrated into the transmission network. Without further work the extent to which a sub-sea cable would support multiple connections is unclear.
- The offshore study considered the cost of an additional 2 GW of north-south *transmission* capacity whereas the onshore studies consider the transmission requirements of additional *generating* capacity.
- The RET study takes account of potential generation closures and the trade off between constraint costs and the cost of transmission reinforcement. The PB study does not explore these issues.
- The cost of local connections is not explored in either study.

- The cost of maintenance and repair of the systems is not quantified in either study. A sub-sea cable might be prone to prolonged periods when it is unable to function should it develop a fault or become damaged.

For all these reasons it is difficult to analyse the comparative costs of the two options. However, the key contribution that the sub-sea cable would offer would be to enable 2+GW of renewable energy to be transmitted to centres of demand in the south without the potential constraint of obtaining the necessary consents for the onshore route. Therefore the most directly relevant cost comparison is between the 2 GW 700 km offshore link which, by virtue of its southerly connection, would be unlikely to require any additional onshore investment, and the 2GW Stage 2 of the RET study. The former would cost £1,700m whilst the latter option would cost £715m without Western Isles reinforcement and £965m with such reinforcement. However this very high level comparison does not take account of detailed factors such as planning considerations that could have a significant bearing on overall costings. Offshore cabling would certainly provide reinforcement of the transmission system at a lower cost than equivalent onshore *underground* schemes.

Conclusion

The Group concluded on the basis of this analysis (bearing in mind both the level of demand already indicated by developers and the need to give confidence to the wind energy sector that transmission capacity would be available for their projects in line with the Government's targets) that detailed preparatory work on the Stage 1 2GW reinforcement -which was the first stage of both the RET and the EWT studies - should begin as soon as possible. The Group agreed that the sub-sea cable option should remain on the table for the future and would be reconsidered particularly if the RET Stage 2 was not feasible because of difficulties in obtaining the necessary consents.

b) Potential Regulatory Issues and Obstacles

The key regulatory issues considered by the group concerned two factors:

- the framework for new investment by the TSOs - in particular, whether the existing regulatory arrangements provided conditions that could be expected to deliver reinforcements of the magnitude put forward in the transmission studies, given the small size of most individual developments, and the probability that a proportion would be connected to distribution systems and located in Scotland but give rise to

the need for transmission reinforcements in England and Wales as well as Scotland.

- how the costs of new investment to provide transmission capacity would be recovered – in particular, how would costs be recovered from different users, including those of adjacent systems.

i) The framework for new investment by the TSOs

In their presentations to the TIWG, the TSOs noted that before any investment could be undertaken, the licensees would require a firm commitment from the regulatory authorities that the capital expenditure would be remunerated through the price control. Provided such regulatory certainty was obtained, the TSOs were confident that the levels of investment highlighted as necessary in the RET and the E&W Transmission studies could be delivered within timescales that were commensurate with meeting the Government's 10% target.

The DTI's independent technical consultant (ITC) was of the opinion that although there were a number of issues with the current regulatory arrangements that would need to be addressed, none of them were insurmountable. The ITC advocated discussion between Ofgem and the transmission companies to address these issues.

A central issue is the fact that the levels of investment highlighted as necessary in order to meet the Stage 1 2GW case would be likely to be considerably in excess of the capital expenditure assumptions that underpin the existing price controls of the TSOs. This raises short-term issues concerning the level of remuneration received by the TSOs for investment undertaken within a price control period, but it also raises very significant issues associated with uncertainty concerning the subsequent long-term regulatory treatment of the investment undertaken.

It was argued by the ITC that issues concerning regulatory uncertainty could be addressed by seeking to ensure that there was upfront regulatory scrutiny of investment cost projections. Remuneration could be provided either through an adjustment of the existing price controls, or the development of some form of incentive scheme focused on incremental transmission capacity release, or a combination of the two.

Ofgem highlighted that there were weaknesses in the existing price control arrangements, in particular relating to additional transmission capacity release above the baseline that was agreed as part of the TO price controls, and that it was considering ways in which these weaknesses could be addressed. Ofgem invited the companies to meet with them to discuss ways in which these issues could be progressed in further detail. Since then Ofgem has held a number of meetings with each of the transmission companies.

ii) *The distribution of investment costs incurred*

The distribution of the costs of transmission investment undertaken to provide capacity for renewable generators will be affected by two key factors:

- The approach taken to cost allocation at the time a new generator connects to the transmission system - that is, the extent to which the connecting party pays directly for costs incurred to reinforce the transmission system;
- The way in which investment costs are recovered from system users through the transmission charging arrangements – in particular, the extent to which the charging arrangements seek to reflect locational variations in the investment costs associated with new connections, and the extent to which the burden of costs arising from transmission investments would fall on the users of particular network or networks.

Both of these issues were raised during the meetings of the group. However it was recognised that they currently both form important aspects of the BETTA process⁵, and that detailed arrangements can therefore be progressed in that context.

The issue of the impact on prices to Scottish consumers if the costs of reinforcing the network were recovered only from them and the extent to which these costs should instead be spread throughout GB were also discussed.

⁵ The Government announced in January 2003 the intention to bring forward legislation to implement BETTA (British Electricity Trading & Transmission Arrangements) by April 2005. BETTA will introduce a single wholesale electricity market for GB. DTI and Ofgem have been working together on the development of BETTA and consultations are ongoing and can be found at <http://www.dti.gov.uk/energy/consultations/index.shtml>. The Electricity (Trading & Transmission) Bill, which will introduce the BETTA reforms has been published in draft and can be found at http://www.dti.gov.uk/energy/domestic_markets/electricity_trading/index.shtml

c) Related issues concerning the framework for offshore wind generation developments.

Issues concerning the framework for offshore wind developments were discussed by the group primarily in the context of the presentations given by Oxera. The importance of providing a set of arrangements that did not unduly favour either onshore or offshore generation projects was highlighted, as was the importance of recognizing that the costs of providing for offshore transmission infrastructure – which are typically considerably higher than onshore capacity for an equivalent capacity level and distance – were not included in the transmission studies conducted by the TSOs.

These issues are discussed further in the DTI's consultation document "Future Offshore" (see above and footnote 4), and will be taken forward in the light of comments received as a result of the consultation.

4. Key Actions Agreed by the TIWG

The key action agreed at the final meeting of the TIWG was that the TSOs and Ofgem would meet to discuss ways in which the various regulatory issues that had been identified could be progressed.

5. Subsequent Developments

Since the final meeting of the TIWG on 24 July 2002, there has been a dialogue between each of the TSOs and Ofgem concerning ways in which regulatory issues concerning the provision of transmission capacity consistent with potential new renewable generation developments can be addressed. Discussions with the Scottish companies have centred on how regulatory arrangements could be developed to take account of the substantial potential for renewable generation developments, consistent with Ofgem's statutory objectives, the TSOs' licence obligations and the pressure from connection applicants. Discussions with NGT have centred on the general issue of the provision of additional transmission capacity in England & Wales via the development of a deep system operator incentive scheme.

Ofgem considers that it would be inappropriate to institute some form of automatic incremental funding arrangement and favours a mechanism in which incremental funding is related to TSOs demonstrating that the market has signalled demand for the release of new capacity. If such signals exist, then the TSOs should be incentivised to release additional capacity over and above agreed baseline price control levels, although clearly there are issues as to what level of incentivisation should be provided.

As noted above, Ofgem have not as yet examined and consulted on the cost estimates shown above for the Stage 1 2GW case in detail. It is important, however, that time delays that might arise in seeking to agree on specific allowance levels, and mechanisms of funding, should not unduly inhibit the preparatory work for the Stage 1 2GW case beginning.

Specific developments have differed between the TSOs, in part as a result of the different price control arrangements that are currently in place for them. Regulatory issues concerning NGT's investment framework are being progressed, as indicated above, through the proposed reforms to its system operator incentive scheme from April 2004.

Ofgem has recently published documents⁶ setting out its initial views on how NGT's system operator incentive scheme from April 2004 could be developed to cover levels of investment above those agreed in its price control arising from market participants' increased capacity requirements in England & Wales. NGT was supportive of the introduction of a deep SO incentive scheme, but indicated several concerns about the overall approach, including in respect of licence exempt generation, a category into which many of the renewable generation developments will fall.

The dialogue between Ofgem and the TSOs is expected to continue with issues turning to the more specific consideration of how the regulatory arrangements could be modified, subject to consultation. In relation to NGT, the issues discussed so far have concentrated on the process by which signals for transmission capacity release are assessed, and the specific incentives that should be provided for the release of incremental transmission capacity. In this context, the specific changes arising from the development of embedded renewable generation in Scotland leading to increased transmission requirements in England and Wales have not been discussed as yet. Changes to the investment funding framework would require licence amendments, and therefore would be subject to the normal consultation processes (including a statutory consultation on any specific licence modification proposals).

For Scotland, Ofgem has, as noted above, continued discussions with both of the Scottish transmission companies to review the regulatory issues involved.

Subject to suitable arrangements being put in place to resolve the regulatory issues, particularly in the short term, the TSOs are confident that the levels of investment highlighted as necessary in the RET and the E & W Transmission studies could be delivered in timescales commensurate with meeting the Government's 10% target.

⁶'NGT system operator incentive scheme 2003/04 – 2005/06, Initial consultation document', Ofgem, October 2002, 'NGT system operator incentive schemes from April 2003, Initial proposals', Ofgem, December 2002 and 'NGT system operator incentive scheme from 1 April 2003 – 31 March 2004, Final Proposals and Statutory Licence Consultation', Ofgem, March 2003.

Annex

Membership of the Transmission Issues Working Group

Department of Trade & Industry

Neil Hirst (Chair)
Nigel Peace
Richard Marriott
Nicola Pitts
Phil Baker

Scottish Executive

Robin Naysmith

Ofgem

Sonia Brown

Scottish and Southern Energy

Rob McDonald
Mike Barlow
Chandra Trikha

Scottish Power

Simon Bucknall
Robin MacLaren
Colin Bayfield

National Grid Transco

Charles Davies
Tim Tutton
Andrew Hiorns

Oxera

Robin Smale

PB Power

David Bailey
Bruce Stedall
Keith Harmer

Independent Technical Consultant

Tim Keyworth, Regulatory Policy Institute

**Department of Trade & Industry
1 Victoria Street
London
SW1H 0ET**

ANNEX 1

Renewable Energy Transmission Study



SP Transmission & Distribution

≡ Scottish and Southern Energy plc

National Grid Transco

SUMMARY.....	3
1. INTRODUCTION.....	5
2. NETWORK OPTIONS	6
2.1 APPROACH.....	6
2.2 METHODOLOGY	6
2.2.1 THERMAL STUDIES.....	6
2.2.2 VOLTAGE COMPLIANCE	6
2.2.3 STABILITY STUDIES.....	6
2.2.4 COST BENEFIT ANALYSIS STUDIES	7
2.3 EXISTING SYSTEM.....	7
2.4 STAGE 1.....	8
2.5 STAGE 2.....	8
2.6 STAGE 3.....	8
2.7 WORK PROGRAMME AND TIMESCALES	9
2.8 COST BENEFIT ANALYSIS.....	9
3 CONCLUSION	11
4 APPENDICES.....	12
4.1 APPENDIX 1: DERIVATION OF RENEWABLE LEVELS.....	12
4.2 APPENDIX 2: ASSUMPTIONS.....	14

Summary

Overview

The United Kingdom Government target is stated as:-

⇒ By 2010 at least 10% of the electricity consumed within the United Kingdom will be produced by renewable sources.

To meet this target the construction of 8000MW to 10000MW of new renewable generation capacity is required.

Scotland has high potential for development of renewable energy resources. To exploit this, the transmission network has to be capable of moving energy from source to point of use.

In order to provide transmission capacity to accommodate this level of renewable generation, on timescales commensurate with the Government targets, network issues need to be addressed now. Accordingly, the DTI invited the three transmission licensees (Scottish and Southern Energy, ScottishPower and National Grid Transco) to develop transmission options for accommodating significant increases in the level of renewable generation in Scotland.

This report proposes a strategy for transmission network development capable of accommodating three possible levels of additional renewable generation in Scotland: 2000MW, 4000MW and 6000MW by 2010. The reinforcements proposed are a co-ordinated development plan across the GB networks in three additive stages, designed to facilitate the addition of new renewable generation while avoiding unnecessary investment if growth to the full 6000 MW fails to materialise. Stage 1 needs to be addressed immediately if Government targets are to be facilitated.

Estimated Costs

The table below identifies the estimated costs of each stage.

Reinforcement Options

	Stage 1	Stage 2	Stage 3
Capacity MW	2000	4000	6000
Total Cost £m	520	1235	1495
£m/MW	0.26	0.31	0.25

Additionally:

Connection of 1000MW on Western Isles £m
250
0.25

As a comparison the table below shows the potential costs of connecting 2000MW from the Western Isles to a point in England, as reported in the ETSU Study 'Concept Study – Western Offshore Transmission Grid'

Sub-Sea West Coast Cable

Sub-sea Option	
Capacity MW	2000
Cost £m	1700-2300
£m/MW	0.85 –1.2

Cost Benefit

Each stage has a positive cost benefit when evaluated against the costs of constraining generation due to network limitations.

Construction

Work on Stage 1 needs to commence now if adequate infrastructure to accommodate the Government targets is to be developed.

The three transmission licensees recognise that there will need to be some regulatory oversight of the work on this report. However, given that this work is time critical, we would urge the government not to embark upon detailed third party repetition of this work.

1. Introduction

The U.K. Government has set a target of 10% of electricity consumed to be produced from renewable sources by 2010. This equates to 43TWh (43 thousand million kWh), which implies an installed capacity in the region of 8000-10000MW across the U.K. Appendix 1 lays out this assumption in more detail. Based on the current level of market activity, it is believed that around 6000MW of this generation could locate in Scotland.

The Scottish Parliament has set a target of 18% of electricity consumed to be from renewable sources by 2010. This amounts to 6.2TWh, or 1000MW of generating capacity. This target has been supported by the Renewables Obligation (Scotland), which was enacted in April 2001. Developers of renewable generation projects have responded enthusiastically, with enquiries for connection to the Scottish networks currently in excess of 5000MW.

A concept study commissioned by the Minister for Energy⁷ assessed the use of sub-sea cables for the north of Scotland. This reported that it would be feasible to connect up to 2000MW of generation on the Western Isles to suitable load centres in England or Wales using a sub-sea cable. The indicative cost of such work was in the range £1700m to £2300m. The report concluded however, that consideration also should be given to significant upgrades to the onshore transmission networks.

A study commissioned by the Scottish Executive⁸ concluded that the level of economically exploitable resource across Scotland was far in excess of that required to reach the Scottish target. Furthermore the DTI, in recognising the transmission issues associated with renewable generation, formed the Transmission Issues Working Group. At the request of this group the transmission companies within GB have initiated a programme of studies to ascertain how best they can develop the national transmission system to accommodate renewable generation in Scotland to contribute to the U.K. targets.

It is intended that this report will provide an input for policy makers and it is hoped it will provide a contribution to the national debate on this topic envisaged in the PIU report on Energy Policy.

⁷ 'Concept Study – Western Offshore Transmission Grid' by PB Power for ETSU

⁸ Scottish Renewable Resource 2001

2. Network Options

2.1 Approach

The levels of renewable generation studied were:

- 2000MW across Scotland
- 4000MW across Scotland
- 6000MW across Scotland

It was assumed that the generators locate equally between the ScottishPower and the Scottish and Southern Energy areas. Within each area a locational pattern was assumed which broadly matches the companies' experience of application volumes. The renewable generation was modelled as generation clusters connected to the main network, hence the local connection details for individual generators to the network were not considered.

In determining the impact of the new renewable generation on the network it is necessary to make a number of assumptions. The full set of the assumptions made regarding demand growth, generation background, etc., are detailed in Appendix 2 and are in line with assumptions made for similar studies undertaken for Ofgem.

2.2 Methodology

The first stage of the work studied the thermal capabilities of the transmission networks against the background of forecast demand growth and increasing penetration of renewable generation. The network reinforcements devised to alleviate thermal issues were then reviewed and modified to take account of voltage and stability requirements.

2.2.1 Thermal Studies

The thermal capacity of the transmission network was investigated for the three levels of renewable generation. The corresponding network reinforcement options were then determined from the application of licensed transmission Planning Standards.

2.2.2 Voltage Compliance

The three stages of network reinforcement were then assessed to ensure the voltage across the networks remained within planning standard limits. Where voltage violations were detected the appropriate reactive compensation and its location was determined. In line with current developments in generator technology it was assumed that the new renewable generators were capable of providing a limited level of system reactive support.

2.2.3 Stability Studies

Stability analysis was carried out on the Stage 1, 2 and 3 networks. Where the proposed networks were found to have insufficient resilience under fault conditions, additional reinforcements were identified.

2.2.4 Cost Benefit Analysis Studies

The cost benefit analysis was undertaken using National Grid Transco's constraint analysis package. The package simulates a year of operation of the grid system taking account of varying system demand levels (seasonal and daily), generator ranking orders and breakdown rates and planned and unplanned transmission system circuit outages. To facilitate a GB analysis the England and Wales system model was extended to include a model of the ScottishPower and Scottish and Southern Energy systems.

The analysis package models generators as fixed outputs. To simulate the variation in wind farm output, several sets of studies were undertaken for each of the Stages with varying amounts of wind farm output. The results for each study were then proportionately combined to produce an annualised constraint volume with a wind farm output that had the correct average load factor.

2.3 Existing System

The existing network across the three companies operates at voltages of 132kV, 275kV and 400kV. While the higher voltages essentially provide the backbone of the networks, some of the 132kV circuits are strategically important, particularly those that form part of the meshed transmission network in Scotland.

The existing Scottish and Southern Energy main interconnected transmission system (MITS) is such that under current application of planning standards, and with generators having full access to the transmission system across all demand periods, new generation cannot connect without reinforcement. Recent initiatives to move to a 'shallow' connection policy and to introduce a constraint mechanism have recently been approved by Ofgem. This allows up to 600MW of suitably located new generation to be connect in the north, albeit on a constrained basis. To accommodate the volume of renewable generation being considered under the new Government targets will inevitably require transmission system reinforcement.

The transmission infrastructure in the ScottishPower area, excluding the Anglo-Scottish Interconnector has remained substantially unchanged for the last 20 years. The current infrastructure is such that there are no significant constraints on generation within the SP area. However, to accommodate both the load flow from the Scottish and Southern Energy system and the anticipated levels of renewable generation in the ScottishPower area requires the networks to be substantially reinforced.

The National Grid Transco system in the north of England has nuclear generation stations connected at Hartlepool and Heysham. In addition there are large concentrations of CCGTs, built within the last ten years, in the Teeside and Killingholme areas. A new double circuit 400kV line is presently under construction in the Vale of York providing a new 400kV circuit from Lackenby through to Thornton. National Grid Transco also has an agreement to connect a new 1320MW DC interconnector to Norway at a new 400kV substation at Hawthorn Pit in 2006. These have been taken into account in developing the proposals, together with the addition of the renewable generation in Scotland. This will increase north to south flows on the National Grid Transco system and will require additional system reinforcements across internal National Grid Transco system boundaries.

2.4 Stage 1

Studies for the connection of 2000MW of renewable generation in Scotland indicate a requirement to strengthen the main interconnected transmission network running through SSE's and SP's areas. There would also be a need to strengthen the transmission infrastructure within NG's system. The table below summarises the cost of the reinforcement requirements arising from the thermal, voltage and stability analysis.

Schedule of Reinforcement	Cost estimate (£m)
Scottish and Southern Energy	190
ScottishPower	160
National Grid Transco	170
Total for Stage 1	520

2.5 Stage 2

Building on the Stage 1 network reinforcement costs, the cost of connecting 4000MW of renewable generation in Scotland is detailed in the following table:

Schedule of Reinforcement	Cost estimate (£m)
Scottish and Southern Energy	+160
ScottishPower	+155
National Grid Transco	+400
Total for Stage 2	+715
Total for Stage 1 and Stage 2	1235

2.6 Stage 3

Building on the previous Stage 1 and 2 network reinforcement options, the cost of connecting 6000MW of renewable generation in Scotland is summarised in the following table.

Schedule of Reinforcement	Cost estimate (£m)
Scottish and Southern Energy	+70
ScottishPower	+70
National Grid Transco	+120
Total for Stage 3	+260
Total for Stage 1, Stage 2 and Stage 3	1495

2.7 Work Programme And Timescales

Detailed preparatory work will be required for each stage. This work will take the staged reinforcements from desktop concepts to a point where firm contracts can be placed. It is estimated that this will require approximately two years for each stage, although Stage 1 could progress more quickly. It is estimated that the construction of the reinforced system will take between three and five years for each stage.

If the stages are run concurrently, for example by overlapping the preparatory phases, the overall delivery time could be reduced to between eight and ten years.

2.8 Cost Benefit Analysis

The reinforcement options were arrived at on the basis of the connected generation capacity that would be required to meet the Government targets. The output of individual generators, however, varies over time and only provides its theoretical maximum for a portion of time. The output from wind generation in particular is likely to correspond to the maximum output for only a short time in any one year. Therefore an assessment was undertaken to estimate the level of system constraints that might result if the generators were connected without the requisite reinforcements. This assessment was achieved by studying 2000MW, 4000MW and 6000MW against existing, Stage 1, 2 and 3 networks.

Table 1 lays out the level of constraints calculated i.e. the number of generated units that could not be accommodated in each of the given scenarios.

Table 1 Constraint Volumes (TWh per annum)

Installed Wind	Base System	Stage 1	Stage 2	Stage 3
2 GW	2.3	0.6		
4 GW	5.0	2.4	0.6	
6 GW	9.1	5.6	2.6	0.9

Table 2 shows the net benefit of the three reinforcement stages for varying levels of connected generation, based on a constrained generation cost of £25/MWh. The Net Benefit in this case is determined from the value of the constraint saving over a 40-year asset life minus the cost of the reinforcement.

Table 2 Net Benefit of Reinforced Networks (£m)

Installed Capacity	Net Benefit Stage 1 (Cost £520m)	Net Benefit Stage 2 (Cost £1235m)	Net Benefit Stage 3 (Cost £1495)
2GW	75		
4GW	425	387	
6GW	736	1132	1480

The analysis concludes that the reinforcements have a positive net benefit, i.e. that over their lifetime they are expected to save in constraint savings more than they cost to build. The analysis undertaken has demonstrated that by developing a range of potential reinforcement options to meet

an increasing volume of wind capacity in Scotland, a robust transmission system will be maintained.

These figures do not include constraint costs associated with construction outages. Transmission system developments are planned to be constructed in advance of the commissioning of new generation projects. If planned developments are not in place prior to the generation being connected then the level of constraints on the system would be increased further, i.e. the additional capacity would be required at a time when there are prolonged construction outages on the system. By committing to the 2000MW solution now, with an anticipated design/construction lead-time of approximately five years, additional capacity can be provided to facilitate the connection of wind farms, ensure compliance with security standards and minimise construction constraint costs.

Similarly the Stage 2 and Stage 3 works should also be undertaken in advance of the level of generation actually connecting to the transmission system.

3 Conclusion

The studies undertaken have indicated that the proposed GB network reinforcements will accommodate an increase in renewable generation of up to 6000MW in Scotland. This will cost in the region of £805m in Scotland and £690m in the north of England. The initial stage, which does not commit to Stages 2 and 3, will accommodate 2000MW and will cost £350m in Scotland and £170m in the north of England. These costs are summarised in the table below.

Table 3 Costs (£m)

	Stage 1	Stage 2	Stage 3	Western Isles
SSE	190	+160	+70	+250
SP	160	+155	+70	
NG	170	+400	+120	
Sub Total	520	+715	+260	+250
Total	520	1235	1495	1745

The analysis undertaken indicates that the completion of the reinforcement suggested for each level of renewable generation is more cost-effective than constraining the generation.

In order to give maximum time for planning and consent issues there should be no delay in progressing this project. Assuming favourable timescales for obtaining consents, construction of the reinforced network would take approximately five years for Stage 1 and eight to ten years to complete all three Stages if tackled concurrently.

These studies have identified a co-ordinated strategy to facilitate the staged development of a transmission system capable of accommodating 6000MW of new renewable generation in Scotland by 2010.

If adequate infrastructure to accommodate the Government targets is to be developed the three transmission licensees consider that there is a strong case for commencing work on the 2000MW upgrade now.

4 Appendices

4.1 Appendix 1: Derivation Of Renewable Levels

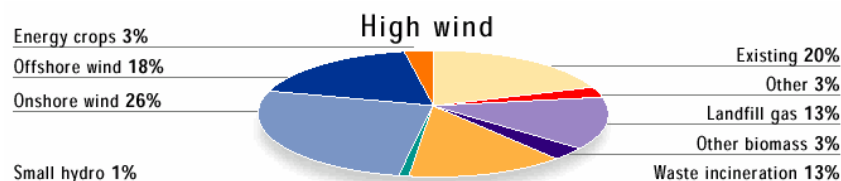
1) *Electricity Demand*

The Digest of U.K. Energy Statistics gives 372.9TWh for annual electricity requirements in the U.K. in 2000. Applying National Grid Transco's 2002 SYS forecast of underlying annual demand gives 432.8TWh for U.K. annual requirements in 2010. From this, 10% of U.K. electricity demand in 2010 is 43.3TWh, which is to come from renewable generation.

From National Grid Transco's 2002 SYS assumptions, the underlying ACS restricted peak demand in England and Wales will increase from 58.2GW in 2000 to 67.9GW in 2010. From assumptions by the Scottish transmission companies, the corresponding peak demand in Scotland will increase by 0.8% p.a. from 5.9GW in 2000 to 6.4GW in 2010.

2) *Renewable Generation in 2010*

In 2000 the DTI published the document: "New and Renewable Energy: Prospects for the 21st Century". This document outlined 3 scenarios for renewable generation in 2010, of which the "high wind" scenario is believed to be the most realistic.



The DTI's high wind scenario shows 44% of renewable electricity generated from wind power, i.e. some 19.0TWh. A second scenario has been examined, whereby the predicted 13% of renewable electricity contribution from waste incineration comes instead from wind power. This modified high wind scenario would increase the percentage of the U.K.'s 10% renewable electricity target to come from wind power to 57%, equivalent to 24.7TWh.

3) *Scotland/England & Wales Wind Generation Split*

Two scenarios have been developed for the geographical distribution of wind generation. One scenario, resource based distribution, is based on BWEA estimates of suitable exploitable land areas for wind generation (extrapolated to include offshore wind). The other scenario, constrained distribution, is based on BWEA estimates which take into account the constraints of the distribution networks.

The resource based scenario leads to Scotland accommodating 63% of the U.K.'s new wind generation (28% in England and Wales), while the constrained scenario leads to 28% of the U.K.'s new wind generation in Scotland (67% in England and Wales).

4) *Other Renewables*

The DTI's high wind scenario and the modified high wind scenario lead to 36% and 23% of new renewable generation to come from "other renewables" (excluding existing sources). The distribution of this generation has been allocated assuming that 2% is in Northern Ireland (the same as in 2000), and that in Scotland 90% of new renewable energy comes from wind.

Assuming 30% load factor for wind generation and 75% for other renewable generation, the table shows the 4 scenarios.

2010 Renewable Generation Scenarios		Wind		Other Renewables	
		Scotland	England & Wales	Scotland	England & Wales
DTI's "High Wind" Scenario	Constrained	2.0GW	4.8GW	0.1GW	2.2GW
	Resource Based	4.5GW	2.0GW	0.2GW	2.1GW
Modified "High Wind" Scenario	Constrained	2.6GW	6.3GW	0.1GW	1.5GW
	Resource Based	5.9GW	2.6GW	0.3GW	1.2GW

NB - these figures are IN ADDITION TO all existing renewable generation in 2000.

4.2 Appendix 2: Assumptions

Demand

- 1) GB transmission network demand growth assumed to be 0.8% per annum until 2010, giving a total increase in the U.K. maximum demand from 64GW in 2000 to 69GW in 2010. This recognises the potential for improved efficiency savings.

SSE demand rises from 1.6GW in 2000 to 1.8GW by 2010

SP demand rises from 4.3GW in 2000 to 4.6GW by 2010

NG demand rises from 52GW in 2000 to 57GW by 2010

Generation Background

- 2) The GB generation background has been derived from the same background that was used by the TO/MO workstream established by Ofgem in 2001 to assess some of the impacts of BETTA. In addition, assumed plant closures of approximately 1300MW of generation in Scotland.

Location of Renewables in Scotland

- 3) Independent studies carried out in 2001 highlighted a vast and economic renewable resource in Scotland. The predominant resource in Scotland is on-shore wind based and this has been confirmed by the rate of applications for wind farms in the SSE and SP areas. The distribution of the projected renewable generation in Scotland has been based on actual applications or enquiries already received by the Scottish companies. Based on this information it is assumed that the renewable generation studied in Scotland will be split 50:50 between the SSE and SP areas. Uniform growth of renewables in each area is assumed when studying different renewable penetration levels.

Diversity Figures for Renewables

- 4) The intermittent and dispersed nature of wind power presents some difficulty in determining the appropriate level of transmission system capacity. For the purposes of assessing transmission capacity at winter peak demand, it is considered that a diversity of 83% should be applied to renewable generation. This takes account of plant availability and diversity and is in accordance with the methodology specified in the Companies Planning and Security Standards.

Planning Standards

- 5) Application of licensed transmission Planning Standards corresponding to the company and area under investigation.

MVAr Contribution From Windfarms

- 6) The analysis undertaken assumes that the wind generators are capable of providing limited MVAr output to support system requirements. The 6GW of wind generation is assumed in this analysis to have the potential to operate at a power factor of 0.95 lead or lag as required.

Stability

- 7) Stability Analysis has been undertaken for a 60% demand. Studies undertaken on the Anglo-Scottish Interconnector capacity indicate that this is a critical demand level at which to achieve high transfers from Scotland to England. The studies were undertaken using the generator

ranking order produced for the BETTA studies (2 Units @ Torness, 2 Units @ Hunterston , 2 Units @ Longannet and 2 x 265MW plus 1 x 660MW Units @ Peterhead). This represents a typical generation pattern for Scotland.

The windfarm generators have been modelled as basic synchronous generators which provide limited response in stabilising the system. Depending upon the detailed design of individual wind generators it may be possible to achieve higher transfer levels.

ANNEX 2

England & Wales Transmission Study

National Grid Transco

SUMMARY	3
1. INTRODUCTION.....	4
2. NETWORK OPTIONS	5
2.1 APPROACH.....	5
2.2 METHODOLOGY.....	5
2.2.1 THERMAL STUDIES.....	5
2.2.2 ADDITIONAL WORKS.....	5
2.2.3 COST BENEFIT ANALYSIS STUDIES	5
2.3 EXISTING SYSTEM.....	7
2.4 REINFORCEMENTS TO ALLOW INCREASED FLOWS FROM SCOTLAND.....	7
2.5 REINFORCEMENTS TO ACCOMMODATE OFFSHORE WIND.....	8
2.6 ADDITIONAL COSTS FOR NORTHWEST UPRATING	8
2.7 WORK PROGRAMME AND TIMESCALES.....	9
2.8 COST BENEFIT ANALYSIS	9
3. CONCLUSION	10
4. APPENDICES.....	11

Summary

Overview

The United Kingdom Government target is stated as:-

⇒ By 2010 at least 10% of the electricity consumed within the United Kingdom will be produced by renewable sources.

To meet this target the construction of 8000MW to 10000MW of new renewable generation capacity is required.

The UK offshore wind resource has high potential for development of renewable generation. To exploit this, the transmission network has to be capable of moving energy from source to point of use.

In order to provide transmission capacity to accommodate this level of renewable generation, on timescales commensurate with the Government targets, network issues need to be addressed now. Accordingly, the DTI invited National Grid to develop transmission options for accommodating significant levels of renewable generation offshore of England & Wales.

This report proposes a strategy for transmission network development capable of accommodating up to 6000MW of wind generation in England & Wales and 2000MW in Scotland by 2010.

This report follows on from the joint Scottish and Southern Energy, ScottishPower and National Grid Transco 'Renewable Energy Transmission Study' (RETS) report which examined scenarios with up to 6000MW of renewable energy in Scotland.

Estimated Costs

The table below identifies the estimated costs of each stage.

Summary of Reinforcements

	Costs for wind in Scotland	Offshore Wind Reinforcement Costs	Additional costs at connection point	Additional Costs for Northwest uprating
SSE	£190m	--	--	--
SP	£160m	--	--	--
NG	£170m	+£205m	+£80m	+£320m
Total	£520m	£725m	£805m	£1125m

Cost Benefit

Each stage has a positive cost benefit when evaluated against the costs of constraining generation due to network limitations.

3. Introduction

The U.K. Government has set a target of 10% of electricity consumed to be produced from renewable sources by 2010. This equates to 43TWh (43 thousand million kWh), which implies an installed capacity in the region of 8000-10000MW across the U.K. Appendix 1 lays out this assumption in more detail. Based on the current level of available resource, it is believed that around 6000MW of this generation could locate in England & Wales, with a further 2000MW in Scotland.

The UK has been identified as having a large and as yet unexploited offshore wind energy resource. This means that there is the potential to generate large amounts of electricity from wind turbines sited off the UK coast. Many of the most favourable locations are off the coast of England and Wales, which has the advantage of being relatively close to the main centres of demand.

It is assumed for the purposes of this study that no more than 1100MW of wind generation would be built onshore in England and Wales, due to planning constraints. This is assumed to be in small, distributed windfarms (all onshore windfarms are assumed to be "embedded" - i.e. connected to the LV distribution system). However, the massive offshore resource means that up to 4900MW of wind generation could be sited offshore by 2010, with scope for further capacity beyond that. The offshore wind generation has been assumed to be located in the most likely areas for large scale offshore wind generation development, as identified by the British Wind Energy Association.

It is intended that this report will provide an input for policy makers and it is hoped it will provide a contribution to the national debate on this topic envisaged in the PIU report on Energy Policy.

4. Network Options

4.1 Approach

The network options to accommodate 2000MW of wind generation in Scotland have been outlined in the RETS report and are not discussed here.

1100MW of the wind generation in England and Wales was assumed to be in small, distributed onshore windfarms. The remaining 4900MW of wind generation was assumed to be in larger, offshore windfarms, geographically located as below.

Region	
Northwest	700MW
The Wash	3000MW
Northeast	100MW
East Anglia	100MW
Thames Estuary	1000MW
Total	4900MW

The wind generation was modelled as generation clusters connected to the main network, hence the local connection details for individual generators to the network were not considered. Figure 1 shows the geographic distribution of the 4900MW of offshore wind generation considered.

In determining the impact of the new renewable generation on the network it is necessary to make a number of assumptions. The full set of the assumptions made regarding demand growth, generation background, etc., are detailed in Appendix 2 and are in line with assumptions made for similar studies undertaken for Ofgem.

4.2 Methodology

The first stage of the work studied the thermal capabilities of the transmission networks against the background of forecast demand growth and increasing penetration of renewable generation.

4.2.1 Thermal Studies

The thermal capacity of the transmission network was investigated for proposed wind generation background. The corresponding network reinforcement options were then determined from the application of licensed transmission Planning Standards.

4.2.2 Additional works

An assessment was then made as to the costs likely to be associated with any additional works arising from the offshore wind connections, such as substation reconfigurations and reactive compensation.

4.2.3 Cost Benefit Analysis Studies

The cost benefit analysis was undertaken using National Grid Transco's constraint analysis package. The package simulates a year of operation of the grid system taking account of varying system demand levels (seasonal and daily), generator ranking orders and breakdown rates and planned and unplanned transmission system circuit outages.

The analysis package models generators as fixed outputs. To simulate the variation in wind farm output, several sets of studies were undertaken with varying amounts of wind farm output. The

results for each study were then proportionately combined to produce an annualised constraint volume with a wind farm output that had the correct average load factor.

Figure 1: Assumed Pattern of Offshore Wind Generation



4.3 Existing System

The existing National Grid Transco network operates at voltages 275kV and 400kV. While these high voltages essentially provide the backbone of the networks, some of the 132kV circuits (owned by distribution companies) are also strategically important. To accommodate the volume of renewable generation being considered under the new Government targets will inevitably require transmission system reinforcement.

The National Grid Transco system in the north of England has nuclear generation stations connected at Hartlepool and Heysham. In addition there are large concentrations of CCGTs, built within the last ten years, in the Teeside and Killingholme areas. A new double circuit 400kV line is presently under construction in the Vale of York providing a new 400kV circuit from Lackenby through to Thornton. National Grid Transco also has an agreement to connect a new 1320MW DC interconnector to Norway at a new 400kV substation at Hawthorn Pit in 2006. These have been taken into account in developing the proposals, together with the addition of the renewable generation in Scotland. This will increase north to south flows on the National Grid Transco system and will require additional system reinforcements across internal National Grid Transco system boundaries.

4.4 Reinforcements to allow increased flows from Scotland

The work done for the RETS study was not duplicated for the England and Wales Transmission study and the information below is based on the RETS paper produced by National Grid Transco, Scottish Power and Scottish and Southern Energy.

Studies for the connection of 2000MW of renewable generation in Scotland indicate a requirement to strengthen the main interconnected transmission network running through SSE's and SP's areas. There would also be a need to strengthen the transmission infrastructure within NG's system. The table below summarises the cost of the reinforcement requirements arising from the thermal, voltage and stability analysis.

Schedule of Reinforcement	Cost estimate (£m)
Scottish and Southern Energy	190
ScottishPower	160
National Grid Transco	170
Total for Stage 1	520

4.5 Reinforcements to accommodate offshore wind

The wind generation in the Northwest, combined with the increased power flows from Scotland, requires transmission reinforcements in the Northwest. The offshore wind generation connections in the Wash and the Thames Estuary also require works such as substation configuration changes, reactive compensation schemes, etc.

Schedule of Reinforcement (National Grid Transco transmission system only)	Cost estimate (£m)
Works in North West	205
Works in East Anglia/Thames Estuary	80
Total for offshore wind reinforcements	285
Total for increased flows from Scotland (from Section 2.4)	520
Total for offshore wind + increased flows from Scotland	805

4.6 Additional costs for Northwest uprating

If the offshore wind generation in the Northwest connects to National Grid Transco's transmission system, for example at Heysham or Stanah, then the reinforcement costs will be as detailed in section 2.5, above.

In addition, if the offshore wind generation in the Northwest connects further north from Stanah/Heysham then the extent of the reinforcement increases.

This reinforcement is consistent with that identified for stage 2 of the RETS report. Therefore this reinforcement would have the added advantage of facilitating a greater level of renewable generation in Scotland.

Schedule of Reinforcement (National Grid Transco transmission system only)	Cost estimate (£m)
Upper Northwest Reinforcements	320
Total for offshore wind + increased flows from Scotland (from section 2.5)	805
Total for offshore wind + increased flows from Scotland + Upper Northwest Reinforcements	1125

4.7 Work Programme And Timescales

All of the reinforcements proposed involve substantial programmes of work. Detailed preparatory work would be required and it is estimated that this would require approximately two years. It is estimated that the construction of the reinforced system would take between five and ten years.

4.8 Cost Benefit Analysis

The reinforcement options discussed in this paper were arrived at on the basis of the connected generation capacity that would be required to meet the Government targets. The output of individual generators, however, varies over time and only provides its theoretical maximum for a portion of time. The output from wind generation in particular is likely to correspond to the maximum output for only a short time in any one year. Therefore an assessment was undertaken to estimate the level of system constraints that might result if the generators were connected without the requisite reinforcements. This assessment was achieved by studying 4900MW of offshore wind against a network reinforced to allow for the increased flows from Scotland.

No cost benefit work was conducted on the reinforcements to allow for increased flows from Scotland as this has been covered in the RETS report conducted by SP, SSE and NG.

Table 1 lays out the level of constraints calculated and the net benefit of the reinforcements, based on a constrained generation cost of £25/MWh. The Net Benefit in this case is determined from the value of the constraint saving over a 40-year asset life minus the cost of the reinforcement.

Table 1: Constraints and Net Benefit of Reinforcements (£m)

Annual Constraint Volume (TWh)	Capitalised Lifetime Constraint Cost (£m)	Transmission System reinforcement Costs (£m)	Net Benefit (£m)
1.6	585	285	300

The analysis concludes that the reinforcements have a positive net benefit, i.e. that over their lifetime they are expected to save in constraint savings more than they cost to build. The analysis undertaken has demonstrated that by reinforcing to meet a large volume of offshore wind capacity, a robust transmission system will be maintained.

These figures do not include constraint costs associated with construction outages. Transmission system developments are planned to be constructed in advance of the commissioning of new generation projects. If planned developments are not in place prior to the generation being connected then the level of constraints on the system would be increased further, i.e. the additional capacity would be required at a time when there are prolonged construction outages on the system.

5. Conclusion

The studies undertaken have indicated that the proposed GB network reinforcements will accommodate an increase in renewable generation of up to 2000MW in Scotland and 6000MW in England and Wales. This will cost in the region of £350m in Scotland and £455m-£775m in England. The costs are summarised in the table below.

Table 2: Costs (£m)

	Costs for wind in Scotland	Offshore Wind Reinforcement Costs	Additional costs at connection point	Additional Costs for Northwest uprating
SSE	£190m	--	--	--
SP	£160m	--	--	--
NG	£170m	+£205m	+£80m	+£320m
Total	£520m	£725m	£805m	£1125m

The analysis undertaken indicates that the reinforcement suggested for connecting the renewable generation is more cost-effective than constraining the generation.

These studies have identified a co-ordinated strategy to facilitate the development of a transmission system capable of accommodating 2000MW of new renewable generation in Scotland and 6000MW in England and Wales by 2010.

It is important that this study be considered alongside the Renewable Energy Transmission Study, which considered an alternate scenario of 6000MW of renewable generation in Scotland and 2000MW in England and Wales.

6. Appendices

4.1 Appendix 1: Derivation Of Renewable Levels

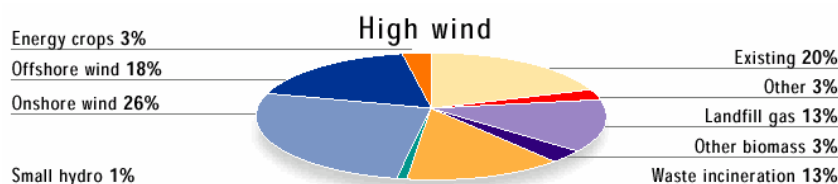
5) *Electricity Demand*

The Digest of U.K. Energy Statistics gives 372.9TWh for annual electricity requirements in the U.K. in 2000. Applying National Grid's 2002 SYS forecast of underlying annual demand gives 432.8TWh for U.K. annual requirements in 2010. From this, 10% of U.K. electricity demand in 2010 is 43.3TWh, which is to come from renewable generation.

From National Grid's 2002 SYS assumptions, the underlying ACS restricted peak demand in England and Wales will increase from 58.2GW in 2000 to 67.9GW in 2010.

6) *Renewable Generation in 2010*

In 2000 the DTI published the document: "New and Renewable Energy: Prospects for the 21st Century". This document outlined 3 scenarios for renewable generation in 2010, of which the "high wind" scenario is believed to be the most realistic.



The DTI's high wind scenario shows 44% of renewable electricity generated from wind power, i.e. some 19.0TWh. A second scenario has been examined, whereby the predicted 13% of renewable electricity contribution from waste incineration comes instead from wind power. This modified high wind scenario would increase the percentage of the U.K.'s 10% renewable electricity target to come from wind power to 57%, equivalent to 24.7TWh.

7) *Scotland/England & Wales Wind Generation Split*

Two scenarios have been developed for the geographical distribution of wind generation. One scenario, resource based distribution, is based on BWEA estimates of suitable exploitable land areas for wind generation (extrapolated to include offshore wind). The other scenario, constrained distribution, is based on BWEA estimates which take into account the constraints of the distribution networks.

The resource based scenario leads to Scotland accommodating 63% of the U.K.'s new wind generation (28% in England and Wales), while the constrained scenario leads to 28% of the U.K.'s new wind generation in Scotland (67% in England and Wales).

8) *Other Renewables*

The DTI's high wind scenario and the modified high wind scenario lead to 36% and 23% of new renewable generation to come from "other renewables" (excluding existing sources). The distribution of this generation has been allocated assuming that 2% is in Northern Ireland (the same as in 2000), and that in Scotland 90% of new renewable energy comes from wind.

Assuming 30% load factor for wind generation and 75% for other renewable generation, the table overleaf shows the 4 scenarios.

2010 Renewable Generation Scenarios		Wind		Other Renewables	
		Scotland	England & Wales	Scotland	England & Wales
DTI's "High Wind" Scenario	Constrained	2.0GW	4.8GW	0.1GW	2.2GW
	Resource Based	4.5GW	2.0GW	0.2GW	2.1GW
Modified "High Wind" Scenario	Constrained	2.6GW	6.3GW	0.1GW	1.5GW
	Resource Based	5.9GW	2.6GW	0.3GW	1.2GW

NB - these figures are IN ADDITION TO all existing renewable generation in 2000.

4.2 Appendix 2: Assumptions

Demand

- 1) GB transmission network demand growth assumed to be 0.8% per annum until 2010, giving a total increase in the U.K. maximum demand from 64GW in 2000 to 69GW in 2010. This recognises the potential for improved efficiency savings.

NG demand rises from 52GW in 2000 to 57GW by 2010.

Generation Background

- 8) The GB generation background has been derived from the same background that was used by the TO/MO workstream established by Ofgem in 2001 to assess some of the impacts of BETTA. Assumed plant closures include all Magnox power stations.

Diversity Figures for Renewables

- 9) The intermittent and dispersed nature of wind power presents some difficulty in determining the appropriate level of transmission system capacity. For the purposes of assessing transmission capacity at winter peak demand, it is considered that a diversity of 83% should be applied to renewable generation. This takes account of plant availability and diversity and is in accordance with the methodology specified in the Companies Planning and Security Standards.

Planning Standards

- 10) Application of National Grid's licensed transmission Planning Standards.

