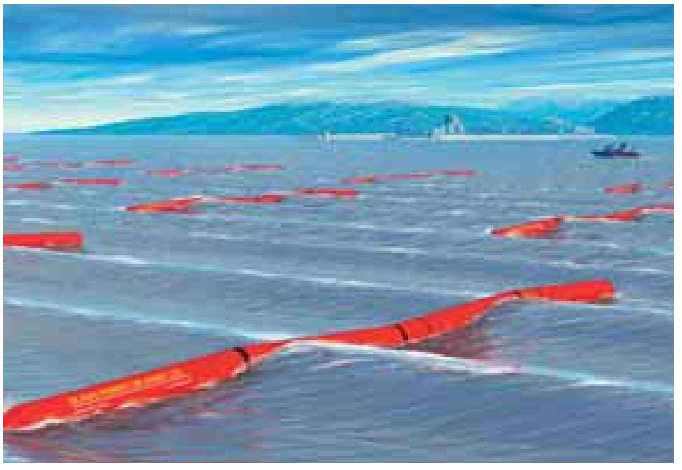
SINCLAIR KNIGHT MERZ
SKM

Scottish Government

Pre-Scoping Study to Determine Grid Requirements to Connect Renewable Energy off the Coasts of Northern Europe



FINAL REPORT

- Version 2.0
- July 2008

Scottish Government

Pre-Scoping Study to Determine Grid Requirements to Connect Renewable Energy off the Coasts of Northern Europe

- Version 2.0 (FINAL REPORT)
- July 2008

Sinclair Knight Merz
Alberton House
St Mary's Parsonage
Manchester M3 2WJ
United Kingdom
Tel: +44 161 833 4883
Fax: +44 161 833 4761
Web: www.skmconsulting.com

COPYRIGHT: The concepts and information contained in this document are the property of Sinclair Knight Merz (Europe) Limited. Use or copying of this document in whole or in part without the written permission of Sinclair Knight Merz constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of Sinclair Knight Merz (Europe) Limited's Client, and is subject to and issued in connection with the provisions of the agreement between Sinclair Knight Merz and its Client. Sinclair Knight Merz accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

The SKM logo trade mark is a registered trade mark of Sinclair Knight Merz Pty Ltd.

SKM

Contents

SKM

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
1.0	06/05/2008	P. Espie	G. Clarke	06/05/2008	Draft Report
2.0	17/07/2008	P. Espie	G. Clarke	17/07/2008	Final Report

Distribution of copies

Revision	Copy no	Quantity	Issued to
1.0	Electronic	N/A	James Simpson
2.0	Electronic	N/A	James Simpson
	Paper	2	Sue Kearns

Printed:	18 August 2008
Author:	Jocelyn Wessling / Geoff Clarke
Project manager:	Paul Espie
Name of organisation:	Scottish Government
Name of project:	Grid Requirements to Connect Renewable Energy off the Coasts of Northern Europe
Name of document:	Draft Report
Document version:	Version 1.0
Project number:	UP00468

1. Introduction

The Scottish Government is interested in finding ways to share the benefits of the essentially unlimited offshore wind and marine renewable generation resources in the North Sea which is bounded by the north and east coasts of Scotland, the west coasts of Norway, Denmark and the Netherlands, and the north coast of Germany. The south-west coast of Sweden, although not bounded by the North Sea, has direct access to it through the Skagerrak[1]. Figure 1 shows a map of the economic development zones within these countries as far as the exploitation of offshore energy resources is concerned. One of the key factors for the shared exploitation of these renewable resources will be whether there is an economic case to generate and transmit a shared renewable electricity resource to the energy markets in each of these six countries.

Figure 1: North Sea offshore economic development zones

Under EU legislation each of the member states has an obligation to increase renewable generation to meet specific targets set to mitigate climate change. Norway, although not a member of the EU,

[1] The Skagerrak strait runs between the south coast of Norway, the southwest coast of Sweden and the Jutland peninsula of Denmark. It connects the North Sea and the Kattegat strait, which leads to the Baltic Sea.

has a similar objective. Norway aims to reduce its greenhouse emissions by 30 percent by 2020[2] over its 1990 level of emissions.

The North Sea renewable energy resources have the potential to contribute significantly to the targets to be met by each country. The objective of this report is to define the scope of a study that will examine the technical, economic, social and financial feasibility of the development of an offshore transmission network or grid to encourage electricity generation from the renewable resources in the North Sea, including wave and tidal energy and deep water offshore wind.

The output of this project will assist the Scottish Government in preparing a submission for funding to the European Commission with the aim of eventually calling for competitive tenders from suitably qualified parties to undertake the study.

[2] Source, "Norway – the official site in the UK", www.norway.org.uk

2. The Concept

The basic concepts of an offshore grid in the North Sea are:

1) The long term strategic development of a shared offshore generation (wind and marine) resource by Scotland, Norway, Sweden, Denmark, Germany and the Netherlands, the prospective “Participants” in the North Sea Study Zone. The sharing of a major renewable energy resource between the Participants will deliver a significant proportion of each country’s energy requirements and will add to the overall security of Northern Europe’s energy supply by reducing reliance on gas imports.
2) The offshore grid will provide opportunities for energy trading at times of reduced offshore generation in some Participants and at times when there is diversity between onshore generation and demand (i.e. through use of the offshore grid for wheeling power between Participants).
3) The offshore grid will also present opportunities for Participants with significant onshore renewable energy resources to become a net exporter under certain scenarios.
4) The offshore grid will provide economies of scale both during installation, and then later in relation to operation and maintenance activities.

3. Study Objectives

This document proposes the terms of reference for a study to examine the feasibility of the strategic long-term development of the renewable energy resources in the North Sea. It is envisaged that the Study would be jointly sponsored by as many regions in the Study Zone as possible, with each taking its own particular interests into account. The sharing of a major renewable energy resource through the offshore grid has the potential to deliver a significant portion of the renewable energy requirements of each Participant in the project and it will also add to the overall security of energy supplies in Northern Europe by reducing reliance on gas imports.

The specific aim of the Study will be to examine the feasibility of constructing an offshore grid to link the transmission systems of the Study Zone Participants with each other and with the offshore renewable generation, thereby connecting the offshore renewable generation to new onshore markets. An offshore grid will also provide opportunities for energy trading and wheeling power between Participant markets when some Participants are experiencing reduced offshore generation and at times when there is diversity between onshore generation and demand.

The output of the Study will be a cost/benefit assessment of renewable offshore generation delivered to onshore markets, as well as a qualitative and quantitative assessment of a raft of additional benefits to be gained from increased interconnection between the Study Zone Participants.

4. Study Terms of Reference

The proposed Terms of Reference of the Study are set out below.

4.1 Onshore Electricity Sectors

In order to place the study analysis and results in context it is necessary to understand the changes that have and continue to be experienced in the electrical generation portfolios of the Participants, plus the drivers for future change. Such drivers include both national and EU current policies and incentives to reduce carbon emissions and exploit renewable generation, plus likely developments and revisions of these mechanisms in the future. A high level summary should be provided of the electricity sector of each of the Participants, including:

a) A review of conventional and renewable onshore and offshore energy resources, with accompanying relevant information including installed, committed and planned capacities plus annual production forecasts and planned plant retirements.

b) Demand forecasts including load duration profiles.

c) Identification of current energy policy and targets and forecasts of long term energy costs, including estimates of the costs of the support mechanisms for renewable generation.

d) An assessment of the long term generation adequacy and the likelihood of achieving national and EU renewable energy targets.

4.2 Onshore Electricity Grids

The offshore grid developed to collect the electrical energy produced by renewable generation in the North Sea must be connected to the onshore grid system in each Participant region. The location of the connection points (i.e. the onshore substations) will not only determine the costs associated with the offshore grid infrastructure, but will also dictate the grid reinforcements required within the onshore grids to transmit and distribute the captured renewable energy generation to the load centres. Consequently, it will be necessary to establish the capabilities of the existing onshore grids of each Participant to accept offshore renewable generation from the North Sea. The review should include:

a) Basic information on each of the existing onshore grids. This will include connection opportunities at coastal and inland sites and identification of the headroom available for the entry of offshore generation in areas that are currently under consideration by the Transmission System Operator (TSO) for that very purpose.

b) Identification of existing bottlenecks in the onshore grids and of any planning, construction, legal or other constraints associated with their removal. Any bottlenecks will affect the ability of the grids to accept offshore generation, influence the choice of connection point to the onshore grid and may reduce the benefits that an offshore grid might deliver.

4.3 Offshore Energy Requirements

The energy sector policies and targets reviewed in Section 4.1 also include a review of energy usage for transportation and heating. While these energy sectors are expected to achieve significant reductions in carbon emissions in the coming years, in order to achieve desired carbon emission targets the electricity generation sector will also have to make a significant contribution. Within the electricity generation sector, offshore generation technologies will be critical in achieving the desired reductions in carbon emissions in many of the regions of Northern Europe. It is essential therefore to determine the amount of offshore renewable generation that each Participant in the study is likely to require to meet its national and EU targets. It is suggested that consideration is given to:

a) The total energy (TWh) that each Participant in the study requires from offshore renewable generation, taking into account their long term renewable energy targets and policies.

b) The cumulative energy (TWh) from offshore renewable generation required across all of the Study Zone Participants.

c) The installed capacity (GW) of offshore renewable generation required to meet the energy requirement of each Participant, plus the cumulative total energy required across all Participants. This should take into account the Capacity Factor of offshore wind generation and the contribution that other marine technologies can make.

4.4 Location of Offshore Renewable Generation Resources

The location of the offshore generation resources is important as it will impact directly on the cost of developing and exploiting the renewable resource. This will in turn impact on the commercial development of the renewable generation and on the outturn increment in installed renewable generation capacity in each of the Participants in the Study Zone. It will also have an impact on the onshore grid infrastructure in each Study Zone Participant, which may require reinforcement or upgrading in order to carry the imported energy from the onshore connection point to the load centres. The cost of onshore grid reinforcement may be substantial. It is therefore essential that the study establishes where the cumulative offshore generation required by each Participant should be located, taking into account the following:

a) The Marine Energy Resource maps produced by the Participants[3] should identify the least cost locations for unexploited offshore renewable generation. These generally follow areas of high power intensity (W/m^2) and relatively shallow water depth.

b) For offshore wind generation the total area (km^2) required to generate the power (GW) to meet the cumulative energy requirement (TWh) of the Participants needs to be determined.

---

[3] For example: The DTI Atlas of UK Marine Renewable Energy Resources

c) The total area (km^2) identified above needs to be apportioned according to each Participant's energy requirements and a suitable location established for development of the resources taking due consideration of territorial boundaries within the Study Zone.

4.5 Conceptual Design

Having identified those areas of the North Sea that should prove most attractive for the Participants to develop, consideration must also be given to a conceptual design for the offshore grid. There are a variety of options that could be pursued, each providing different levels of interconnection and redundancy as well as other benefits and costs such as access to alternative markets, sharing of generation reserve etc. Therefore, a high level design should be developed for an offshore grid that interconnects the collector substations for renewable generation in the Study Zone and associated international boundaries, with the respective onshore grid systems.

The conceptual design should take account of the following:

a) The security of supply philosophy that takes account of the intermittency of the offshore generation resource, equipment fault rates and the weather limitations associated with maintaining offshore facilities.

b) Potential limitations on renewable generator array ratings including typical string switchgear and cable rating limitations, and collector substation limitations.

c) The number of collector substations and their ratings required to meet the power generation requirements (GW) and the cumulative energy requirement (TWh) of each Participant.

d) The offshore collector substation interconnection topology (e.g. ring, star or hybrid), the offshore connection technology (HVAC and/or HVDC), the number of circuits and the operating voltages and currents.

e) The subsea connections from the offshore collector substations to the onshore substations at landfall in each Participant of the Study Zone, taking into account the previously determined offshore renewable capacity (GW) requirements. The design should identify the technology, voltage and current ratings of cables and the number of circuits required.

f) The onshore connection should include specification of the technology and the connection voltage to the existing infrastructure. Consideration should be given to deep onshore connection works that might be required if there is congestion at coastal sites with recommendations made regarding further studies on onshore grid issues that might be required.

4.6 Capital and Operating Costs

The capital and operating costs associated with the offshore renewable generation and the costs associated with the onshore and offshore grids, have major implications for the future commercial development of North Sea sites and generation technologies. This will subsequently impact on the take-up of the offshore renewable schemes and the outturn incremental generation capacity that is likely to be achieved across the Study Zone Participants. The study should therefore determine the capital and operating costs of the complete integrated offshore grid system to provide the costs of capacity and loss-adjusted energy delivered to shore (€/MW and €/MWh), taking due account of the following:

a) Capital costs including renewable generation, array string cable connections, offshore collector substations, offshore substation cable interconnections, offshore to onshore subsea and underground interconnectors and onshore substations.
b) The cost of construction, operation and maintenance (including equipment spares, manpower requirements, handling equipment, vessels, etc) and the allocation of these costs between the Study Zone Participants[4].

4.7 Additional Benefits

The offshore interconnected grid system is expected to deliver a number of additional benefits to Scotland and the other Study Zone Participants and it is important that these are identified and quantified in the study. To achieve this account should be taken of the following:

a) The particular benefits associated with the nature of the offshore renewable resources, including higher capacity factors for offshore generation, as well as the predictability of offshore resources and their ability to add to national energy resources and potentially reduce reliance on gas imports.
b) Reduced institutional barriers (such as gaining planning permissions, public antipathy etc) to achieving renewable energy targets compared to onshore renewable resources.
c) The potential benefits for generation scheduling[5] of conventional and hydropower plants, including the diversity between the offshore and onshore renewable generation as well as the demand diversity between Participants and across time zones.
d) Existing onshore network constraints which might be alleviated by greater interconnection between the Study Zone Participants. Any such benefits should be quantified in terms of the avoided onshore transmission infrastructure costs, taking due account of costs and delays that might be associated with achieving planning permission for such onshore infrastructure.

---

[4] In determining an appropriate cost allocation philosophy it is expected that the costs would be funded by commercial rather than public organisations in each of the Study Zone Participants.

[5] Generation scheduling of conventional and hydropower plants is concerned with ensuring that sufficient reserve and back-up capacity is available to manage short-term and longer term variations in conventional and renewable plant power outputs.

SKM

e) The transmission infrastructure needed for collection of the output from onshore or near offshore generation, for example in the north of Scotland, that would otherwise be largely prevented from entry into the market due to onshore transmission constraints.

f) The potential effect of increased offshore interconnection on energy costs in each of the Participants in the Study Zone.

g) The potential for local manufacturing, and service industries involved in the offshore wind and marine energy projects to develop cutting edge skills based on new and developing technologies. The benefits to employment prospects in areas where traditional shipbuilding and fisheries industries are in decline shall be considered, as well as any other macro/overall economic benefits to the Participants.

4.8 Implementation

Given the complexity and number of Participants that could be involved in the project, it is important that the key development aspects are identified, adequately scoped and arranged to facilitate the successful delivery of the "phased implementation" of an offshore grid. This should be presented in the form of a detailed project delivery programme (Gantt Chart). The programme should take into account the time and resources required to undertake the following key aspects of the project as a minimum requirement:

a) Front End Engineering Design (FEED) of the integrated offshore grid.

b) Setting up an "Authority"[6] to oversee and coordinate the implementation of the offshore grid.

c) Procurement strategy including identification of tender packages.

d) Delivery times for the principal components taking into account manufacturing capacities and supply chain constraints.

e) Installation of the principal components taking into account the availability of suitable handling equipment, vessel logistics and the limited weather window for North Sea operations.

From the programme for the phased implementation of the project the incidence of capital expenditure should be developed.

It is recommended that a body be set up to oversee the progress made on the project (see comment on an "Authority" above), compliance with the budget and to coordinate the implementation of the offshore grid by the various parties. It should also be responsible for ensuring the grid is designed and constructed to international standards that are consistent with those adopted by the

[6] Although it is envisaged that the offshore grid system would be a commercial rather than public development, given the cross-border nature of the project it will be necessary for an "Authority" to be established, comprised of representatives from the Participants involved.

transmission system operators in each of the Study Zone Participants to be interconnected through the offshore grid.

4.9 Financing and Regulation of an Offshore Grid System

The unparalleled nature of an offshore grid system interconnecting a number of regions goes significantly further than existing offshore interconnection schemes. The scale of the capital required to finance the project will be significant, but could come from a variety of alternative sources with additional support and funding also likely to be available from the EU. Additionally, the development, implementation and operation of an offshore grid system is not fully catered for under the existing regulatory structures of the Study Zone Participants. The study should therefore identify the possible means of financing and regulating an offshore grid system, including consideration of the following:

a) Private, state and EU funding or a combination of these. Consideration should be given as to what market or other mechanisms might be used to secure the funding, with reference to the existing regulatory and financing systems in each country and their compatibility, and the opportunities and barriers thus presented.

b) The means for securing the development of the generation should also be considered. The Participants currently have different regulatory structures and support schemes for renewable generation. It will be necessary to give consideration as to what sort of mechanism might apply to funding offshore generation in the North Sea and how this would be regulated in the future. Options will include setting up a special joint mechanism, or applying existing schemes on the basis of location within a particular exclusive economic zone.

c) Factors such as asset lifetimes and appropriate rates of return for the different financing options.

d) Allocation of costs (including risks such as stranded or under-utilised assets) and benefits between stakeholders, including developers, grid companies, governments, consumers and others as appropriate. Allocation of costs and benefits may be related to capacity or usage (through production and consumption) and interaction with current market arrangements. The extent that the allocation of costs and benefits will be market driven must also be considered.

4.10 Costs and Benefits of an Offshore Grid System

As a final step the study should summarise the costs and benefits that an offshore grid in the North Sea could be expected to provide to Scotland and the other Participants. This will include those costs and benefits identified previously plus any additional factors that could potentially be a cost or benefit that may have not already been identified.

5. Full Study Outputs

The principal outputs of the Study will be:

a) The Inception Report, clearly detailing the proposed project management of the Study, confirming periods and timescales for reporting, deliverable submission dates, estimated invoicing and billing dates.

b) The Interim Report, required mid-way through the project, specifying in detail the methodology for the Study, initial findings to date, overall progress against schedule.

c) The Draft Report, which should contain all of the outputs outlined in Section 4 as well as preliminary recommendations for taking the project forward.

d) The Final Report, as per the Draft Report, but addressing comments and additional work areas not fully covered in the Draft Report.

The above reports will be complemented with:

i. Regular progress reports, detailing project progress since the previous report including any milestones reached and details of any conclusions reached, issues identified or areas of concern.

ii. Maps for each scenario/grid option combination with the main resource areas and grid components shown.

iii. A Single line diagram for each offshore grid option.

iv. Cost breakdowns, clearly identifying all assumptions.

v. Details of any system, financial, economic or other models used to produce the results in the Final Report.

vi. Presentation to stakeholders of the key findings and recommendations of the study.

The draft and final reports should include recommendations for the next stage in the exploitation of North Sea renewable resources as well as suggestions for further detailed studies that may be necessary to quantify any aspects not fully examined through the study.

6. Full Study Costs and Timescale

The proposed Terms of Reference for the Study as outlined in Section 4 have been given due consideration and an estimate made of the likely cost of the individual components and the timescales for their completion. The cost estimates are based on a daily rate of £800 / day, a typical average engineering consultancy rate at this time for the different grades of staff likely to be employed on the project, although depending on experience, skills and staff resourcing, potential bidders could submit tenders with daily rates up to 25% higher than this. It is also worth noting that submitted quotations well below the estimated total cost would seem to have grossly underestimated the magnitude and complexity of the work. The cost estimate has included an estimated cost for project expenses, although the final cost for this will be influenced by the number and duration of project meetings, including those overseas.

In the assessment of study costs it is important to note that the costs will be dependent on the number of participants. If all potential project partners in the Study Zone (i.e. Norway, Sweden, Denmark, Germany and the Netherlands) agree to participate in the Offshore Grid study there will be six Participants, including Scotland. Clearly the extent of work involved in establishing data/information on the respective onshore grids, the legislation, opportunities/barriers etc for each Participant will be a substantial piece of work that would involve an element of overseas travel for meetings and fact finding purposes. The size of the proposed grid will also be dependent on how many Study Zone Participants are involved. In the most basic scenario, only Scotland and one other Participant would be involved and the size of the grid, and the work involved in the study and in undertaking preliminary design would be considerably less than if all six Study Zone Participants are involved.

Table 1 summarises the cost and timescales required to undertake the individual tasks and the sub-tasks which have to be addressed in the course of the study. A detailed commentary is provided in the following sub-sections.

Tasks	Description	Man-Days	Rate	Total
4.1	**Onshore Electricity Sectors**			
	Visits to Study Zone Participants	15	£800	£12,000
	Review conventional and renewable onshore & offshore energy resources	12	£800	£9,600
	Compilation of capacity, production forecasts and retirement data	18	£800	£14,400
	Demand forecasts and load duration profiles	9	£800	£7,200
	Identification of current energy policy and targets	12	£800	£9,600
	Forecasts of long-term energy costs	6	£800	£4,800
	Long term generation adequacy assessment	6	£800	£4,800
	Assessment of probability of meeting National and EU renewable targets	6	£800	£4,800
		84	-	£67,200
4.2	**Onshore Electricity Grids**			
	Compilation of information and data on existing onshore grids	6	£800	£4,800
	Identification of connection opportunities at coastal and inland sites	12	£800	£9,600
	Determination of headroom available for entry of offshore generation	6	£800	£4,800
	Identification of existing bottlenecks in grids	12	£800	£9,600
	Identification of constraints associated with removal of bottlenecks	12	£800	£9,600
	Summary of impact of constraints in participating states	12	£800	£9,600
		60	-	£48,000
4.3	**Participating State's Offshore Energy Requirements**			
	Determine total offshore renewable energy for each state to meet EU target	6	£800	£4,800
	Determine cumulative energy from offshore renewable in each state	6	£800	£4,800
	Determine energy contribution from other marine technologies	6	£800	£4,800
	Determine offshore renewable capacity to meet cumulative energy requirements	6	£800	£4,800
		24	-	£19,200
4.4	**Location of Offshore Renewable Generation Resources**			
	Identify least cost locations of unexploited offshore renewable generation	12	£800	£9,600
	Calculate total area to generate the power for cumulative energy requirements	6	£800	£4,800
	Apportion total area according to participating state's energy requirements	9	£800	£7,200
	Establish suitable locations for development in each state's boundaries	3	£800	£2,400
		30	-	£24,000
4.5	**Conceptual Design to Develop High-Level Design of Offshore Grid System**			
	Overview of effects of security, intermittency, faults, weather etc on design	12	£800	£9,600
	Identify limitations on array / switchgear / cable ratings and collector subs	6	£800	£4,800
	Calculate no. and rating of collector subs to meet power & energy requirements	6	£800	£4,800
	Identify offshore grid topology, type (AC / DC), voltage, no. of circuits, etc	12	£800	£9,600
	Propose subsea connections from collector subs to each participating state	6	£800	£4,800
	Propose onshore connection, incl. technology, voltage, onshore grid works	18	£800	£14,400
	Recommendations for further studies on onshore grid issues if required	3	£800	£2,400
		63	-	£50,400
4.6	**Determine Capital and Operating Costs of Complete Integrated Offshore Grid System**			
	Assess capital costs of offshore grid, renewable generation, and onshore works	12	£800	£9,600
	Estimate shared cost of construction, and operation and maintenance costs	6	£800	£4,800
	Estimate shared operation costs of manning, spares, handling equipment, vessels	6	£800	£4,800
	Determine the cost of capacity and loss-adjusted energy delivered to shore	6	£800	£4,800
		30	-	£24,000
4.7	**Additional Benefits obtained from the Offshore Grid**			
	Determine benefits of higher capacity factor, added energy resources, etc	6	£800	£4,800
	Identify benefits of reduced institutional barriers to achieving energy targets	6	£800	£4,800
	Identify benefits for offshore gen. scheduling & demand diversity across regions	6	£800	£4,800
	Impact of interconnection in reducing generation and transmission capacity	3	£800	£2,400
	Quantify benefits from removal of onshore constraints (infrastructure, delays, etc)	6	£800	£4,800
	Identify grid infrastructure needed to allow constrained generation to be connected	24	£800	£19,200
	Determine effect of offshore interconnection on energy costs in each state	6	£800	£4,800
	Identify potential skill transfers from projects & other economic benefits to states	3	£800	£2,400
		60	-	£48,000

Tasks	Description	Man-Days	Rate	Total
4.8	**Implementation**			
	Estimation of key FEED developments, procurement, manufacturing, installation	12	£800	£9,600
	Production of Gantt chart reflecting above, plus phasing of Capex requirements	3	£800	£2,400
		15	-	£12,000
4.9	**Financing and Regulating an Offshore Grid System**			
	Review of regulatory regimes, incl. cross compatibility and impact on financing	20	£800	£16,000
	Identify sources of possible finance, means to secure, plus opportunities & barriers	12	£800	£9,600
	Consider sources of funding offshore generation plus mechanisms that may apply	3	£800	£2,400
	Identify factors influencing financing options (asset lifetimes, rate of return, etc)	6	£800	£4,800
	Allocation of cost / risk / benefits across stakeholders & market driven influences	6	£800	£4,800
		47	-	£37,600
4.10	**Costs and Benefits of an Offshore Grid Interconnection System**			
	Summary of costs & benefits for participating states and other relevant factors	12	£800	£9,600
		12	-	£9,600
5.0	**Deliverables**			
	Project management and reporting (i.e. progress, interim, draft and final reports)	45	£800	£36,000
	Sundry reporting (i.e. maps, SLDs, cost breakdowns, modelling details)	15	£800	£12,000
	Presentation of project outcomes to stakeholders (i.e. preparation, logistics, etc)	8	£800	£6,400
	Recommendations for exploitation of North Sea resources and further work areas	6	£800	£4,800
		74	-	£59,200
	Estimated Project Expenses*	-	-	£10,000
	GRAND TOTAL	499	-	£409,200
	* This is for direct project related expenses (i.e. air travel, hotel accommodation, financial and logistical data including maps and other resources required directly for the project).			

Table 1: Estimated Task Resourcing and Costs

6.1 Review of Electricity Sectors, Grids and Energy Requirements

The three tasks summarised in Table 1 as items 4.1, 4.2 and 4.3 establish the present and future status of the electricity sectors, onshore grids and offshore energy requirements of the Study Zone Participants and the factors that are likely to influence their eventual participation in the project when it reaches the implementation stage.

To understand the changes that have been and are being experienced in the electrical generation portfolios of the Participants and identify the drivers for future change, a high-level review will be undertaken of the electricity sector in each country. This would be done initially through a visit to meet with stakeholder representatives and get an up to date assessment of the changes affecting the electricity sector. The visits would also provide the opportunity to obtain information on their respective energy policies, energy costs, the onshore grids, existing and planned onshore and offshore renewable generation, production forecasts, plant retirements, demand forecasts, load duration profiles and offshore energy requirements. The series of initial visits would likely take around two to three weeks to complete, depending on how many Participants are involved in the study.

The analysis of the data, information and stakeholder views would then be undertaken as a desktop exercise. The amount of data collected is likely to be extensive and proportionate to the number of Participants in the study. The visits to the Study Zone Participants plus the analysis of this initial data is expected to take around 34 man-weeks to complete.

6.2 Location of Offshore Renewables and Conceptual Grid Design

Tasks 4.4 and 4.5 of Table 1 examine in some detail the existing renewable energy resources in the North Sea and the scope for further development. The analysis will be undertaken as a desktop study reviewing existing marine energy resource maps to establish areas suitable for development within the territorial boundaries of each Participant. From the offshore energy requirements established under item 4.3 an estimate of the area required to meet those requirements will be determined for each Participant and a suitable location identified.

The provisional findings will be discussed with stakeholders before agreement is reached on the most suitable locations for developing offshore energy resources. The work to establish the locations should take around six man-weeks to complete.

With the locations for the generation established, the work to establish the conceptual design of the offshore grid will commence. This is detailed work and will require up to 13 man-weeks to complete.

6.3 Estimation of Offshore Grid Costs and Associated Benefits

Task 4.6 in Table 1 requires an estimate to be made of the total capital and operating cost of the offshore grid. To establish this, typical costs for onshore and offshore power equipment and construction materials will be used, based on current market prices. This will require some effort to review the market and establish the latest unit costs. Discussions with stakeholders will provide cost information to support the unit cost data used in the estimates. Detailed schedules of equipment will be produced and the costs estimated. Installation costs, including the cost of vessels etc will be obtained and typical operation and maintenance charges estimated.

From the basic capital and operating expenditure estimates the shared costs between the participants will be determined. The costs of capacity and of loss-adjusted energy delivered to shore will be estimated.

The work on capital and operating costs will be undertaken as a desktop study and is expected to take up to 6 man-weeks to complete.

The additional benefits to be obtained from the offshore grid that are identified in Task 4.7 of Table 1 are expected to take a number of forms and the value of these will be estimated. The estimation will be undertaken as a desktop study and take up to 12 man-weeks to complete.

6.4 Implementation, Financing and Regulation of the Offshore Grid

A detailed assessment will be made of the key factors affecting the Front End Engineering Design, and other important issues such as procurement strategy, manufacturing and installation timescales. A provisional programme for the project presented in a Gantt Chart will be produced for review by the individual stakeholders.

The review of the finance available, the means of securing it and how the costs and benefits should be shared by the participants will require some discussion with the stakeholders, government agencies and financial institutions. Similarly, the impact of the current regulatory regimes and proposed future structures, in terms of encouraging or hindering the development, implementation and operation of an offshore grid system will likewise require discussion with similar interested parties.

The work on tasks 4.8, 4.9 and 4.10 of Table 1 is estimated to take up to 15 man-weeks to complete.

6.5 Reporting and Presentations

The deliverables from the study are an inception report, interim report, draft report and then a final report, with a presentation to the stakeholders at the end of the study. This final presentation would be expected to take place in a mutually convenient location for all Participants involved and would see the findings of the study presented as well as recommendations for further work areas, if this is considered necessary. The various reports will be developed as the study proceeds, with regular progress plus inception and interim reports produced for comment without introducing any delays in the work whilst stakeholder comments are produced.

Given the duration of the project plus the number of reports and other information produced as well as the final presentation to project partners and stakeholders, it is expected that this task would require up to 15 man-weeks to complete in total, although obviously this would be spread throughout the entire project duration.

6.6 Comment on Project Costs and Timescales

The total length of time estimated to complete the project with the proposed scope of work, and involving all six potential Participants, is around 499 man-days, with an estimated total project cost of £409,200. While it is expected that there will be some degree of overlap across the considered tasks, it is not expected that the overall project completion time will be radically shorter, a total project time of around 22 months is considered likely if six Participants are involved.

If the number of final project Participants is lower than six then obviously the length of time and associated cost for the project would decrease. That said, there is a large proportion of the work that would be essentially the same, albeit slightly less involved, with fewer Participants. Thus, the total project cost and required project duration is not linear in relation to the number of Participants. We would expect that if there were four Participants the project cost would drop around 20%, and if only two Participants (i.e. Scotland and one other) then the total cost would drop around 40%. In both cases there would be a concomitant reduction in the man-effort required for the project. For these two cases the total project cost and man-power requirements would reduce to around £327,000 and 400 man-days (around 18 months project duration) for four Participants or to around £246,000 and 300 man-days (around 14 months project duration) if there are only two Participants.