aquatera.co.uk
environmental services and products

Strategic Renewable Energy Resource Assessment for the Highland Area

Report to

The Highland Council

by

Aquatera Ltd

in collaboration with NorthStar New Media and The Macaulay Institute

P091 RERA Report – Rev 3
October 2005

Aquatera Ltd
Stromness Business Centre
Stromness, Orkney, Scotland
KW16 3AW

This study was completed for:

The Highland Council
Renewable Energy Working Group
Glenurquhart Road
INVERNESS
IV3 5NX

Contact: Mike Greaves, Head of Development & Strategy
Tel: 01463 702260
Mobile: 07971 667494
Fax: 01463 702298
Email: mike.greaves@highland.gov.uk

This study was completed by:

Aquatera Ltd
Stromness Business Centre
Stromness
Orkney
KW16 3AW

Contact: Dr Gareth Davies, Managing Director
Tel: 01856 850 088
Fax: 01856 850 089
Email: office@aquatera.co.uk

Revision record
Revision number is indicated on the footer of every page.

Revision Number	Issue Date	Revision Details
Rev 2	Sept 2005	Draft for Committee consultation
Rev 3	Oct 2005	Draft for Public consultation

Contents

List of Figures

List of Tables

1 Introduction

This resource assessment of renewable energy resources throughout the Highland Area has been commissioned by The Highland Council and completed by Aquatera Ltd. The study was undertaken during 2004. This summary report supports a comprehensive database produced on CD ROM. The summary report collates the overall outputs for the various energy sources and provides details of the input parameters and sources of information used in the study.

The CD ROM provides copies of all of the input parameters used in the resource assessment models. It also provides the geographical outputs from the models and a mechanism for applying variable filter levels to these model outputs. In addition it contains a PDF version of this summary report.

2 Description of the Methodology

The core approach in this study is to create a database of input data which is geographically distributed at a 1 km grid resolution. Models have then been established that estimate power outputs and technical constraints. These models are related to each of the various individual renewable technologies. A set of variable input parameters for the models have also been defined. The models and parameters combined are then used to generate possible development scenarios under certain sets of assumptions. The outcomes from these scenarios enable the user to understand from an overall sense and at a local level the range of potential scenarios that can arise.

An example of the grid pattern used in this study is provided below. There are around 44,000 grid squares in the study area.

Figure 2.1 Map illustrating the data grid over Highland Region

Each of the grid squares in the study area has been allocated to a sub area and ward. These classifications are used to determine area specific resource and potential energy production levels.

2.1 Resource potential

The resource potential is considered to arise from the following renewable energy sources.

Table 2.1 Renewable resource categories

Renewable resource categories	
Onshore wind	*Turbines installed by land crane*
Offshore wind	*Turbines installed by vessels at sea*
Offshore wave	*Devices situated away from the coast, floating or on seabed*
Coastal wave	*Devices attached to the coastline*
Tidal current	*Energy from tidal streams*
Tidal head	*Opening up channels across land barriers*
Tidal barrage	*Damming of coastal embayment/firths*
Biomass	*From combustion of forestry products, crops, natural harvest*
Waste	*From incineration of garbage and other wastes with power generation and/or heat recovery*
Digestion	*Breakdown of organic materials to form methane*
Hydro	*Traditional hydro schemes incorporating water storage*
Civil infrastructure	*Energy fluxes associated with bridges, sea walls etc*
Utility infrastructure	*Energy potential from water mains, drains, electrical distribution and transmission systems*
Micro generation	*Systems designed for localised embedded generation*
Energy efficiency	*Passive reduction of energy demand, both domestic & industrial*
Research & development	*Sub commercial schemes that are undertaken to develop technologies*

With regard to tidal head schemes no suitable areas were identified and with regard to tidal barrage schemes the tidal range in the highlands is insufficient to deliver cost effective power production. These two energy sources were therefore not considered any further

2.2 Technical limits

A variety of factors affect the technical viability of exploiting the raw resource potential. Non-geographical factors include the efficiency of a given system at extracting the available energy. The geographically distributed factors are outlined below:

Table 2.2 Technical limits

Factor	***Limiting factor***
Land gradient	*Very steep land may inhibit onshore turbine construction*
Land height	*Elevated land will be subject to climatic conditions that can create operational difficulties*
Seabed gradient	*Steep/unstable seabed may preclude developments in an area*
Sea conditions	*Exposed sea areas and over falls may inhibit construction and maintenance activities*
Water depth	*Some technologies are constrained to shallow water*
Vegetation/habitat type	*Certain types of vegetation such as natural woodland, marshes, lochs etc will create severe operational difficulties for land operations*

2.3 Planning constraints (likelihood of obtaining a licence to operate)

The likelihood of getting planning approval is influenced by a set of factors associated with the acceptability of a possible development scenario. For example large wind turbines are unlikely to get approval near particularly scenic areas or particularly sensitive wildlife populations.

Factors that are considered to be possible constraints and the categories used to classify them are outlined below.

Table 2.3 Possible planning constraints applied in this study

Factor	*Category*	
Land		
Visibility	*Visibility from dwellings* *Visibility from view points* *Visibility from Munros and Corbetts* *Visibility from recreation and tourism centres* *Visibility from West Highland way*	
Designated landscapes	*Built conservation areas* *Listed buildings* *Areas of Great Landscape Value* *National Scenic Areas* *Designed landscapes*	
Wilderness value	*Distance from roads and tracks*	
Land use & character	*Montane* *Agricultural* *Water* *Urban* *Woodland*	*Upland* *Wetland* *Industrial* *Dunes*
Tourism	*Visitor sites and attractions* *Major – developed* *Moderate – no development* *Minor – occasional use*	
Recreation	*Outdoor pastimes (Walking, Shooting, Relaxation etc*	
Wildlife conservation	*International designations (RAMSAR sites, SAC, SPA)* *National designations (NNR, SSSI)* *Local designations (Local Nature Reserve, RSPB reserve, SWT reserve)* *Other* *Ancient woodland* *Semi natural woodland* *Tree preservation orders*	
Geological conservation	*Geological SSSI*	
Archaeology	*Scheduled ancient monuments* *Recognised sites* *Potential sites*	
Dwellings	*Number*	
Hazardous areas	*Hazardous sites map*	*Transco pipeline buffer*
Nuclear	*Dounreay consultation areas*	
Land and sea		
Military	*Marine exercise areas* *Technical research sites*	*Bombing ranges* *RAF tactical flying areas*
Aviation	*Airport safeguarding*	*ILS approaches*
Telecommunications	*Line of sight microwave links*	*Zones around aerials*
Sea		
Fishing	*Trawling* *Dredging*	*Creeling*
Cables	*Route*	
Oil & gas developments	*Pipeline routes* *Exploration areas*	*Surface facilities*
Shipping	*Shipping routes* *Anchorage areas* *Coastal routes*	*Charted routes* *Manoeuvring areas*
Conservation	*Designated sites*	*Voluntary areas*
Recreation and leisure	*Boating* *Bathing*	*Diving* *Visitor attractions*
Dredging areas	*License areas*	
Sand extraction	*License areas*	
Fish farming	*License areas*	

2.4 Cost of developing the renewable resources

These factors take account of the capital and operating costs associated with the various technologies. Capital costs relate to installed capacity (£/kW) whilst operating costs relate more appropriately to generated power (£/kWh). The main cost items associated with the various technologies are outlined below:

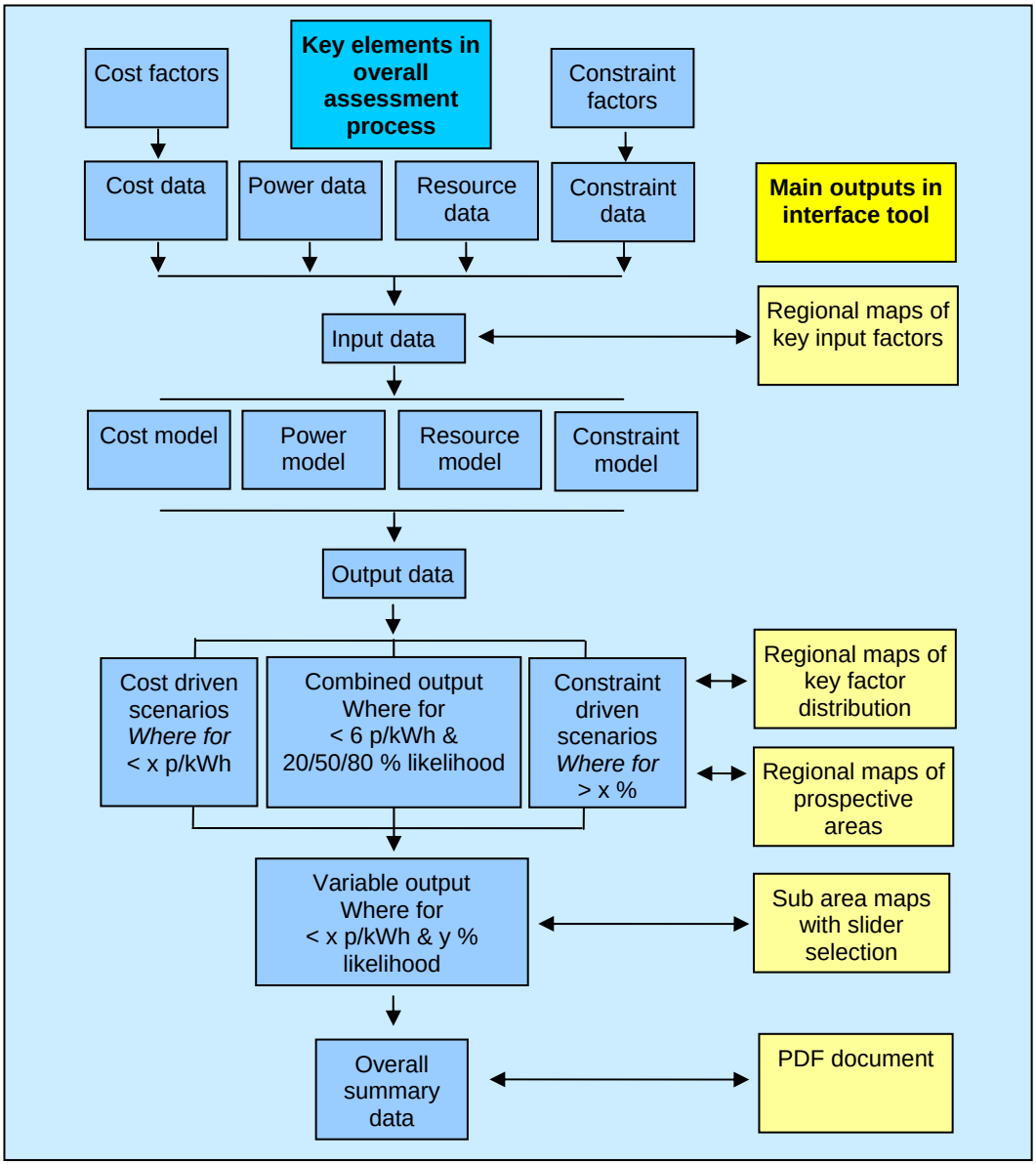
Table 2.4 Cost factors

Factor	*Category*
Soil type	*Ground conditions were classified as either rock, soil or bog*
Seabed type	*Seabed conditions were classified as either mud, sand or rock*
Distance to grid	*km range from grid lines and/or grid connection points (existing sub stations)*
Distance from port	*Km range by road or sea from designated industrial ports – not all ports qualified as industrial.*
Vehicle accessibility	*Land type and distance*

2.5 Overall resource assessment model

The structure of the overall project around the model is shown in Figure 2.2.

Figure 2.2 Overall schematic for the study



3 Resource Model Outputs

These maps show the base scenario outputs from the various constraint and cost models, as well as the overall combined model outputs for each energy resource.

3.1 Onshore wind

The onshore wind model was run with a universal development scenario of four 2MW turbines per km^2, unless that square was otherwise restricted by dwellings (less than four turbines per km^2) or by other constraint factors (no turbines per km^2).

The following section shows the results for the onshore wind model, including overall generating costs per km^2 (Figure 3.2), overall constraints per km^2 (Figure 3.3), potential development areas under cumulative constraint levels (Figure 3.4 to Figure 3.9) and potential development areas at individual constraint levels (10% increments) (Figure 3.10 to Figure 3.14).

Figure 3.1 Onshore wind speeds

Figure 3.2 Onshore wind generation costs (excluding transmission)

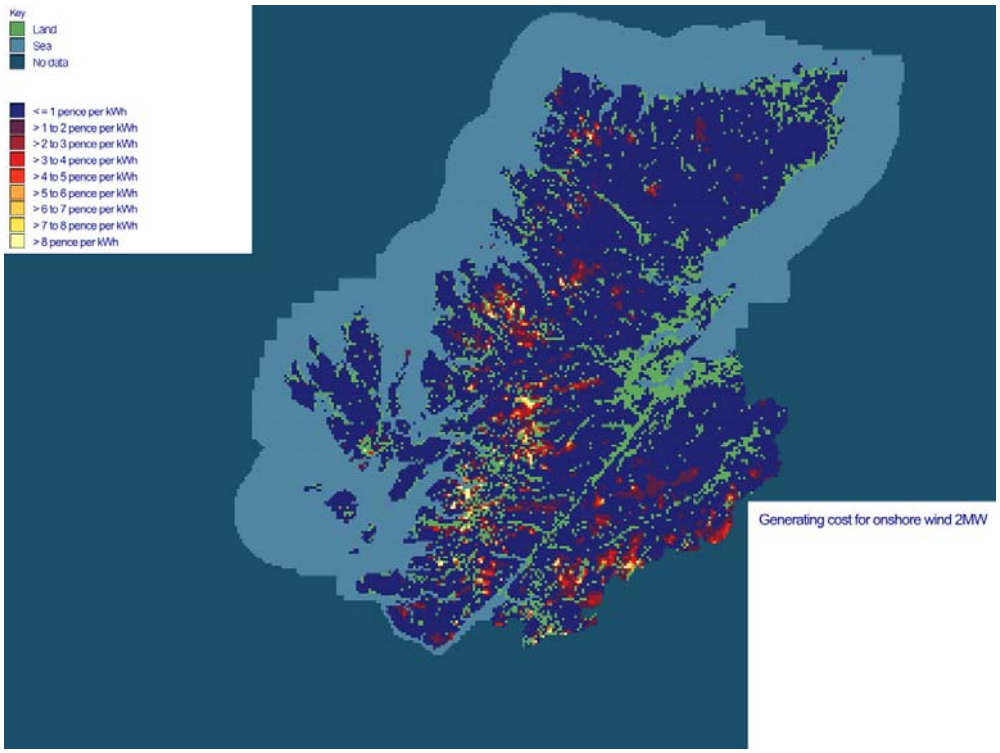


Figure 3.3 Onshore wind overall constraint levels

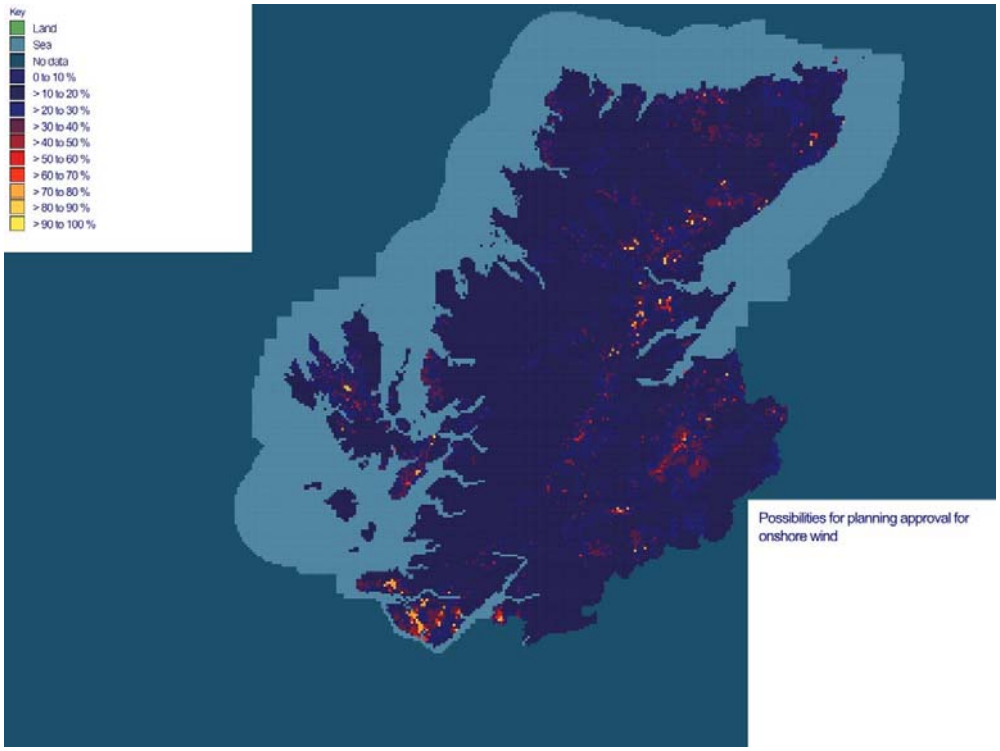


Figure 3.4 Onshore wind productivity under an extremely high unconstrained planning regime (0 to 100% likelihood and 3p wholesale revenue)

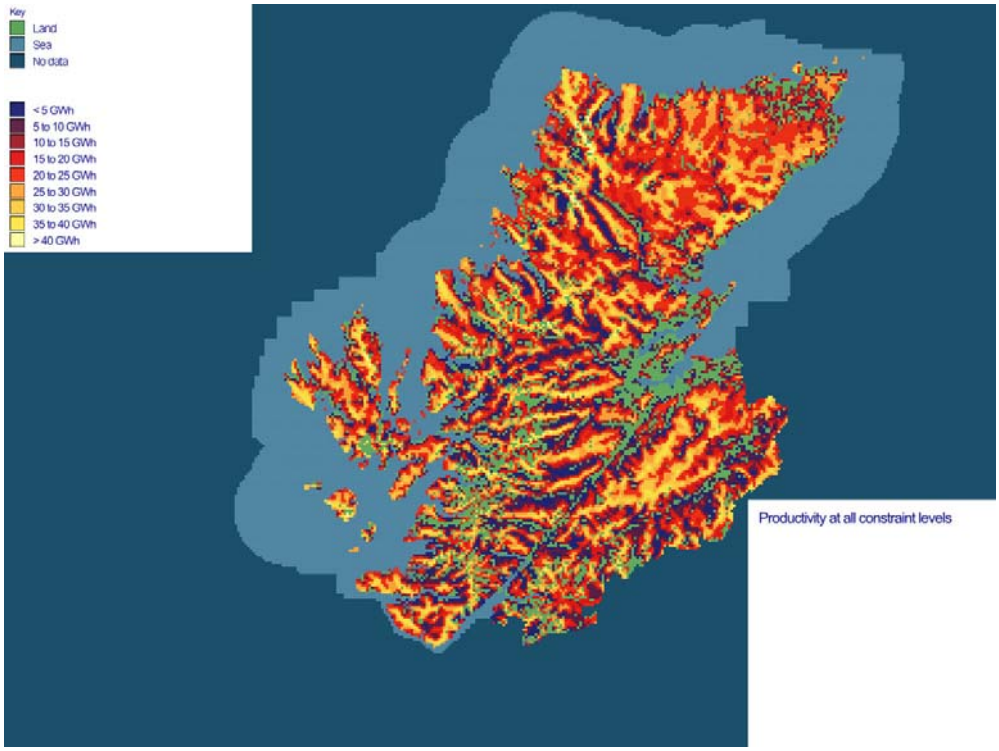


Figure 3.5 Onshore wind productivity under an extremely unconstrained planning regime (10 to 100% likelihood and 3p wholesale revenue)

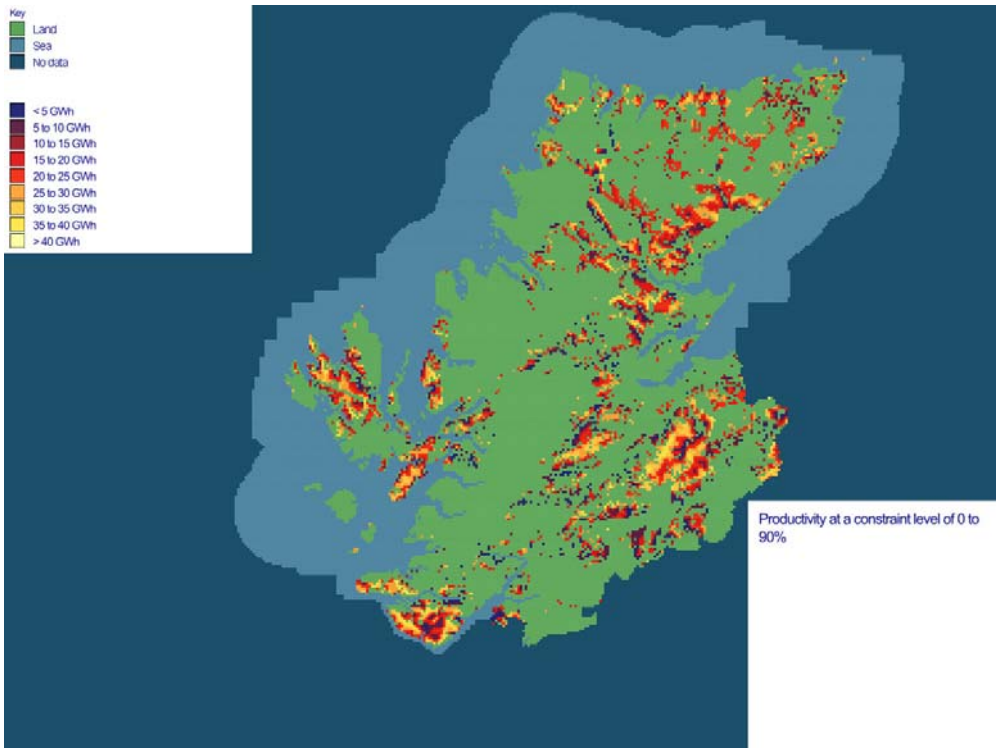


Figure 3.6 Onshore wind productivity under a very unconstrained planning regime (20 to 100% likelihood and 3p wholesale revenue)

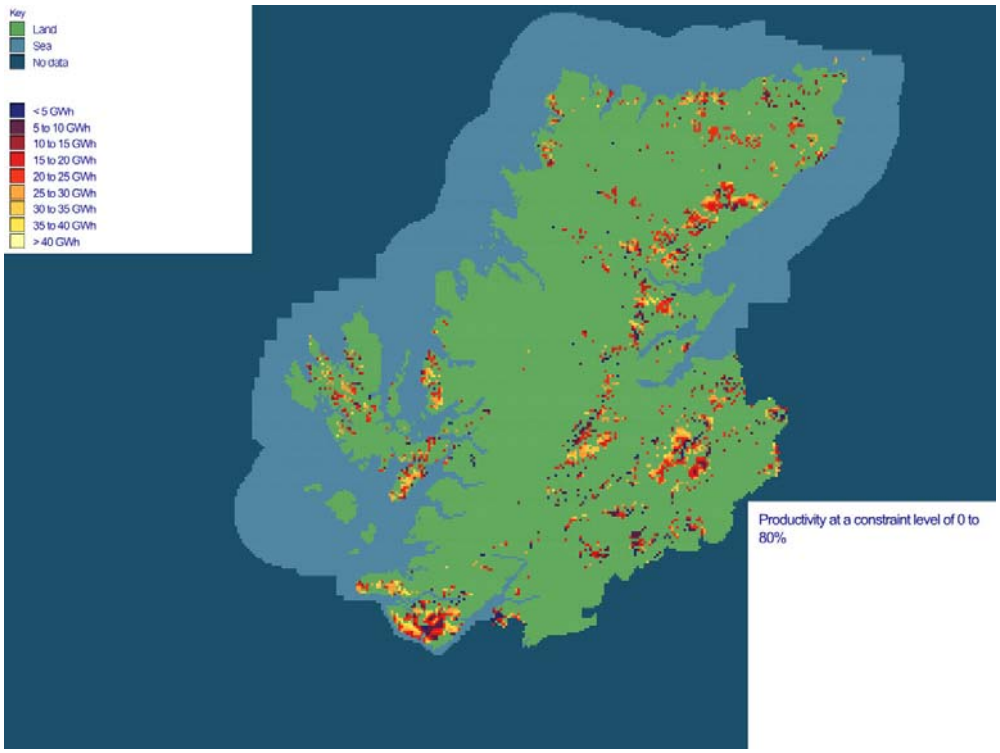


Figure 3.7 Onshore wind productivity under an unconstrained planning regime (30 to 100% likelihood and 3p wholesale revenue)

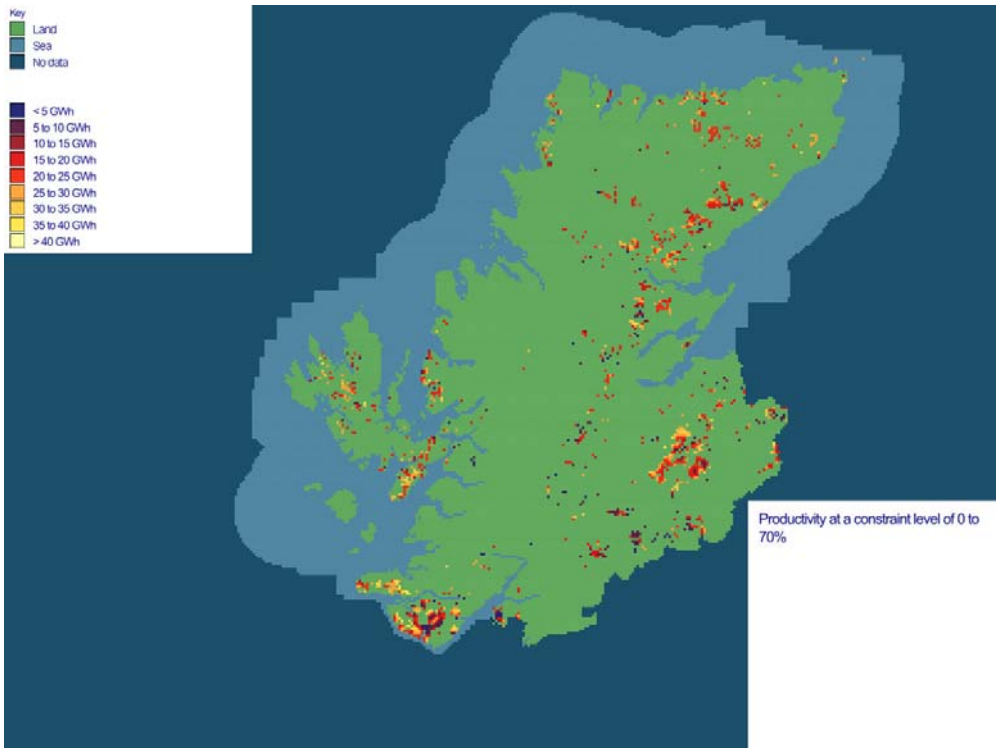


Figure 3.8 Onshore wind productivity under a moderately unconstrained planning regime (40 to 100% likelihood and 3p wholesale revenue)

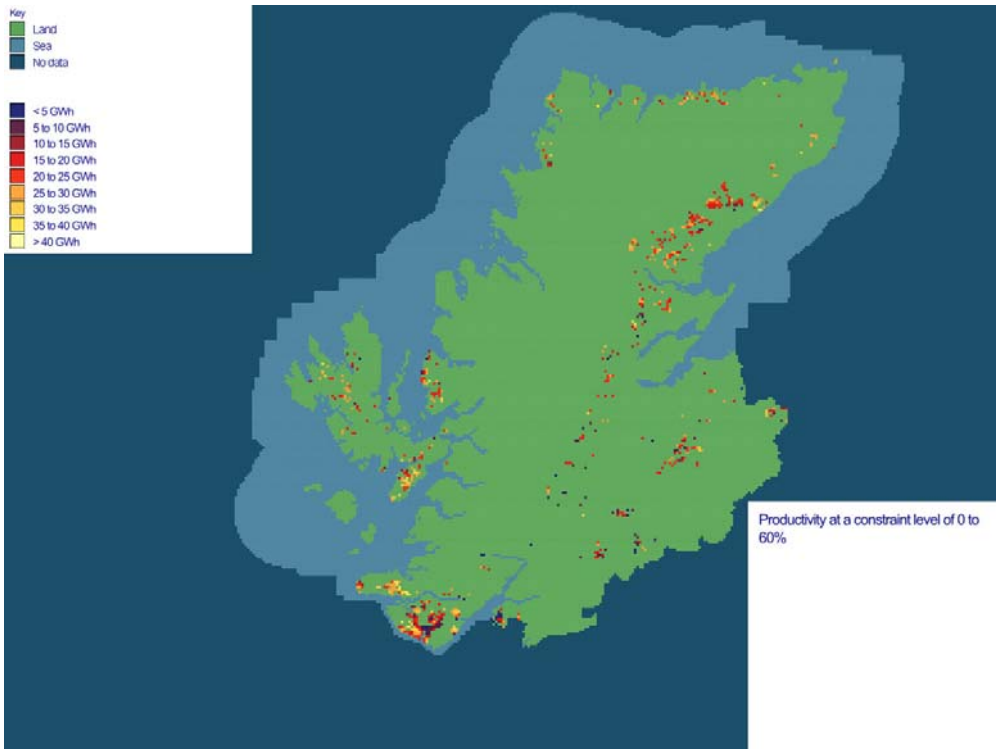


Figure 3.9 Onshore wind productivity under moderate planning regime (50 to 100% likelihood and 3p wholesale revenue)

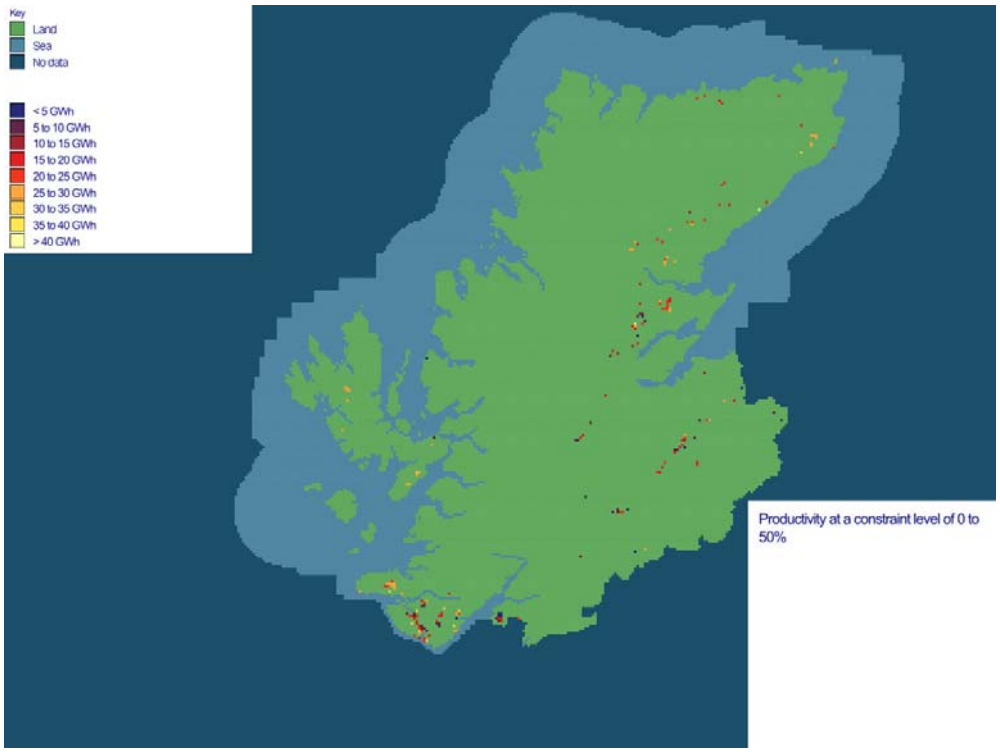


Figure 3.10 Onshore wind productivity under an extremely high unconstrained planning regime (0 to 10% likelihood and 3p wholesale revenue)

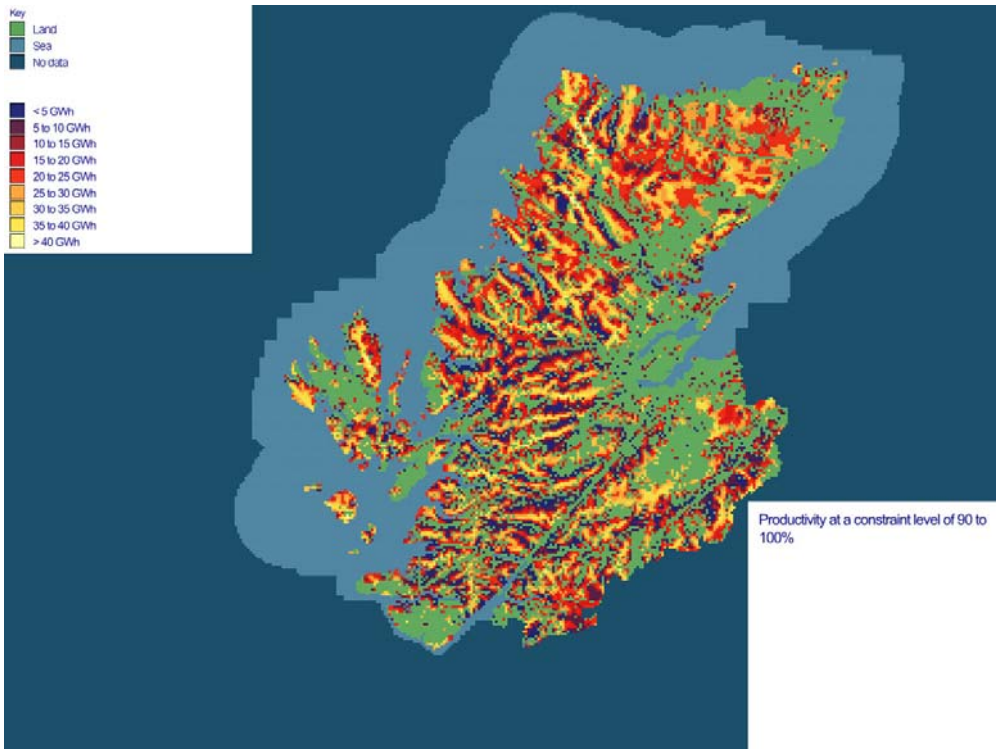


Figure 3.11 Onshore wind productivity under an extremely unconstrained planning regime (10 to 20% likelihood and 3p wholesale revenue)

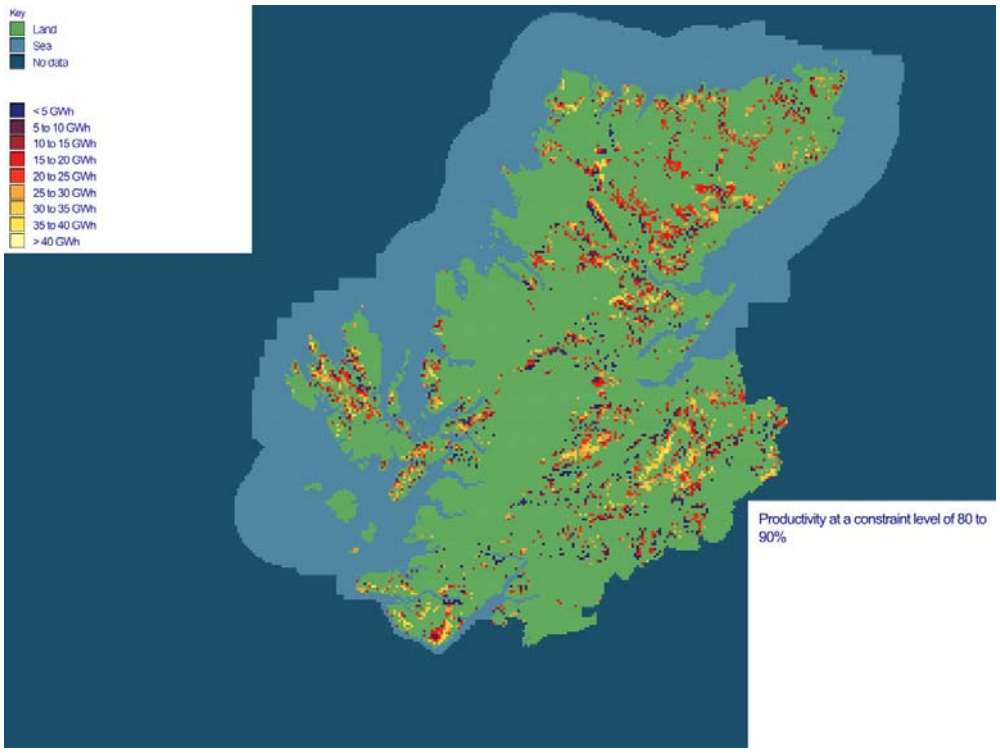


Figure 3.12 Onshore wind productivity under a very unconstrained planning regime (20 to 30% likelihood and 3p wholesale revenue)

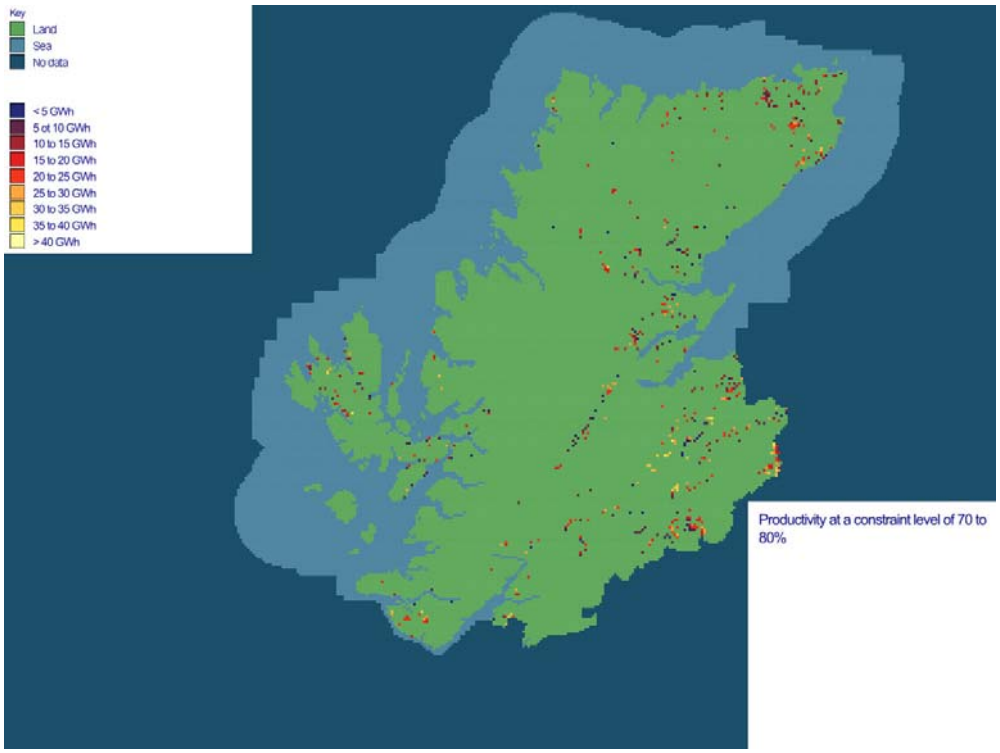


Figure 3.13 Onshore wind development under an unconstrained planning regime (30 to 40% likelihood and 3p wholesale revenue)

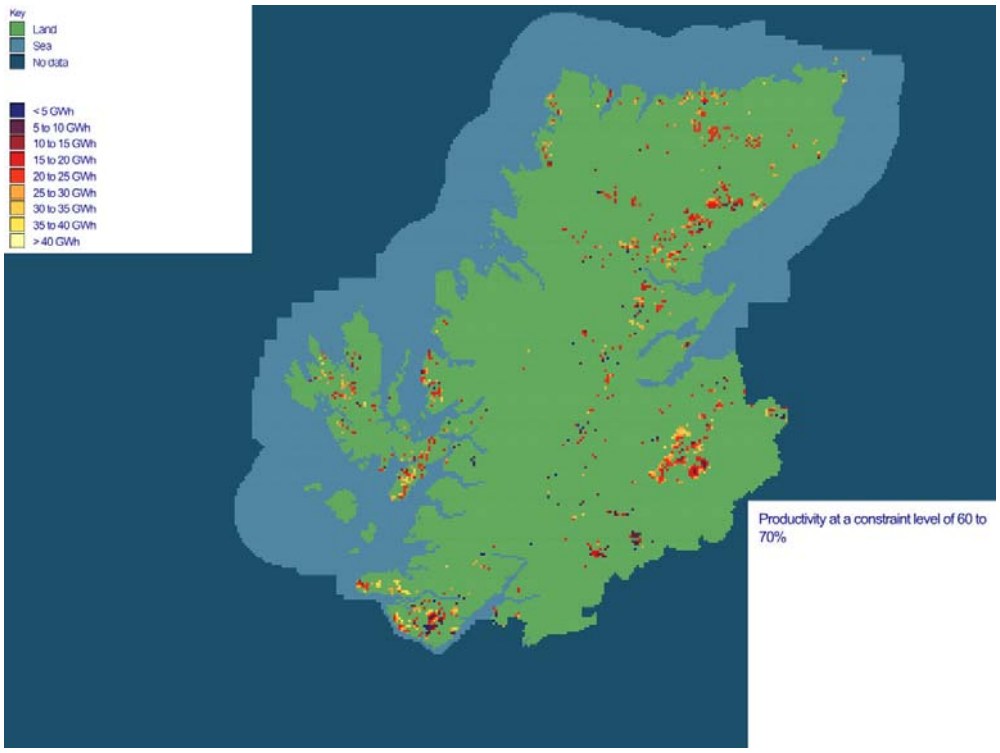


Figure 3.14 Onshore wind development under a moderately unconstrained planning regime (40 to 50% likelihood and 3p wholesale revenue)

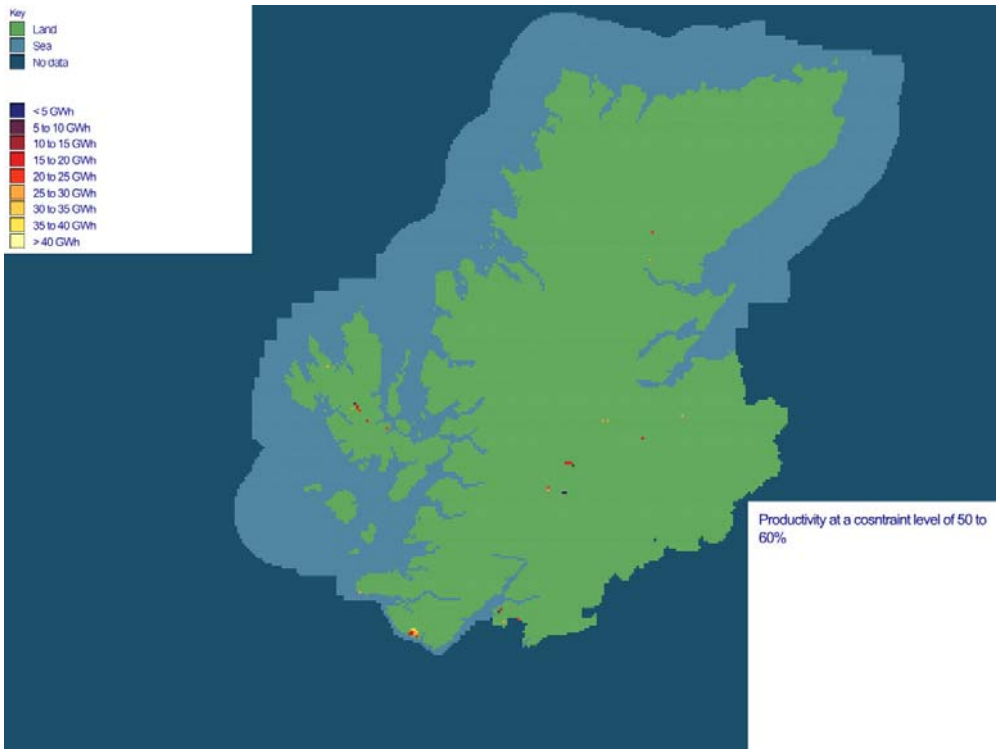


Figure 3.15 Existing and proposed development areas for onshore wind scheme

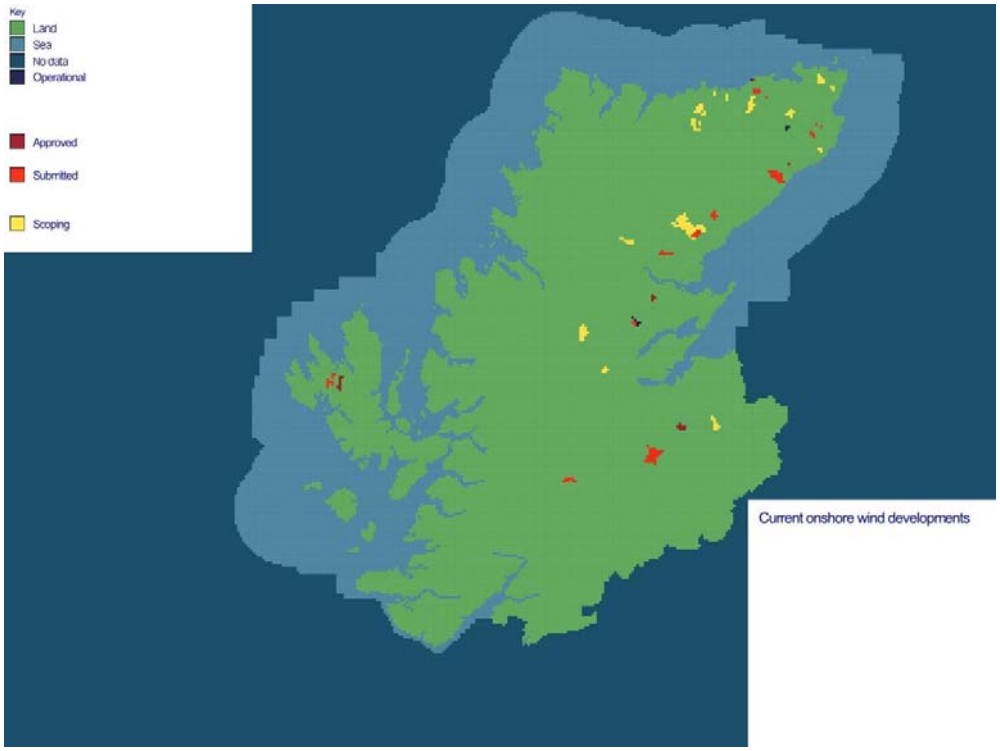


Figure 3.16 shows the prospective development areas identified by the RERA model. The table to the left of Figure 3.16 can be used to identify the areas by name and can also be used in conjunction with Table 3.1 to Table 3.5.

Figure 3.16 Prospective search areas

Area	Number
Cape Wrath	1
Strathy	2
John O'Groats	3
Lybster	4
Langwell	5
Auchentoul	6
Helmsdale	7
Brora	8
Golspie	9
Strath Brora	10
Ben Armine Forest	11
Strath Fleet	12
Dornoch Firth North	13
Dornoch Firth South	14
Beinn Tharsuinn	15
Strath Glass	16
Duirinish	17
Sleat	18
Glenaffric	19
Monadliath Mountains West	20
Monadliath Mountains East	21
Ardnamurchan	22
Morvern West	23
Morvern East	24
West Skye	25
Trotternish	26
Tungadal	27

Table 3.1 and Table 3.2 rank the prospective development areas according to average and total values for power, constraint and cost (Table 3.1) and average values for power, constraint and cost (Table 3.2). Sites were also ranked by total values as well as average values to give an indication of the pros associated with large developments. For example a large development with a poor average will have a greater overall value for the site than a small development site with a higher average. This helps show that to obtain the equivalent power from one large development several small developments would be required. These could be widespread, resulting in greater costs and possible greater environmental impact. Table 3.3 and Table 3.4 show the results for existing and proposed wind farm developments based on the same criteria as Table 3.1 and Table 3.2. Table 3.5 shows the average rankings for a mixture of modelled developments and existing/proposed developments.

Table 3.1 Prospective search areas ranked according to average and absolute values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Total power (GWh)	Total power rank	Average constraint	Average constraint rank	Total constraint	Total constraint rank	Average cost	Average cost rank	Total rank
Morvern West	80	24.0	7	1920.0	19	0.61	1	48.8	3	0.3	12	42
Sleat	125	20.3	19	2541.3	13	0.74	3	92.5	11	0.2	5	51
Helmsdale	122	21.0	16	2600.3	12	0.80	6	97.6	14	0.2	5	53
Ardnamurchan	94	23.2	10	2184.6	16	0.77	4	72.38	7	0.4	18	55
Dornoch Firth South	118	18.6	23	2189.6	15	0.80	6	94.4	12	0.2	5	61
Duirinish	93	26.3	4	2442.9	14	0.95	21	88.35	10	0.3	12	61
Golspie	51	22.4	12	1144.9	27	0.93	20	47.43	2	0.1	1	62
Tungadal	62	23.8	8	1476.1	24	0.84	14	52.08	4	0.3	12	62
Beinn Tharsuinn	75	23.4	9	1751.9	23	0.83	13	62.25	6	0.3	12	63
Strath Fleet	177	19.3	21	3410.8	11	0.81	8	143.37	20	0.2	5	65
Cape Wrath	142	28.5	1	4241.6	6	0.95	21	134.9	19	0.4	18	65
Brora	81	23.0	11	1866.4	20	0.95	21	76.95	9	0.2	5	66
Strath Brora	287	20.5	18	5893.8	3	0.81	8	232.47	25	0.3	12	66
Skye West	69	20.6	17	1422.0	25	0.85	16	58.65	5	0.2	5	68
Strathy	211	20.1	20	4235.8	7	0.84	14	177.24	22	0.2	5	68
Lybster	232	18.7	22	4338.5	5	0.89	17	206.48	24	0.1	1	69
Monadliath Mountains East	192	21.9	13	4197.0	8	0.78	5	149.76	21	0.5	22	69
Morvern East	192	21.2	14	4079.4	9	0.70	2	134.4	18	0.7	27	70
Langwell	131	25.9	5	3595.8	10	0.95	21	124.45	17	0.4	18	71
Monadliath Mountains West	338	21.1	15	7133.8	1	0.82	11	277.16	26	0.4	18	71
Dornoch Firth North	120	14.8	27	1776.2	22	0.82	11	98.4	15	0.1	1	76
John O'Groats	121	15.9	25	1922.0	18	0.89	17	107.69	16	0.1	1	77
Trotternish	46	28.4	2	1306.0	26	0.96	26	44.16	1	0.5	22	77
Auchentoul	79	27.3	3	2132.9	17	0.97	27	76.63	8	0.5	22	77
Ben Armine Forest	202	24.7	6	4990.3	4	0.95	21	191.9	23	0.6	25	79
Glen Glass	120	15.0	26	1798.3	21	0.81	8	97.2	13	0.3	12	80
Balmacaan Forest	380	17.7	24	6735.5	2	0.89	17	338.2	27	0.6	25	95

Table 3.2 Prospective search areas ranked according to average values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Morvern West	80	24.0	7	0.61	1	0.3	12	20
Sleat	125	20.3	19	0.74	3	0.2	5	27
Helmsdale	122	21.0	16	0.80	6	0.2	5	27
Ardnamurchan	94	23.2	10	0.77	4	0.4	18	32
Golspie	51	22.4	12	0.93	20	0.1	1	33
Dornoch Firth South	118	18.6	23	0.80	6	0.2	5	34
Tungadal	62	23.8	8	0.84	14	0.3	12	34
Beinn Tharsuinn	75	23.4	9	0.83	13	0.3	12	34
Strath Fleet	177	19.3	21	0.81	8	0.2	5	34
Duirinish	93	26.3	4	0.95	21	0.3	12	37
Brora	81	23.0	11	0.95	21	0.2	5	37
Strath Brora	287	20.5	18	0.81	8	0.3	12	38
Skye West	69	20.6	17	0.85	16	0.2	5	38
Strathy	211	20.1	20	0.84	14	0.2	5	39
Dornoch Firth North	120	14.8	27	0.82	11	0.1	1	39
Cape Wrath	142	28.5	1	0.95	21	0.4	18	40
Lybster	232	18.7	22	0.89	17	0.1	1	40
Monadliath Mountains East	192	21.9	13	0.78	5	0.5	22	40
Morvern East	192	21.2	14	0.70	2	0.7	27	43
John O'Groats	121	15.9	25	0.89	17	0.1	1	43
Langwell	131	25.9	5	0.95	21	0.4	18	44
Monadliath Mountains West	338	21.1	15	0.82	11	0.4	18	44
Glen Glass	120	15.0	26	0.81	8	0.3	12	46
Trotternish	46	28.4	2	0.96	26	0.5	22	50
Auchentoul	79	27.3	3	0.97	27	0.5	22	52
Ben Armine Forest	202	24.7	6	0.95	21	0.6	25	52
Balmacaan Forest	380	17.7	24	0.89	17	0.6	25	66

Table 3.3 Existing and proposed developments ranked according to average and absolute values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Total power (GWh)	Total power rank	Average constraint	Average constraint rank	Total constraint	Total constraint rank	Average cost	Average cost rank	Total rank
Kilbraur	8	26.2	12	210.0	11	0.79	7	6.34	21	0.1	2	53
Farr	8	26.5	10	211.7	10	0.85	16	6.77	23	0.1	2	61
Hill of Lieurary	1	21.4	18	21.4	35	0.83	13	0.83	1	0.1	2	69
Strathy North	14	28.4	6	397.2	4	0.80	8	11.22	34	0.3	18	70
Flex Hill	1	27.2	7	27.2	32	0.92	27	0.92	3	0.1	2	71
Lochluichart	12	26.3	11	315.7	6	0.88	21	10.61	33	0.1	2	73
Achany	9	24.5	14	220.3	8	0.80	8	7.24	25	0.3	18	73
Strathy South	12	33.5	3	401.6	3	0.82	11	9.86	30	0.4	27	74
Achairn	1	32.2	4	32.2	30	0.92	27	0.92	3	0.2	12	76
Novar II	3	21.3	21	63.9	26	0.76	4	2.28	11	0.3	18	80
Forss II Extension	1	27.2	7	27.2	32	1.00	35	1.00	5	0.1	2	81
Novar	5	33.8	2	135.2	16	0.88	21	4.41	16	0.4	27	82
Burn of Whilk	3	16.8	32	50.3	29	0.68	1	2.04	9	0.2	12	83
South Shebster	1	21.4	18	21.4	35	0.86	19	0.86	2	0.2	12	86
Broubster Forest	13	15.5	34	186.3	15	0.78	5	10.12	32	0.1	2	88
Scoolary	9	24.3	15	218.9	9	0.88	21	7.96	27	0.3	18	90
Beinn Tharsuinn	4	21.1	23	84.3	23	0.82	11	3.28	15	0.3	18	90
Forss	1	27.2	7	27.2	32	1.00	35	1.00	5	0.2	12	91
Ben Aketil	10	20.6	25	206.3	12	0.84	15	8.44	28	0.2	12	92
Causeymire	3	21.4	18	64.1	25	0.71	2	2.12	10	1.0	37	92
Dunmaglass	30	25.7	13	771.9	2	0.85	16	25.58	36	0.4	27	94
Spittal Hill	8	23.5	17	187.9	14	0.90	24	7.19	24	0.3	18	97
Cambusmore	7	18.5	29	129.8	17	0.83	13	5.80	20	0.3	18	97
Glenkirk	11	19.5	27	194.8	13	0.92	27	10.07	31	0.1	2	100
Ackron	3	21.3	21	63.9	26	0.91	25	2.73	12	0.3	18	102
Stroupster	3	36.4	1	109.1	21	0.96	33	2.88	13	0.6	34	102
Buolfruich	1	20.4	26	20.4	37	1.00	35	1.00	5	0.0	1	104
Gordonbush	7	17.1	31	120.0	19	0.93	30	6.48	22	0.1	2	104
South of Glen Moriston	9	30.2	5	271.6	7	0.94	31	8.49	29	0.5	32	104
Strath Brora (West)	53	23.7	16	1256.8	1	0.85	16	45.00	37	0.6	34	104
Corriemoillie	6	19.3	28	116.0	20	0.80	8	4.80	17	0.5	32	105
Dunbeath	20	17.9	30	358.1	5	0.73	3	14.68	35	0.6	34	107
Melvich	2	16.0	33	32.1	31	0.86	19	1.71	8	0.3	18	109
Camster	4	13.9	35	55.8	28	0.78	5	3.12	14	0.4	27	109
Baillie Hill	6	20.8	24	125.1	18	0.91	25	5.44	18	0.4	27	112
Edinbane	8	11.7	36	93.2	22	0.98	34	7.86	26	0.1	2	120
Fairburn	6	11.7	36	69.9	24	0.95	32	5.68	19	0.2	12	123

Table 3.4 Existing and proposed developments ranked according to average values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Kilbraur	8	26.2	12	0.79	7	0.1	2	21.0
Farr	8	26.5	10	0.85	16	0.1	2	28.0
Strathy North	14	28.4	6	0.80	8	0.3	18	32.0
Hill of Lieurary	1	21.4	18	0.83	13	0.1	2	33.0
Lochluichart	12	26.3	11	0.88	21	0.1	2	34.0
Flex Hill	1	27.2	7	0.92	27	0.1	2	36.0
Achany	9	24.5	14	0.80	8	0.3	18	40.0
Strathy South	12	33.5	3	0.82	11	0.4	27	41.0
Broubster Forest	13	15.5	34	0.78	5	0.1	2	41.0
Achairn	1	32.2	4	0.92	27	0.2	12	43.0
Novar II	3	21.3	21	0.76	4	0.3	18	43.0
Forss II Extension	1	27.2	7	1.00	35	0.1	2	44.0
Burn of Whilk	3	16.8	32	0.68	1	0.2	12	45.0
South Shebster	1	21.4	18	0.86	19	0.2	12	49.0
Novar	5	33.8	2	0.88	21	0.4	27	50.0
Beinn Tharsuinn	4	21.1	23	0.82	11	0.3	18	52.0
Ben Aketil	10	20.6	25	0.84	15	0.2	12	52.0
Scoolary	9	24.3	15	0.88	21	0.3	18	54.0
Forss	1	27.2	7	1.00	35	0.2	12	54.0
Dunmaglass	30	25.7	13	0.85	16	0.4	27	56.0
Glenkirk	11	19.5	27	0.92	27	0.1	2	56.0
Causeymire	3	21.4	18	0.71	2	1.0	37	57.0
Spittal Hill	8	23.5	17	0.90	24	0.3	18	59.0
Cambusmore	7	18.5	29	0.83	13	0.3	18	60.0
Buolfruich	1	20.4	26	1.00	35	0.0	1	62.0
Gordonbush	7	17.1	31	0.93	30	0.1	2	63.0
Ackron	3	21.3	21	0.91	25	0.3	18	64.0
Strath Brora (West)	53	23.7	16	0.85	16	0.6	34	66.0
Dunbeath	20	17.9	30	0.73	3	0.6	34	67.0
Camster	4	13.9	35	0.78	5	0.4	27	67.0
Stroupster	3	36.4	1	0.96	33	0.6	34	68.0
South of Glen Moriston	9	30.2	5	0.94	31	0.5	32	68.0
Corriemoillie	6	19.3	28	0.80	8	0.5	32	68.0
Melvich	2	16.0	33	0.86	19	0.3	18	70.0
Edinbane	8	11.7	36	0.98	34	0.1	2	72.0
Baillie Hill	6	20.8	24	0.91	25	0.4	27	76.0
Fairburn	6	11.7	36	0.95	32	0.2	12	80.0

Table 3.5 Ranked table comparing existing/proposed developments and prospective search areas

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Kilbraur	8	26.2	15	0.79	12	0.1	2	29.0
Farr	8	33.1	4	0.85	29	0.1	2	35.0
Lochluichart	12	26.3	13	0.88	34	0.1	2	49.0
Morvern West RERA	80	24.0	21	0.61	1	0.3	28	50.0
Strathy North	14	28.4	11	0.80	13	0.3	28	52.0
Hill of Lieurary	1	21.4	29	0.83	24	0.1	2	55.0
Achany	9	24.5	19	0.80	13	0.3	28	60.0
Sleat RERA	125	20.3	42	0.74	6	0.2	16	64.0
Achairn	1	32.2	5	0.92	43	0.2	16	64.0
Strathy South	12	33.5	3	0.82	20	0.4	41	64.0
Edinbane	8	30.7	6	0.98	58	0.1	2	66.0
Broubster Forest	13	15.5	55	0.78	9	0.1	2	66.0
Helmsdale RERA	122	21.0	37	0.80	13	0.2	16	66.0
Novar II	3	21.3	32	0.76	7	0.3	28	67.0
Burn of Whilk	3	16.8	53	0.68	2	0.2	16	71.0
Ardnamurchan RERA	94	23.2	25	0.77	8	0.4	41	74.0
Golspie RERA	51	22.4	27	0.93	46	0.1	2	75.0
Beinn Tharsuinn RERA	75	23.4	24	0.83	24	0.3	28	76.0
South Shebster	1	21.4	29	0.86	32	0.2	16	77.0
Melvich	2	25.0	17	0.86	32	0.3	28	77.0
Novar	5	33.8	2	0.88	34	0.4	41	77.0
Dornoch Firth North RERA	120	14.8	56	0.82	20	0.1	2	78.0
Dornoch Firth South RERA	118	18.6	49	0.80	13	0.2	16	78.0
Dunmaglass	30	29.7	8	0.85	29	0.4	41	78.0
Strath Fleet RERA	177	19.3	46	0.81	18	0.2	16	80.0
Ben Aketil	10	20.6	39	0.84	27	0.2	16	82.0
Scoolary	9	24.3	20	0.88	34	0.3	28	82.0
Beinn Tharsuinn	4	21.1	35	0.82	20	0.3	28	83.0
Strathy RERA	211	20.1	43	0.84	27	0.2	16	86.0
Strath Brora RERA	287	20.5	40	0.81	18	0.3	28	86.0
Lybster RERA	232	18.7	48	0.89	37	0.1	2	87.0
Monadliath Mountains East RERA	192	21.9	28	0.78	9	0.5	51	88.0
Glenkirk	11	19.5	45	0.92	43	0.1	2	90.0
Duirinish RERA	93	26.3	13	0.95	49	0.3	28	90.0
Ben Wyvis RERA	81	23.0	26	0.95	49	0.2	16	91.0
Spittal Hill	8	23.5	23	0.90	40	0.3	28	91.0
John O'Groats RERA	121	15.9	54	0.89	37	0.1	2	93.0
Causeymire	3	21.4	29	0.71	4	1.0	61	94.0
Monadliath Mountains West RERA	338	21.1	35	0.82	20	0.4	41	96.0
Morvern East RERA	192	21.2	34	0.70	3	0.7	60	97.0
Brora RERA	142	28.5	9	0.95	49	0.4	41	99.0
Gordonbush	7	17.1	52	0.93	46	0.1	2	100.0
Cape Wrath RERA	142	28.5	10	0.95	49	0.4	41	100.0
Buolfruich	1	20.4	41	1.00	59	0.0	1	101.0
Ackron	3	21.3	32	0.91	41	0.3	28	101.0
Cambusmore	7	18.5	50	0.83	24	0.3	28	102.0
Flex Hill	1	14.0	58	0.92	43	0.1	2	103.0
Dunbeath	20	19.9	44	0.73	5	0.6	55	104.0
Langwell RERA	131	25.9	16	0.95	49	0.4	41	106.0
South of Glen Moriston	9	30.2	7	0.94	48	0.5	51	106.0
Strath Brora (West)	53	23.7	22	0.85	29	0.6	55	106.0
Camster	4	13.9	59	0.78	9	0.4	41	109.0
Corriemoillie	6	19.3	46	0.80	13	0.5	51	110.0
Stroupster	3	36.4	1	0.96	56	0.6	55	112.0
Baillie Hill	6	20.8	38	0.91	41	0.4	41	120.0
Auchentoul RERA	79	27.3	12	0.97	57	0.5	51	120.0
Fairburn	6	14.7	57	0.95	49	0.2	16	122.0
Ben Armine Forest RERA	202	24.7	18	0.95	49	0.6	55	122.0
Forss II Extension	1	0.0	61	1.00	60	0.1	2	123.0
Forss	1	7.0	60	1.00	60	0.2	16	136.0
Glenaffric RERA	380	17.7	51	0.89	37	0.6	55	143.0

3.2 Offshore wind

The offshore wind model was run with a universal development scenario of four 5MW turbines per km^2, unless that square was otherwise restricted by dwellings (less than four turbines per km^2) or by other constraint factors (no turbines per km^2).

The following section shows the results for the onshore wind model, including overall generating costs per km^2 (Figure 3.18), overall constraints per km^2 (Figure 3.19), potential development areas under cumulative constraint levels (Figure 3.20 to Figure 3.25) and potential development areas at individual constraint levels (10% increments) (Figure 3.26 to Figure 3.30).

Figure 3.17 Offshore wind speeds

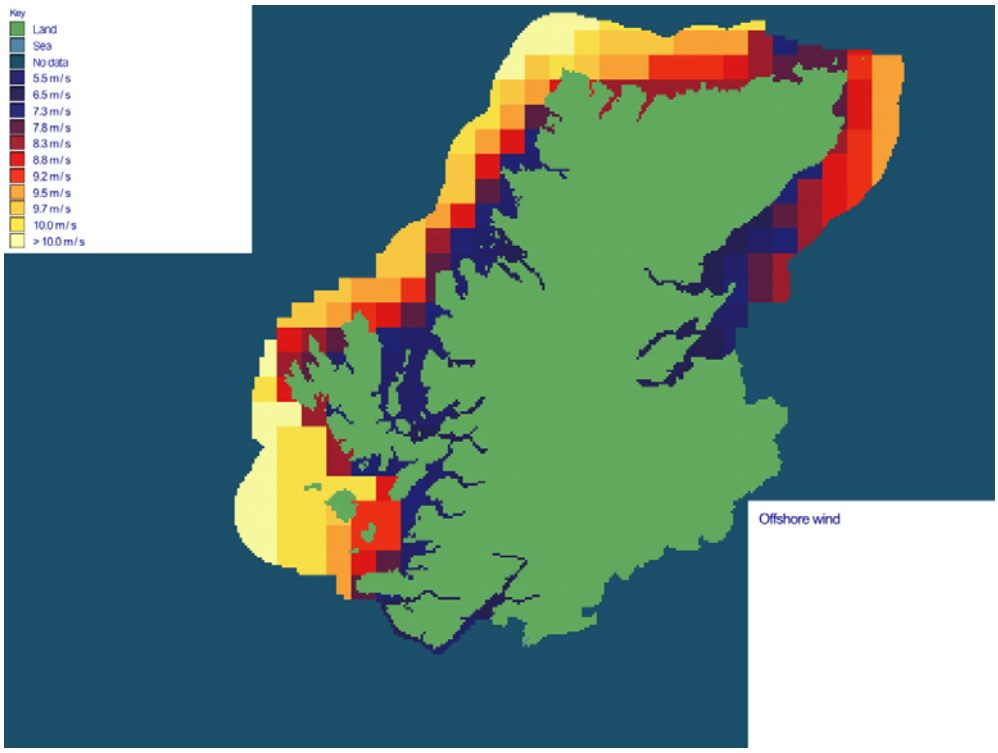


Figure 3.18 Offshore wind generation costs (excluding transmission)

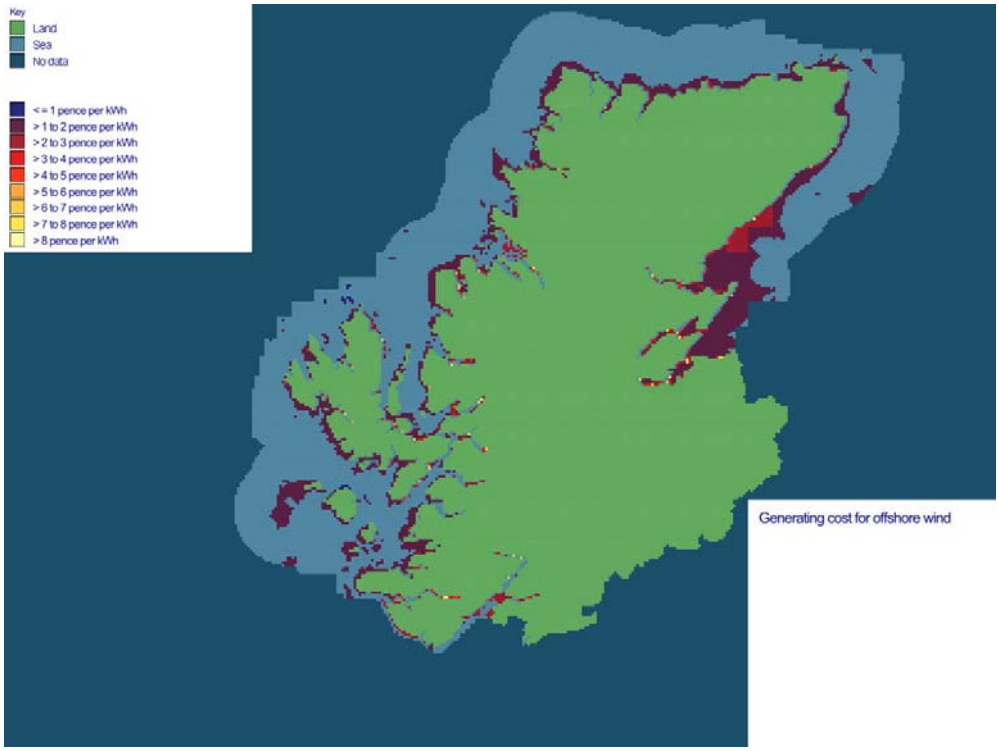


Figure 3.19 Offshore wind overall constraint levels

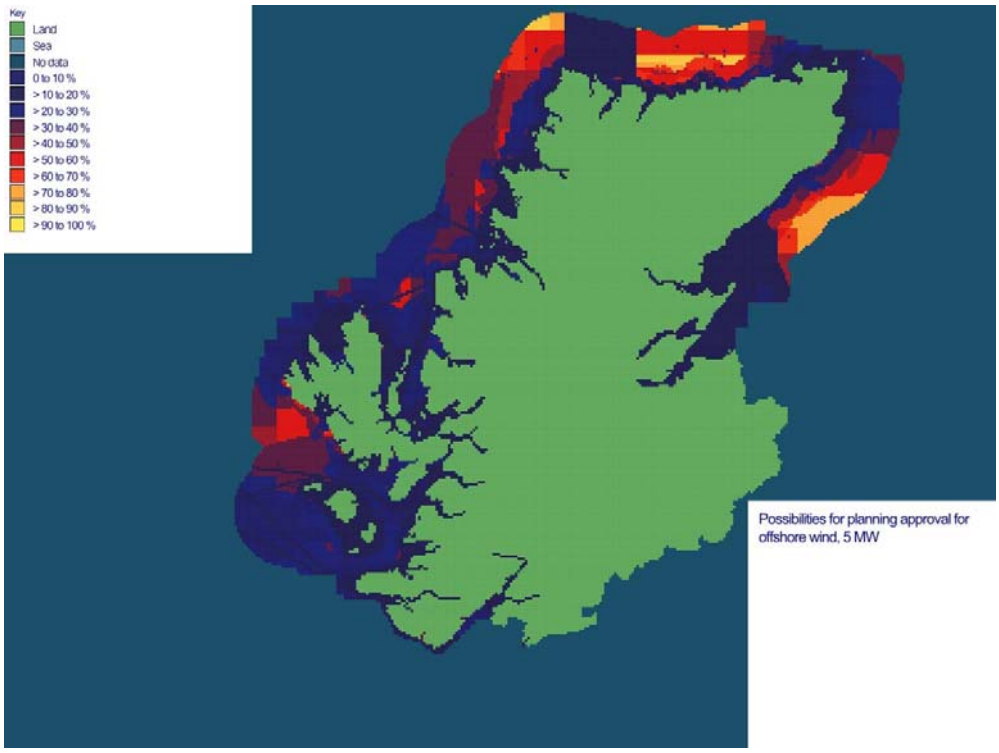


Figure 3.20 Offshore wind productivity under an extremely high unconstrained planning regime (0 to 100% likelihood and 3p wholesale revenue)

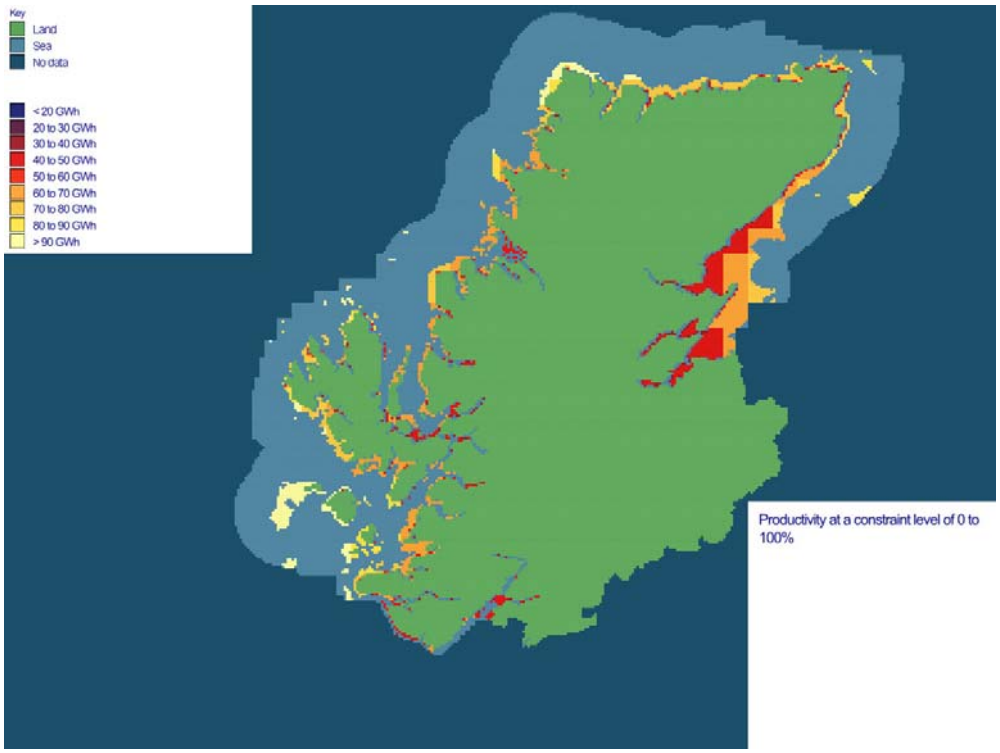


Figure 3.21 Offshore wind productivity under an extremely unconstrained planning regime (10 to 100% likelihood and 3p wholesale revenue)

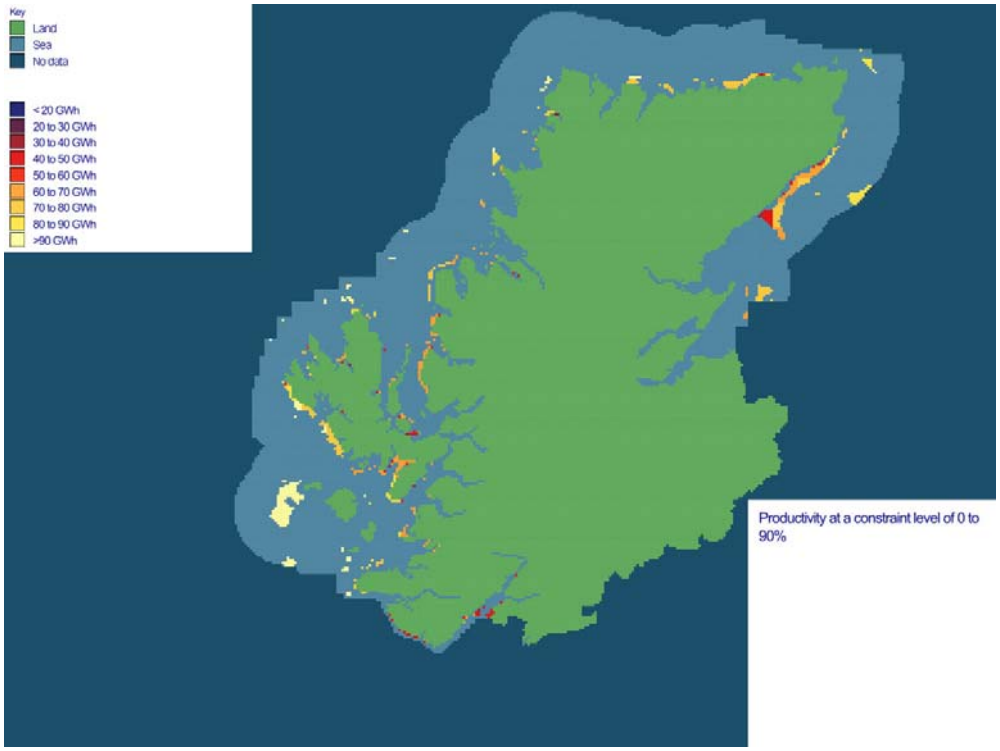


Figure 3.22 Offshore wind productivity under a very unconstrained planning regime (20 to 100% likelihood and 3p wholesale revenue)

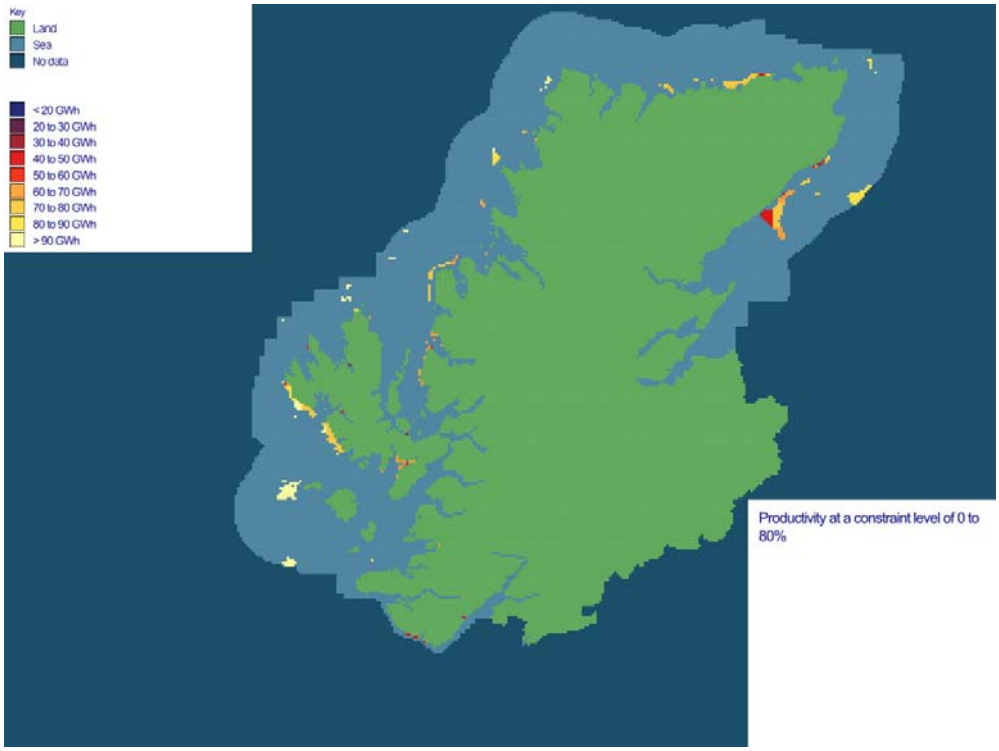


Figure 3.23 Offshore wind productivity under an unconstrained planning regime (30 to 100% likelihood and 3p wholesale revenue)

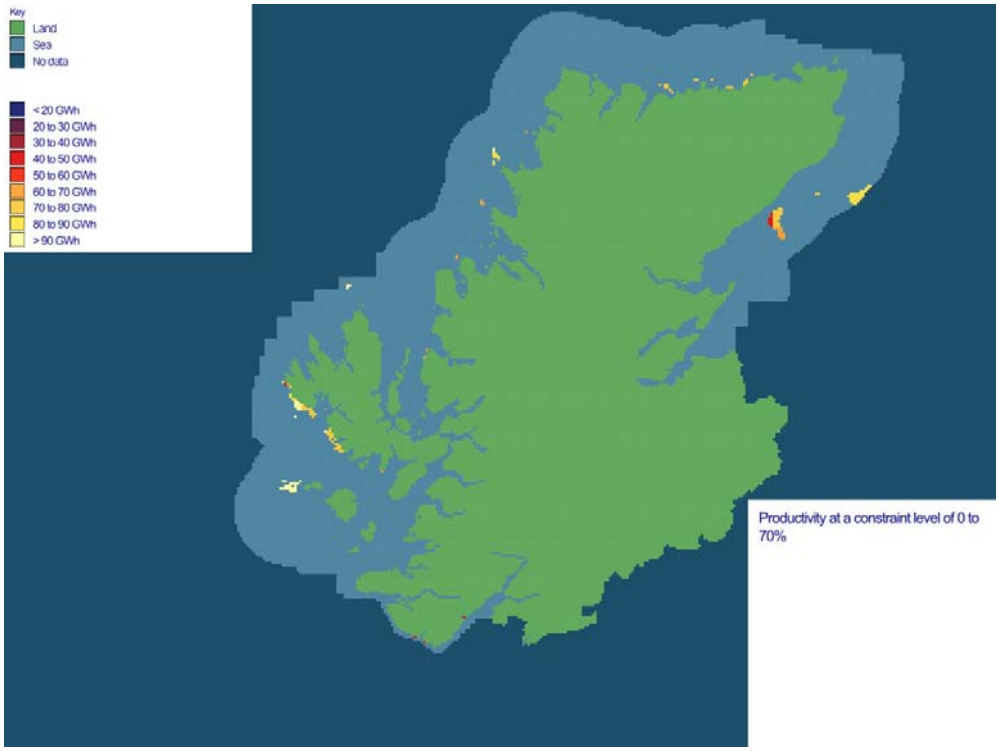


Figure 3.24 Offshore wind productivity under a moderately unconstrained planning regime (40 to 100% likelihood and 3p wholesale revenue)

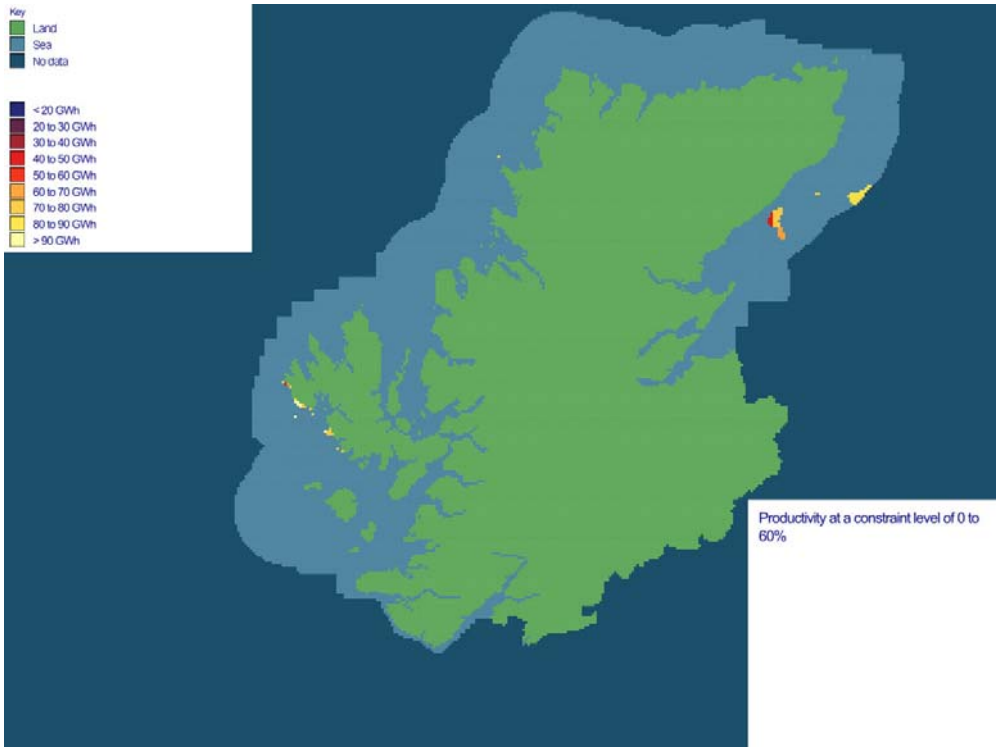


Figure 3.25 Offshore wind productivity under a moderate planning regime (50 to 100% likelihood and 3p wholesale revenue)

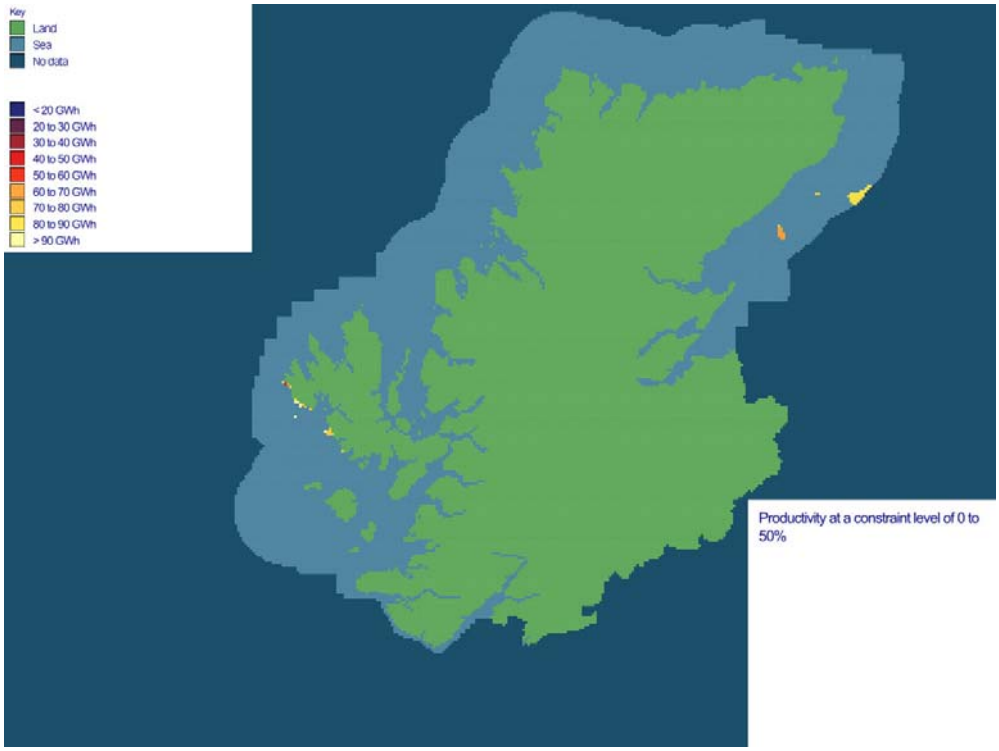


Figure 3.26 Offshore wind productivity under an extremely high unconstrained planning regime (0 to 10% likelihood)

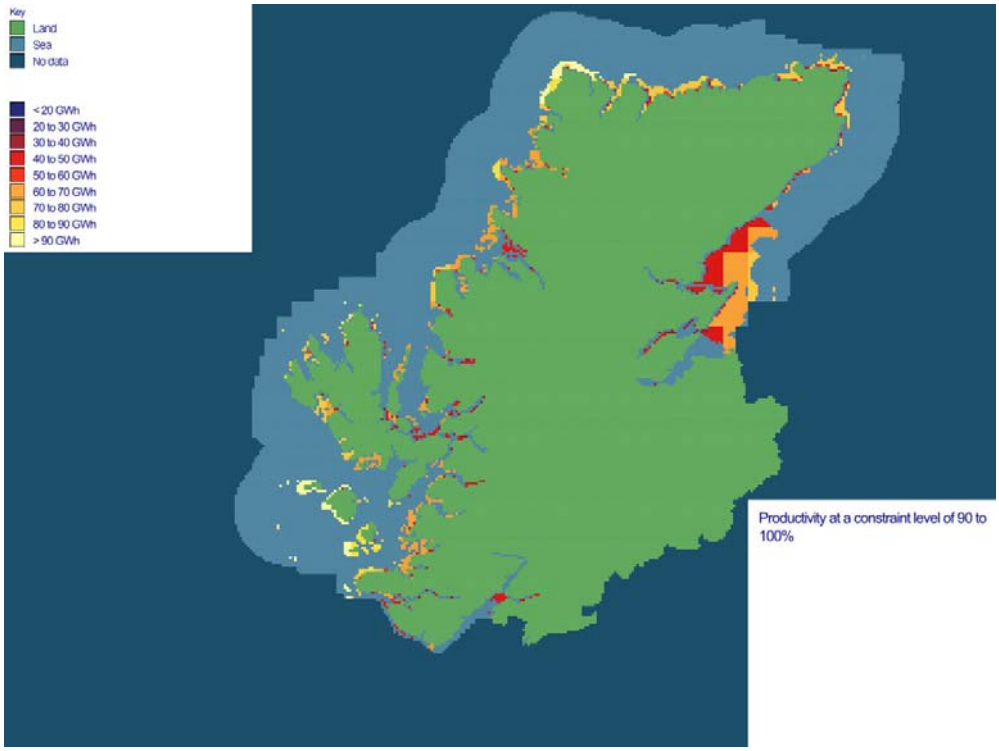


Figure 3.27 Offshore wind productivity under a very unconstrained planning regime (10 to 20% likelihood)

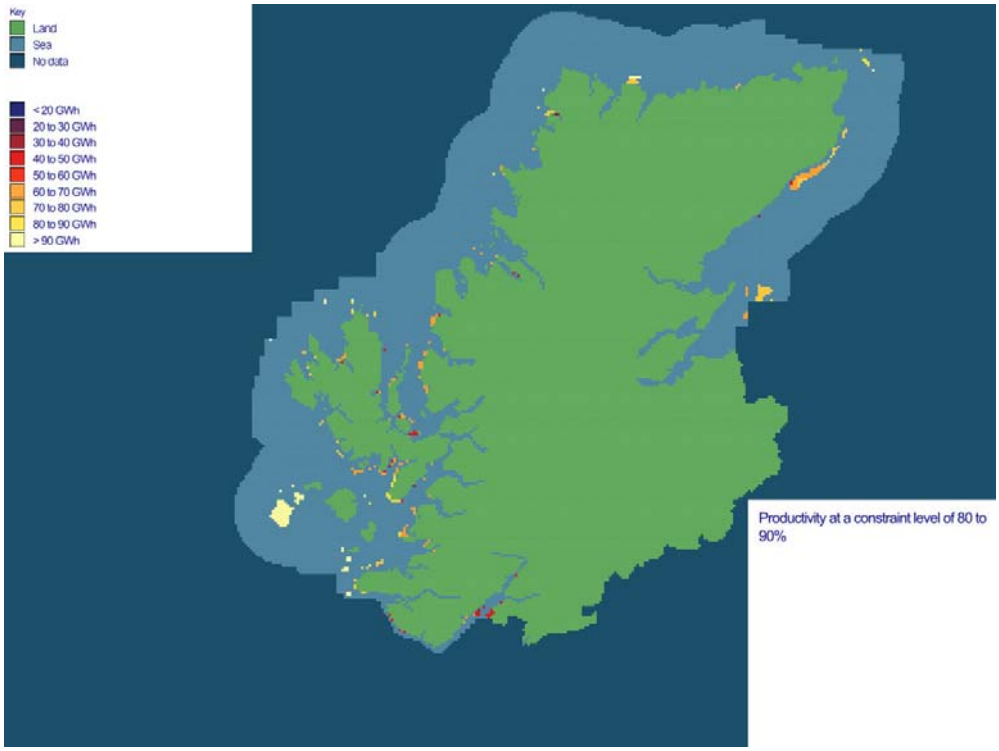


Figure 3.28 Offshore wind productivity under an unconstrained planning regime (20 to 30% likelihood and 3p wholesale revenue)

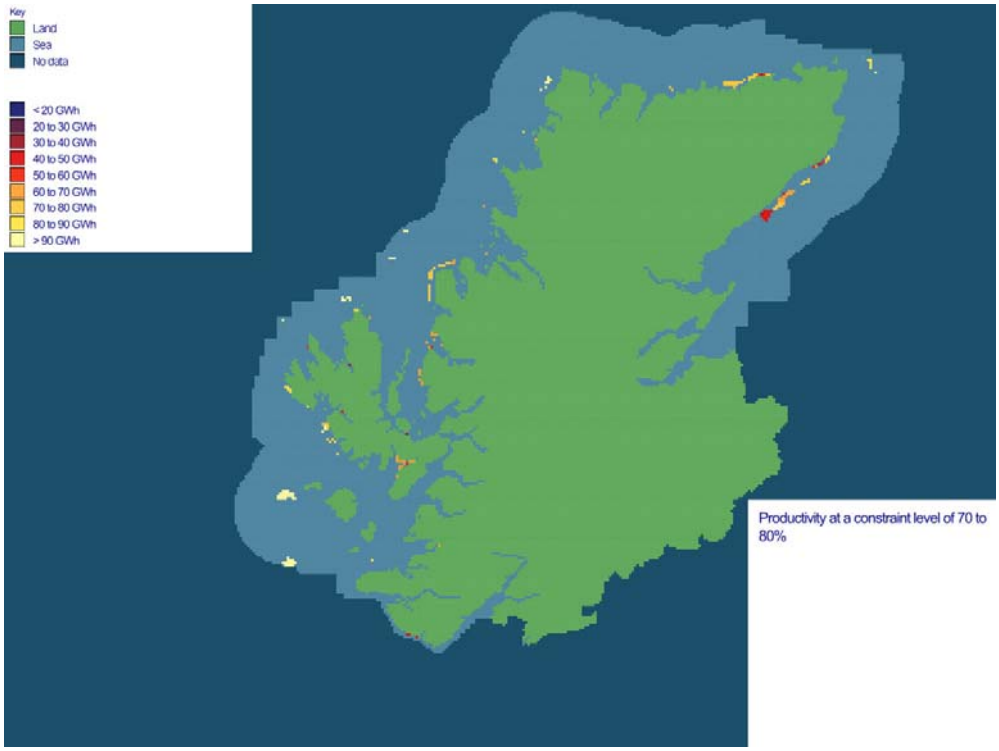


Figure 3.29 Offshore wind productivity under a moderately unconstrained planning regime (30 to 40% likelihood and 3p wholesale revenue)

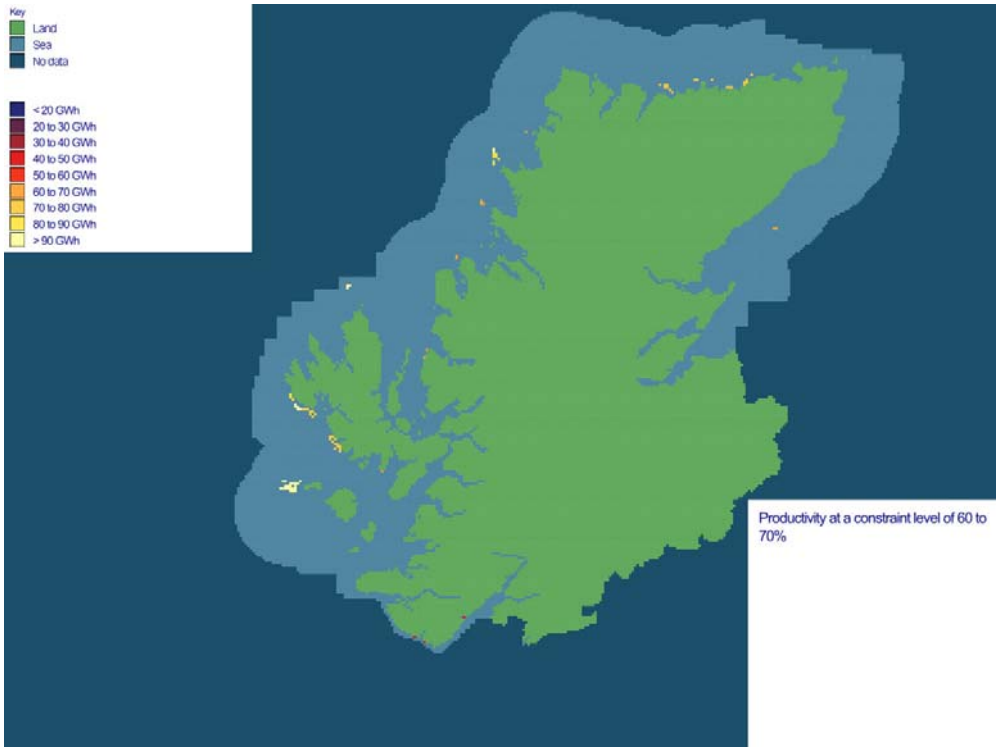


Figure 3.30 Offshore productivity under a moderate planning regime (40 to 50% likelihood and 3p wholesale revenue)

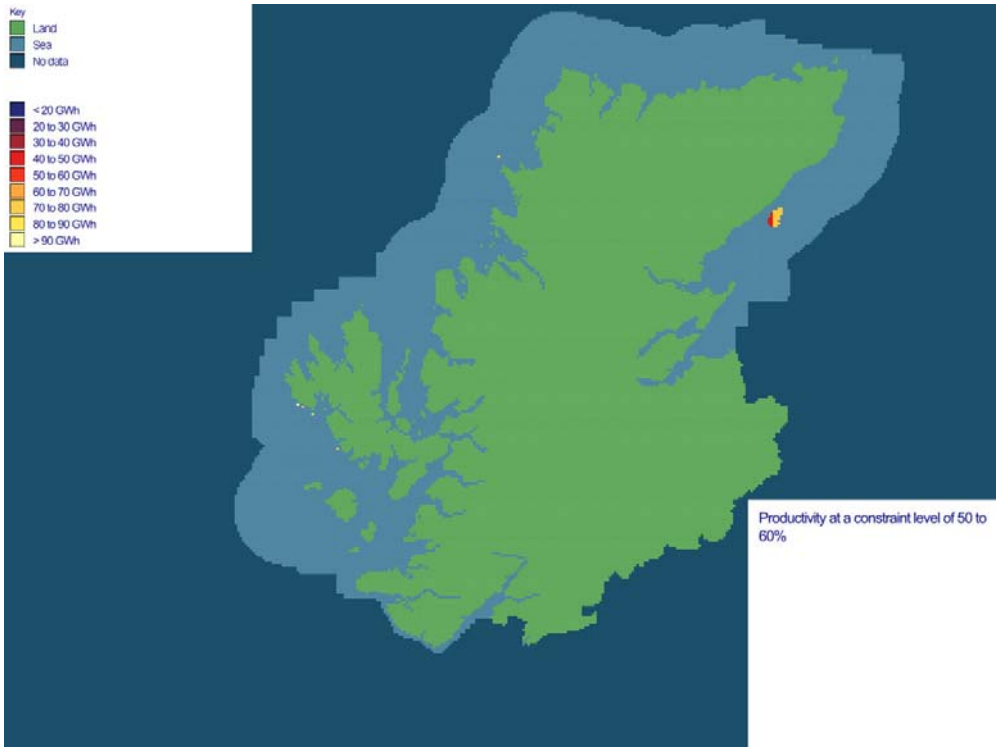


Figure 3.31 shows the prospective development areas identified by the RERA model. The table to the left of Figure 3.31 can be used to identify the areas by name and can also be used in conjunction with Table 3.6 and Table 3.7.

Table 3.6 and Table 3.7 rank the prospective development areas according to average and total values for power, constraint and cost (Table 3.6) and average values for power, constraint and cost (Table 3.7). Sites were also ranked by total values as well as average values to give an indication of the pros associated with large developments. For example a large development with a poor average will have a greater overall value for the site than a small development site with a higher average. This helps show that to obtain the equivalent power from one large development several small developments would be required. These could be widespread, resulting in greater costs and possible greater environmental impact.

Figure 3.31 Prospective offshore wind areas

Area	Number
Cape Wrath	1
Whiten Head	2
Coomb Island	3
Melvich	4
Sandy Riddle	5
Clyth Ness	6
Dunbeath Bay	7
Smith Bank	8
Tarbat Ledge	9
Ardnamurchan	10
Hawes Bank	11
Sea of the Hebrides	12
Sleat	13
SW Skye	14
Moonen Bay	15
Waternish Peninsula	16
Stoerhead	17

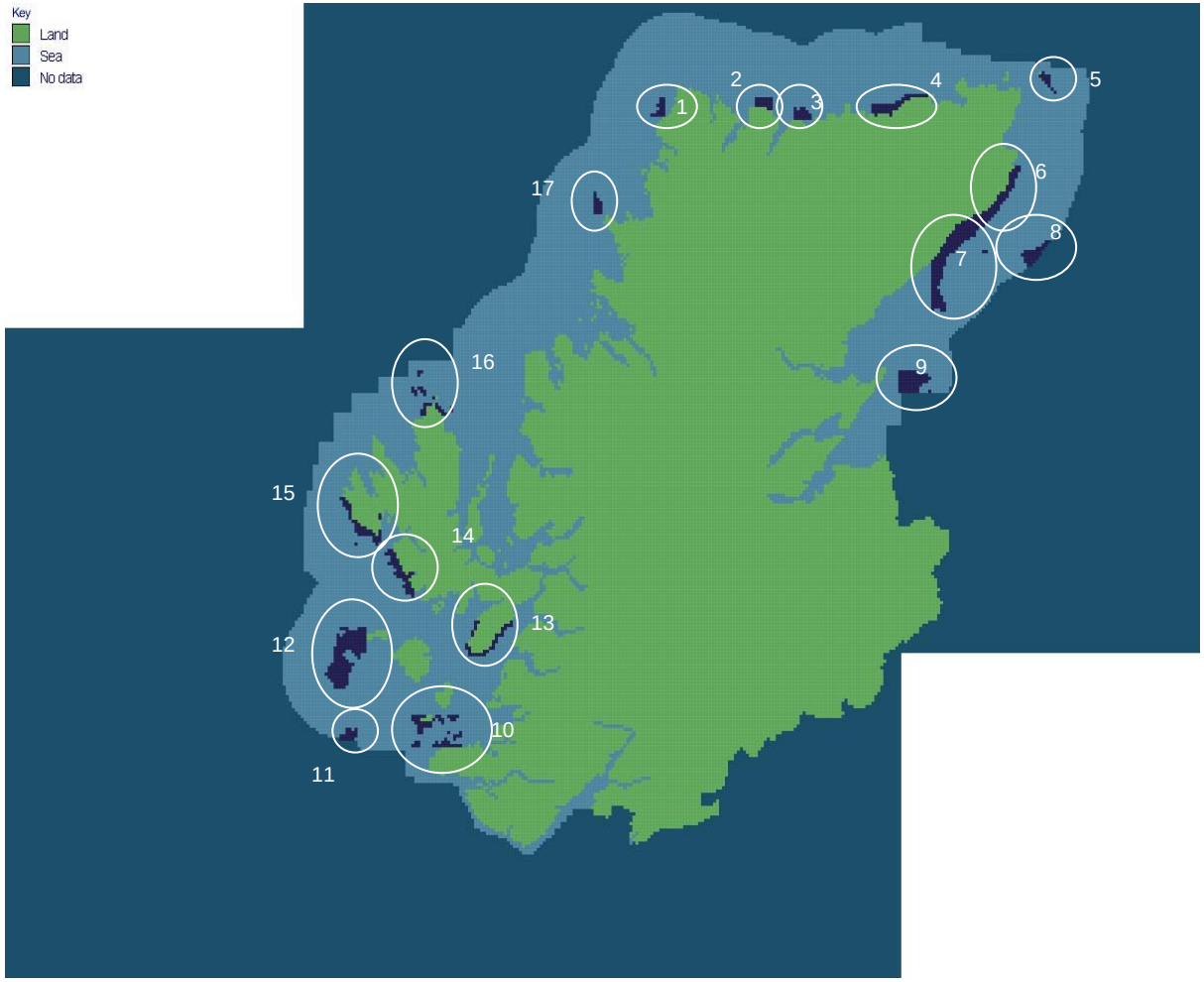


Table 3.6 Prospective search areas ranked according to average and absolute values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Total power (GWh)	Total power rank	Average constraint	Average constraint rank	Total constraint	Total constraint rank	Average cost	Average cost rank	Total rank
Smith Bank	31	87.1	6	2699.3	9	0.32	1	9.92	1	1.1	2	19
Hawes Bank	18	90.7	4	1632.2	11	0.79	7	14.22	4	1.1	2	28
Sea of the Hebrides	141	96.0	2	13537.4	1	0.79	7	111.39	17	1.1	2	29
SW Skye	45	75..2	1	3383.5	6	0.69	3	31.05	11	1.2	9	30
Moonen Bay	44	74.3	11	3269.3	7	0.61	2	26.84	9	1.1	2	31
Cape Wrath	17	93.4	3	1587.5	12	0.87	13	14.79	5	1.1	2	35
Stoerhead	16	88.2	5	1411.1	16	0.69	3	11.04	2	1.2	9	35
Sandy Riddle	14	82.1	8	1149.8	17	0.80	9	11.20	3	1.1	2	39
Waternish Peninsula	30	77.2	10	2314.8	10	0.83	11	24.90	8	0.9	1	40
Ardnamurchan	61	86.9	7	5303.3	3	0.93	17	56.73	14	1.1	2	43
Dunbeath Bay	119	60.5	15	7198.4	2	0.73	5	86.87	16	1.3	13	51
Whiten Head	20	77.5	9	1550.9	14	0.88	14	17.60	7	1.2	9	53
Melvich	42	68.7	14	2886.9	8	0.75	6	31.50	12	1.3	13	53
Tarbat Ledge	60	73.3	12	4399.8	4	0.91	16	54.60	13	1.3	13	58
Clyth Ness	87	48.3	16	4203.8	5	0.85	12	73.95	15	1.3	13	61
Coomb Island	20	73.1	13	1462.2	15	0.81	10	16.20	6	1.4	17	61
Sleat	34	46.3	17	1573.1	13	0.88	14	29.92	10	1.2	9	63

Table 3.7 Prospective search areas ranked according to average values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Smith Bank	31	87.1	6	0.32	1	1.1	2	9
Sea of the Hebrides	141	96.0	2	0.79	7	1.1	2	11
Hawes Bank	18	90.7	4	0.79	7	1.1	2	13
SW Skye	45	75..2	1	0.69	3	1.2	9	13
Moonen Bay	44	74.3	11	0.61	2	1.1	2	15
Stoerhead	16	88.2	5	0.69	3	1.2	9	17
Cape Wrath	17	93.4	3	0.87	13	1.1	2	18
Sandy Riddle	14	82.1	8	0.80	9	1.1	2	19
Waternish Peninsula	30	77.2	10	0.83	11	0.9	1	22
Ardnamurchan	61	86.9	7	0.93	17	1.1	2	26
Whiten Head	20	77.5	9	0.88	14	1.2	9	32
Dunbeath Bay	119	60.5	15	0.73	5	1.3	13	33
Melvich	42	68.7	14	0.75	6	1.3	13	33
Coomb Island	20	73.1	13	0.81	10	1.4	17	40
Sleat	34	46.3	17	0.88	14	1.2	9	40
Tarbat Ledge	60	73.3	12	0.91	16	1.3	13	41
Clyth Ness	87	48.3	16	0.85	12	1.3	13	41

3.3 Offshore wave

The offshore wave model was run with a universal development scenario of 40 750kW Pelamis devices per $km^{2,}$ unless that square was otherwise restricted by constraint factors (no devices per km^2).

The following section shows the results for the offshore wave model, including overall generating costs per km^2 (Figure 3.33), overall constraints per km^2 (Figure 3.34) and selected sites for offshore wave generation (Figure 3.35). Due to the nature of offshore wave energy and the Pelamis device, it is not possible to place Pelamis devices throughout the Highland area as it is for onshore and offshore wind turbines. Instead it was decided to place three strings of Pelamis farms at strategic points to utilise the full power of the wave front. The result can be seen in Figure 3.35.

Figure 3.32 Offshore wave energy

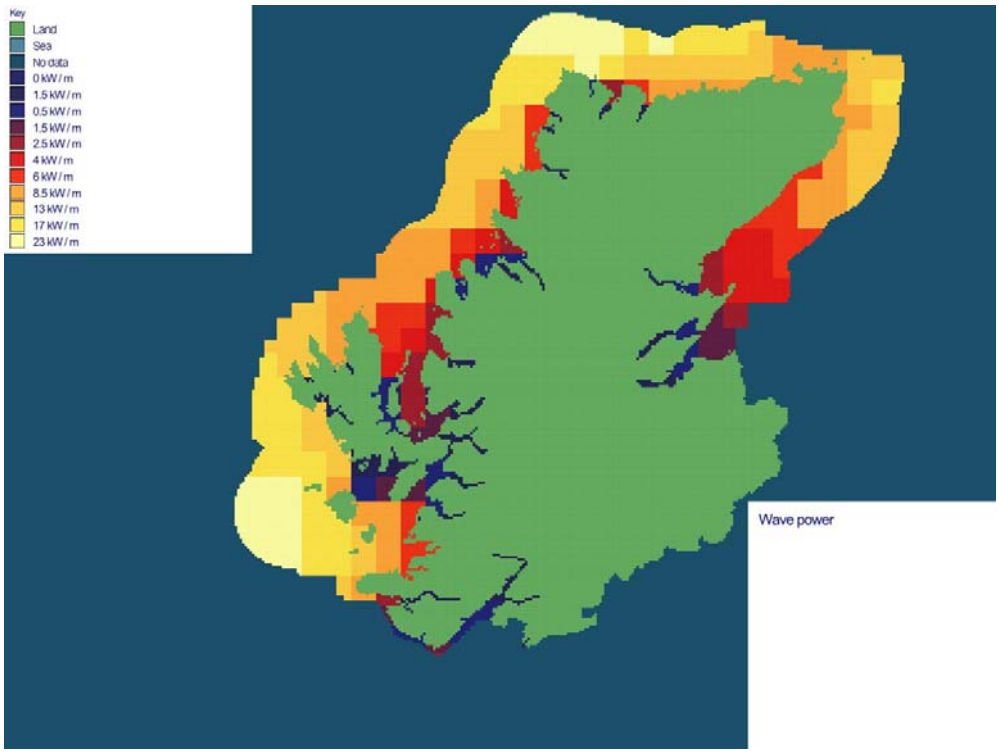


Figure 3.33 Offshore wave generation costs (excluding transmission)

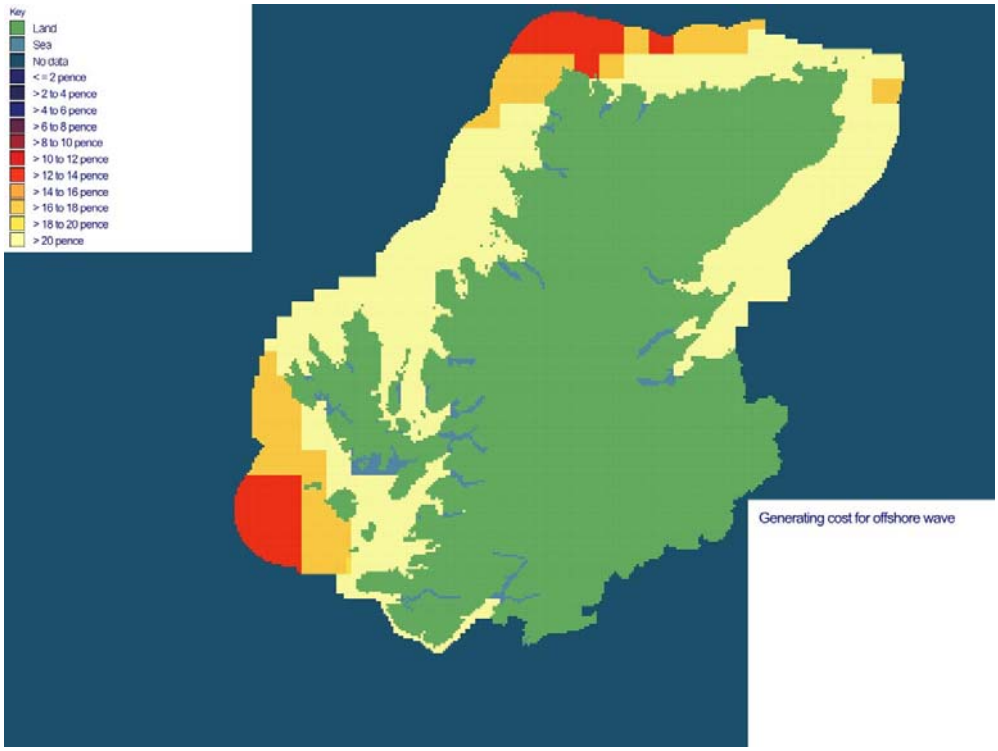


Figure 3.34 Offshore wave overall constraint levels

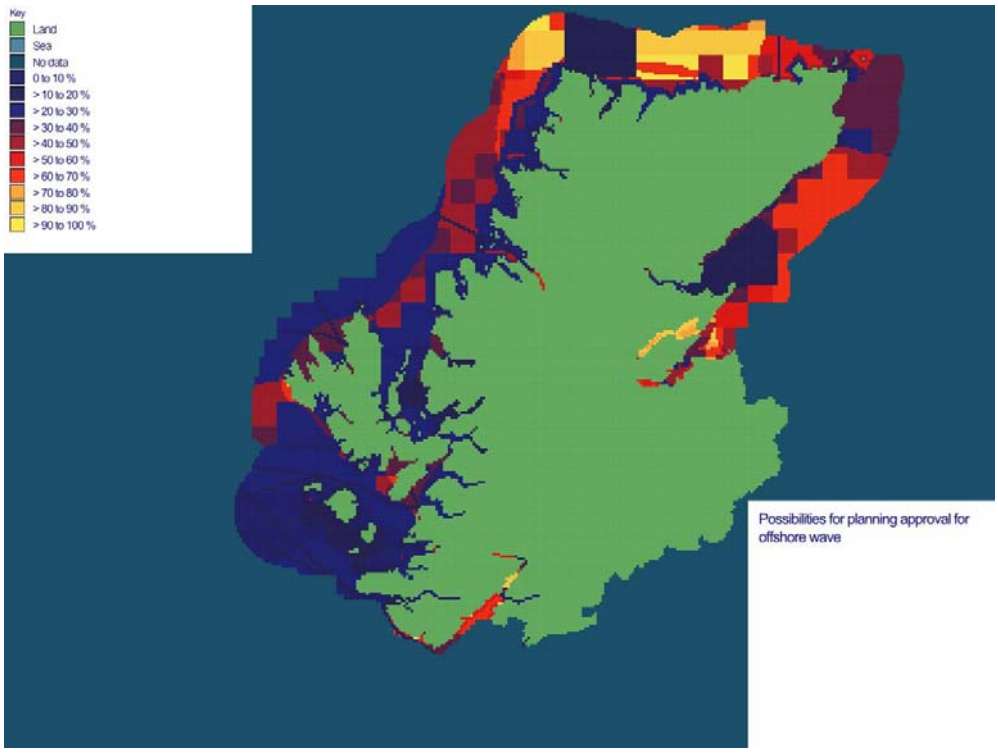


Figure 3.35 Selected offshore wave sites

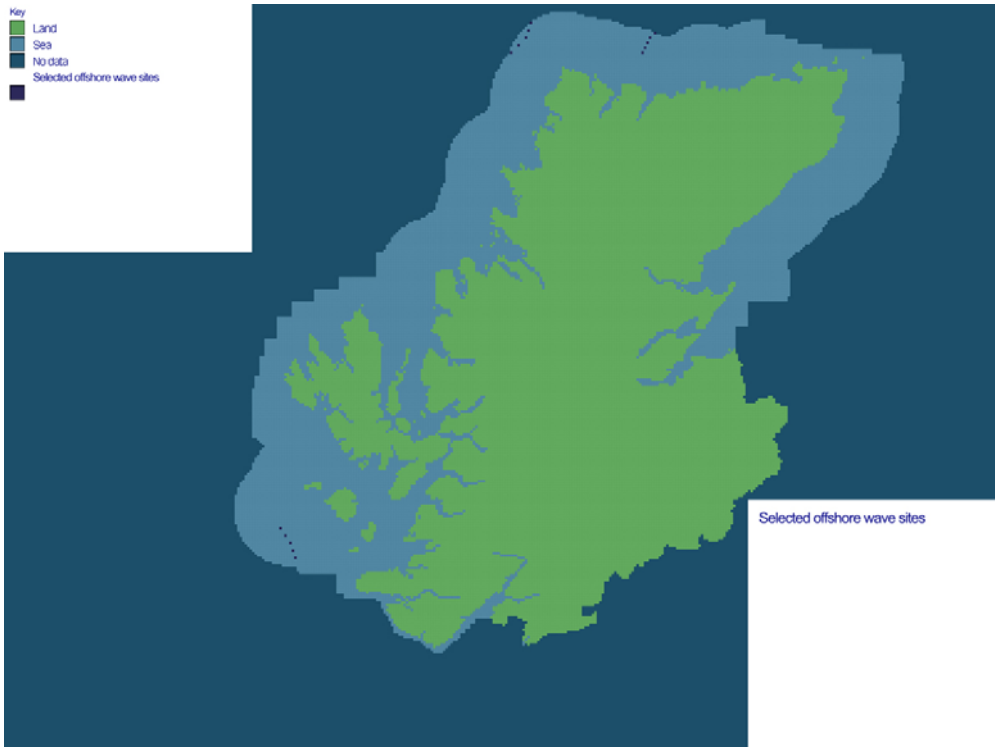


Table 3.8 and Table 3.9 rank the prospective development areas according to average and total values for power, constraint and cost (Table 3.8) and average values for power, constraint and cost (Table 3.9). Sites were also ranked by total values as well as average values to give an indication of the pros associated with large developments. For example a large development with a poor average will have a greater overall value for the site than a small development site with a higher average. This helps show that to obtain the equivalent power from one large development several small developments would be required. These could be widespread, resulting in greater costs and possible greater environmental impact.

Table 3.8 Table of outputs for offshore wave ranked by average and absolute values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Total power (GWh)	Total power rank	Average constraint	Average constraint rank	Total constraint	Total constraint rank	Average cost	Average cost rank	Total rank
Cape Wrath West	5	45.2	1	225.8	1	0.12	2	0.60	2	12.5	1	7
Sea of the Hebrides	5	45.2	1	225.8	1	0.92	3	4.60	3	12.5	1	9
Cape Wrath East	5	38.1	3	190.5	3	0.10	1	0.50	1	14.9	3	11

Table 3.9 Table of outputs for offshore wave ranked by average values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Cape Wrath West	5	45.2	1	0.12	2	12.5	1	4
Sea of the Hebrides	5	45.2	1	0.92	3	12.5	1	5
Cape Wrath East	5	38.1	3	0.10	1	14.9	3	7

3.4 Tidal current

The tidal current model was run to show the required number of tidal current devices required to extract the energy from the tide.

The following section shows the results for the tidal current model, including overall constraint levels per km^2 (Figure 3.37) and selected sites for tidal current generation (Figure 3.38). Due to the nature of the energy in tidal currents, it is not possible to place devices throughout the Highland area as it is for onshore and offshore wind turbines. Instead it was decided to place varying numbers of devices in km squares that best utilised the energy. Devices were places strategically to prevent the energy lost through one development being used in another. The result can be seen in Figure 3.38.

Figure 3.36 Tidal current speeds

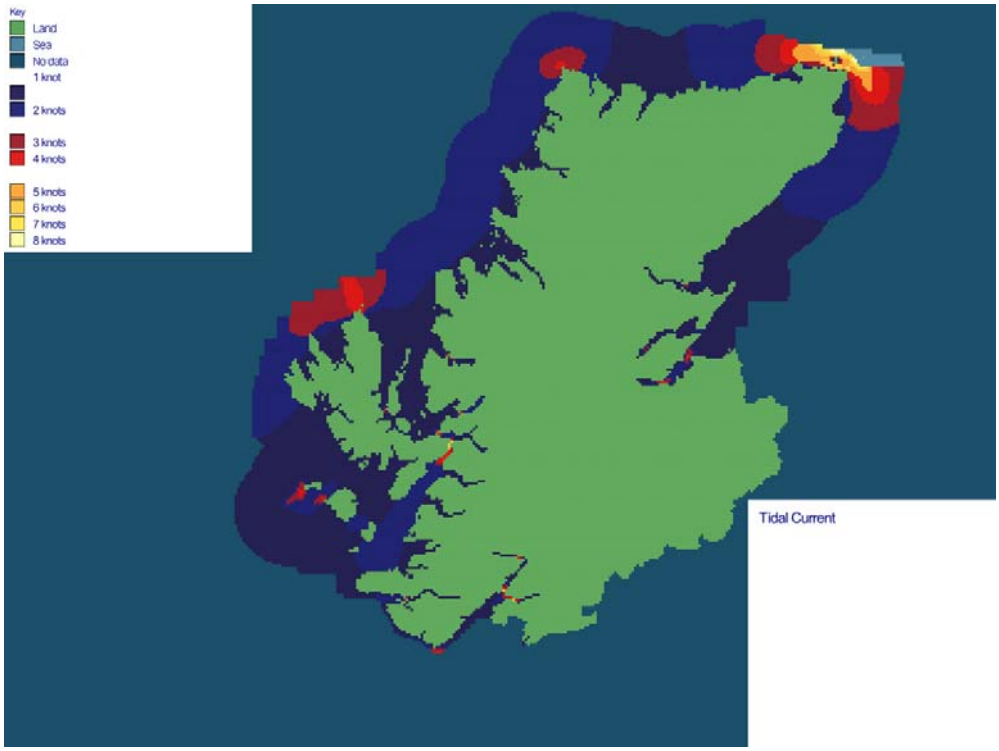


Figure 3.37 Tidal current overall constraint levels

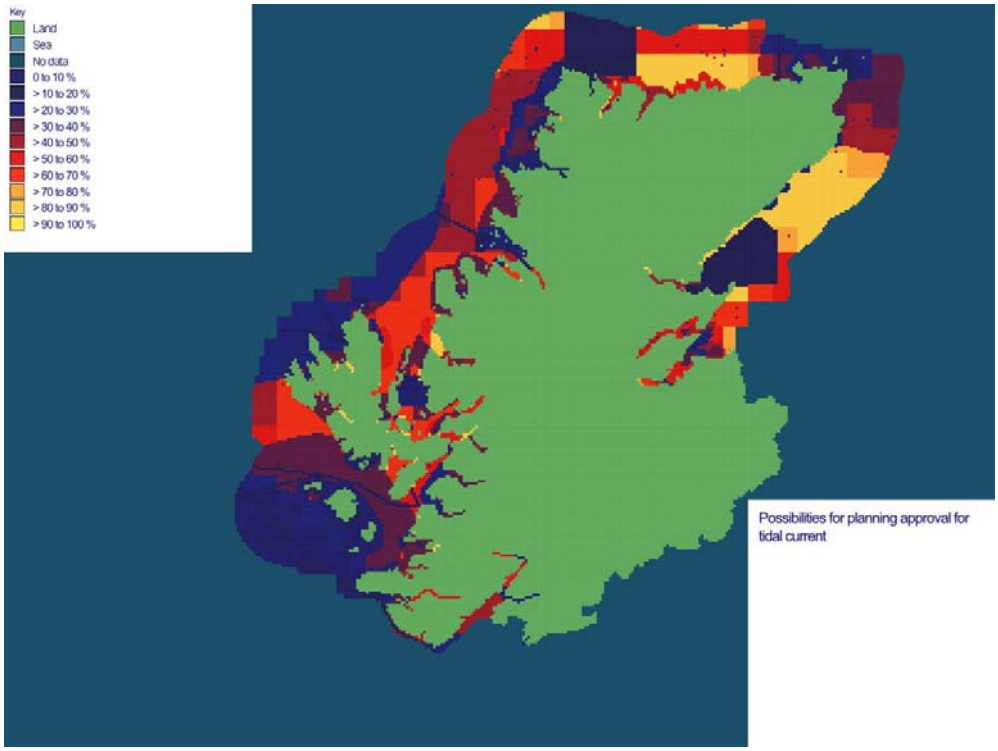


Figure 3.38 Selected tidal current sites

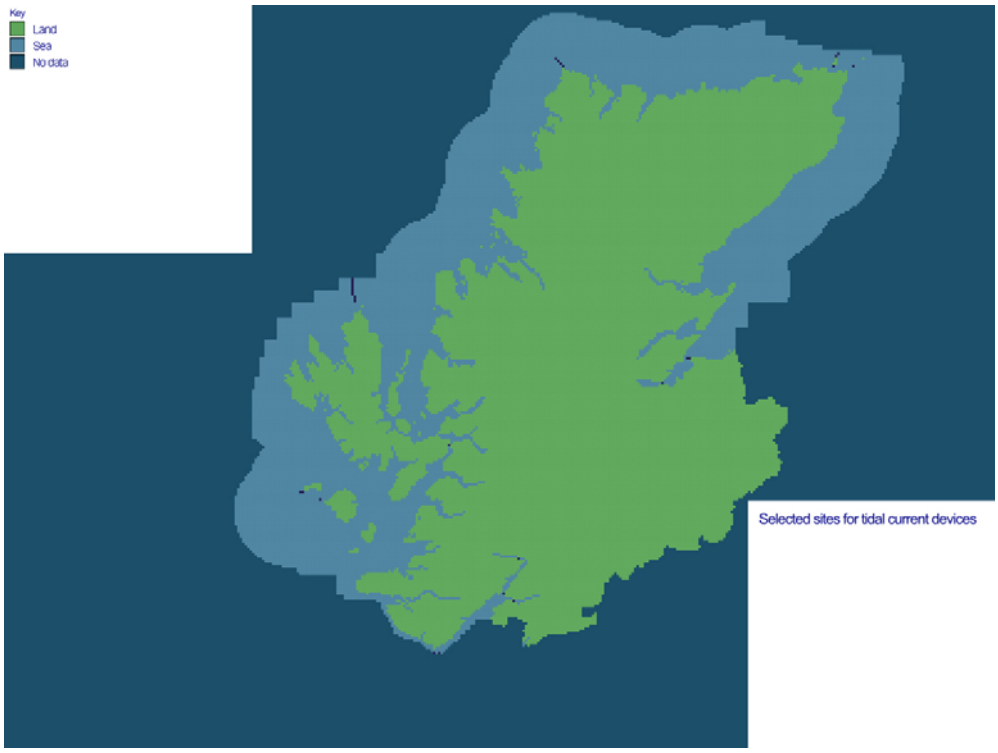


Table 3.10 and Table 3.11 rank the prospective development areas according to average and total values for power, constraint and cost (Table 3.10) and average values for power, constraint and cost (Table 3.11). Sites were also ranked by total values as well as average values to give an indication of the pros associated with large developments. For example a large development with a poor average will have a greater overall value for the site than a small development site with a higher average. This helps show that to obtain the equivalent power from one large development several small developments would be required. These could be widespread, resulting in greater costs and possible greater environmental impact.

Table 3.10 Table of outputs for tidal current ranked by average and absolute values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Total power (GWh)	Total power rank	Average constraint	Average constraint rank	Total constraint	Total constraint rank	Average cost	Average cost rank	Total rank
Kyle Rhea	1	185.5	6	185.5	8	0.37	1	0.37	1	1.7	3	19
Sound of Mull (East)	1	640.4	3	640.4	4	0.75	6	0.75	3	5.5	5	21
John O'Groats	1	1298.3	2	1298.3	3	0.80	10	0.80	6	1.6	2	23
North Stroma	2	1547	1	3093.9	2	0.78	9	1.56	12	0.9	1	25
The Minch	10	333.4	5	3333.6	1	0.72	5	7.20	14	5.5	5	30
Loch Leven	1	185.5	6	185.5	8	0.88	12	0.88	8	1.7	3	37
Sound of Mull (West)	1	514.5	4	514.5	6	0.95	15	0.95	10	5.5	5	40
Corran Narrows	1	98.5	11	98.5	12	0.76	7	0.76	4	5.6	8	42
Inverness	1	27.4	14	27.4	14	0.54	2	0.54	2	5.8	12	44
Cape Wrath	4	157.8	9	631.2	5	0.67	3	2.68	14	9.45	13	44
Loch Eil	1	54.7	12	54.7	13	0.76	7	0.76	4	5.7	10	46
Chanonry Point	2	54.7	12	109.5	11	0.69	4	1.38	11	5.7	10	48
Sound of the Hebrides (Rum)	1	182.7	8	182.7	10	0.87	11	0.87	7	13.2	14	50
Sound of the Hebrides (Canna)	2	128.6	10	257.3	7	0.91	14	1.82	13	5.6	8	52
Pentland Firth	1	22.8	15	22.8	15	0.88	12	0.88	8	13.7	15	65

Table 3.11 Table of outputs for tidal current ranked by average values for power, constraint and cost

Area	Number of technically feasible km squares	Average power (GWh)	Average power rank	Average constraint	Average constraint rank	Average cost	Average cost rank	Total rank
Kyle Rhea	1	185.5	6	0.37	1	1.7	3	10
North Stroma	2	1547	1	0.78	9	0.9	1	11
Sound of Mull (East)	1	640.4	3	0.75	6	5.5	5	14
John O'Groats	1	1298.3	2	0.80	10	1.6	2	14
The Minch	10	333.4	5	0.72	5	5.5	5	15
Loch Leven	1	185.5	6	0.88	12	1.7	3	21
Sound of Mull (West)	1	514.5	4	0.95	15	5.5	5	24
Cape Wrath	4	157.8	9	0.67	3	9.45	13	25
Corran Narrows	1	98.5	11	0.76	7	5.6	8	26
Chanonry Point	2	54.7	12	0.69	4	5.7	10	26
Inverness	1	27.4	14	0.54	2	5.8	12	28
Loch Eil	1	54.7	12	0.76	7	5.7	10	29
Sound of the Hebrides (Canna)	2	128.6	10	0.91	14	5.6	8	32
Sound of the Hebrides (Rum)	1	182.7	8	0.87	11	13.2	14	33
Pentland Firth	1	22.8	15	0.88	12	13.7	15	42

3.5 Hydro

Hydro schemes throughout the Highland region were not modelled, in the same way that wind, wave and tide were. Instead the RERA model was only used to display potential locations and not to interrogate the model to locate the most suitable locations.

Figure 3.39 Potential hydro schemes

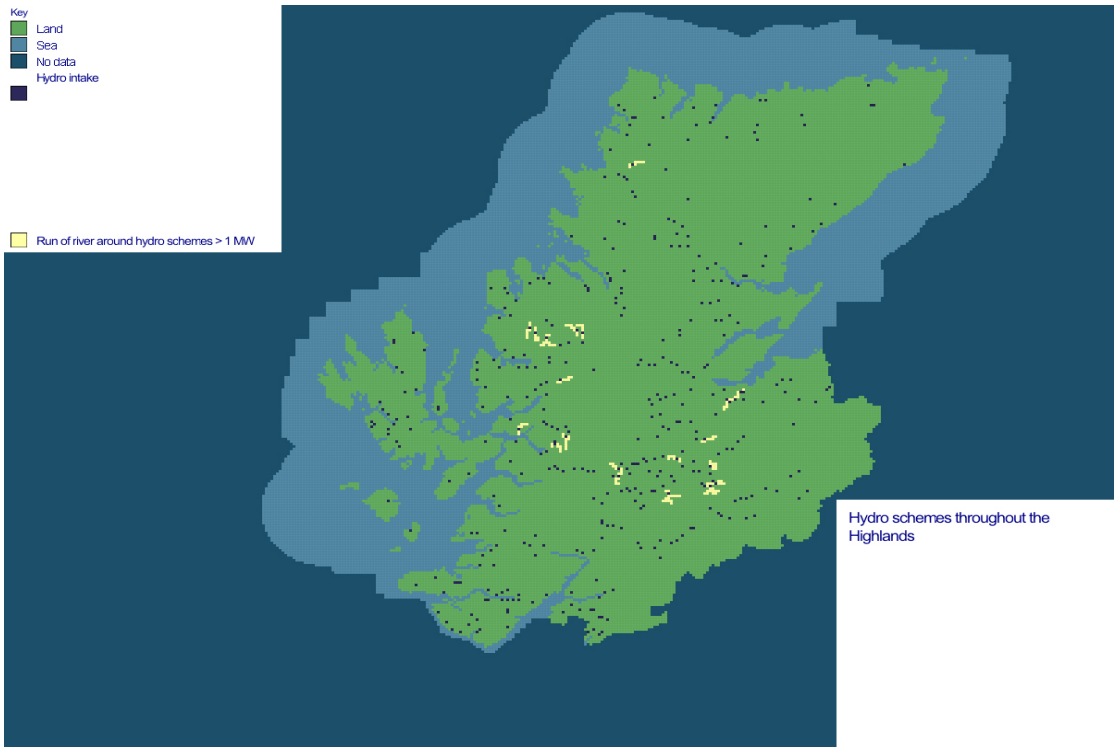


Figure 3.40 Potential hydro scheme capacities

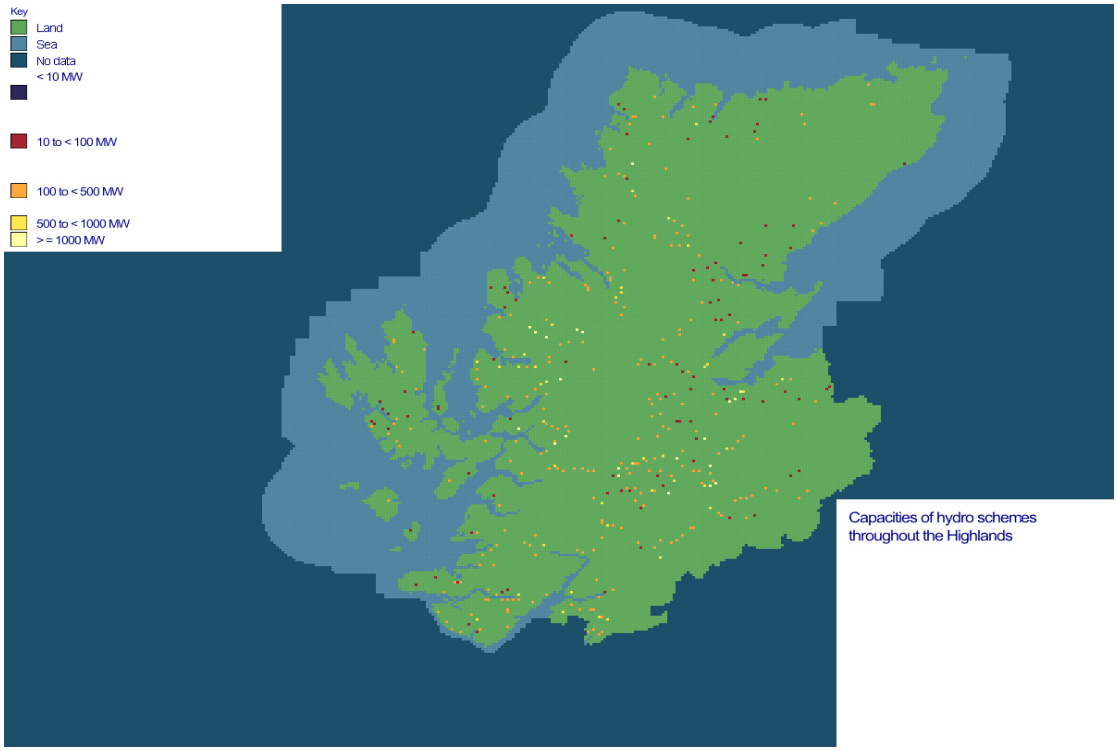


Figure 3.41 Hydro scheme constraint levels

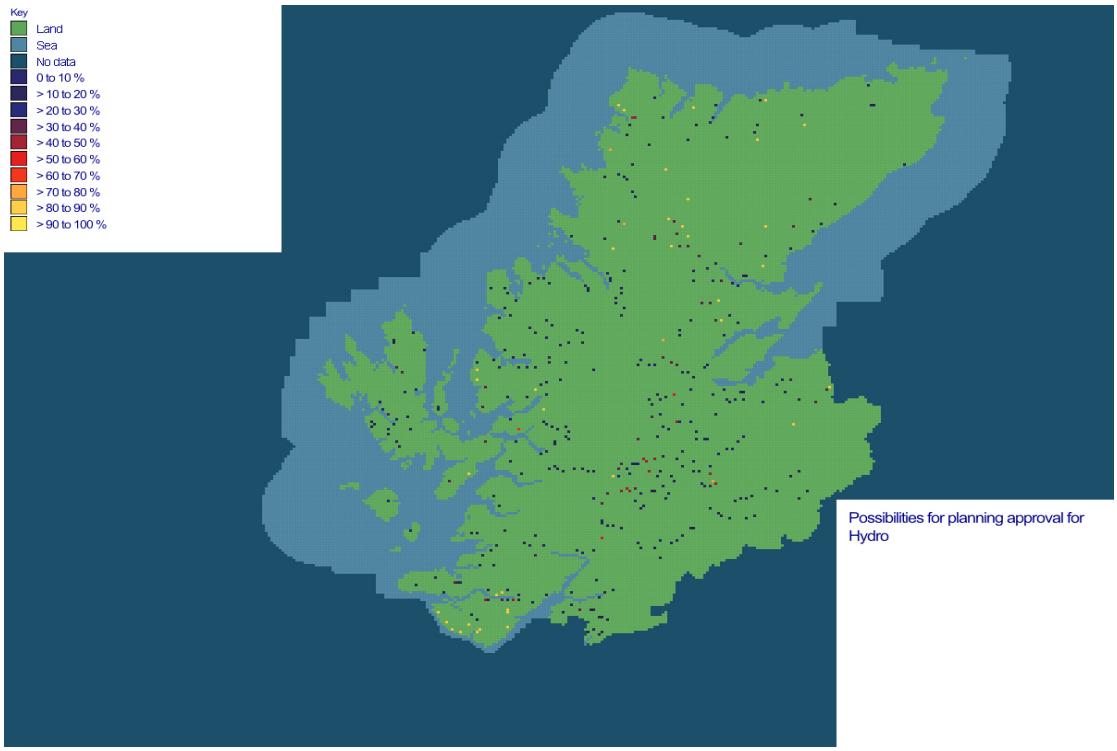


Figure 3.42 Prospective hydro schemes under a highly constrained planning regime

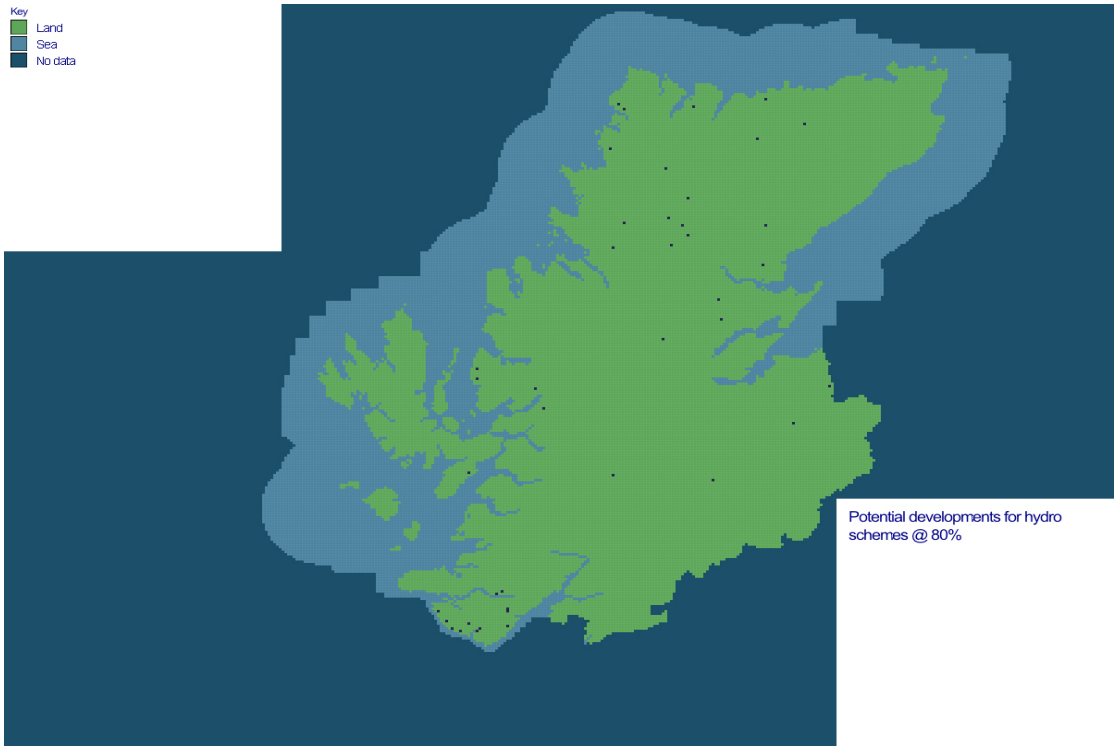


Figure 3.43 Prospective hydro schemes under a moderately constrained planning regime

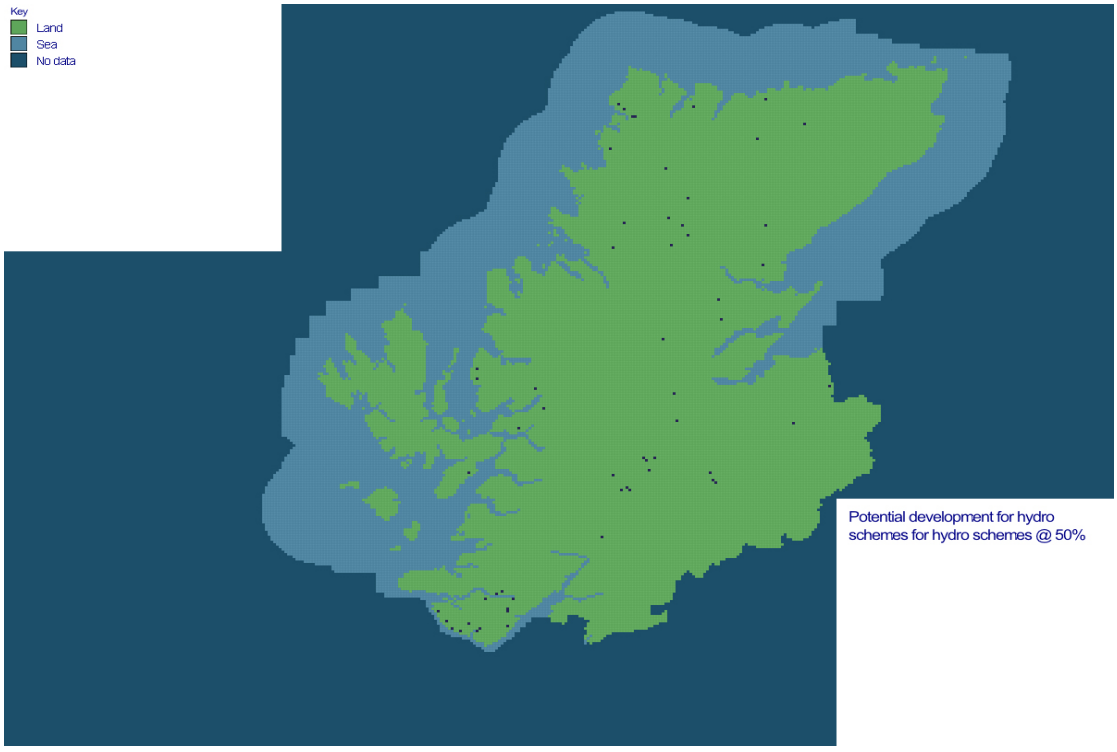
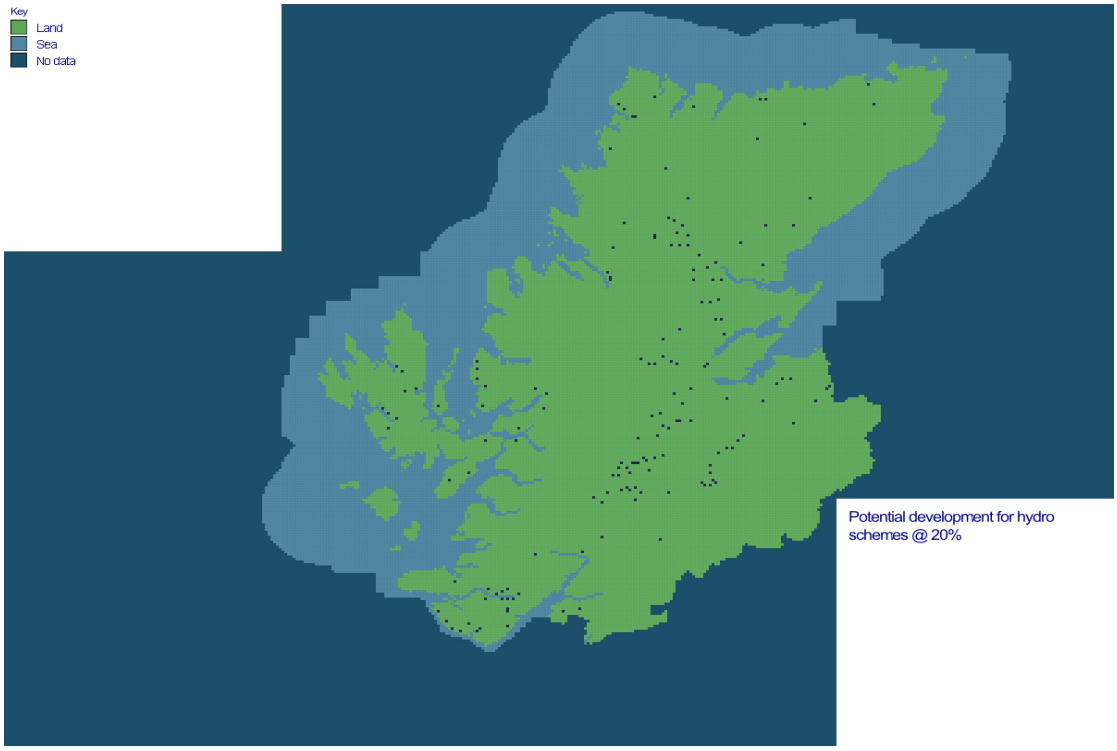


Figure 3.44 Prospective hydro schemes under a lightly constrained planning regime



4 Collated Capacity and Power Output Results

4.1 Onshore wind

The matrix below presents the build up of possible onshore wind capacity as planning pressures decrease and whole sale energy prices increase. Generally there should be a trend of lowest capacity and power levels in the bottom left quadrant and highest capacity and power outputs in the top right quadrant.

Figure 4.1 Cumulative energy production matrix for onshore wind given certain planning and wholesale price scenarios

		Generating cost (pence kWh $^{-1}$) excluding transmission cost									
		0 to 1	0 to 2	0 to 3	0 to 4	0 to 5	0 to 6	0 to 7	0 to 8	0 to 9	0 to 10
Percentage probability of obtaining planning permission	10 to 100 %	102.44	106.62	106.98	107.06	107.09	107.10	107.10	107.10	107.10	107.10
		13704	22674	29854	31856	34072	35804	36406	36842	37170	37650
	20 to 100 %	46.69	48.22	48.38	48.43	48.44	48.44	48.44	48.45	48.45	48.45
		6152	10120	13136	14212	15274	15964	16252	16446	16646	16918
	30 to 100 %	27.40	28.56	28.68	28.71	28.71	28.71	28.71	28.71	28.71	28.71
		4016	6288	8004	8560	9084	9468	9708	9838	9990	10150
	40 to 100 %	15.21	15.41	15.46	15.48	15.48	15.49	15.49	15.49	15.49	15.49
		2340	3588	4502	4750	4982	5156	5268	5324	5380	5428
	50 to 100 %	3.59	3.63	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66
		668	902	1104	1168	1232	1292	1316	1340	1356	1380
	60 to 100 %	3.00	3.04	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06
		572	770	932	964	1012	1056	1080	1104	1104	1112
	70 to 100 %	2.55	2.58	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		480	654	784	816	856	892	916	940	940	948
	80 to 100 %	1.59	1.62	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
		244	378	484	508	524	540	564	588	588	588
	90 to 100 %	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
		86	166	182	198	198	198	198	198	198	198
	100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0	0	0	0	0	0	0	0	0	0

Total available power for scenario (TW hrs yr $^{-1}$)
Installed capacity (MW)

The results show that under the most highly constrained conditions from a planning perspective all development would be curtailed. In fact planning considerations dominate the capacity levels that could be anticipated down to the 50% threshold. Below this level cost factors begin to have more of an impact.

The maximum installed capacity, at today's wholesale price of 6p per unit, is suggested to be 36,000 MW. However the maximum likely capacity, at the 80% threshold is 16,000 MW. This reduces to 1,300 MW under a mid way planning strategy and only 540 MW under a strict planning framework. Further analysis has shown the distribution of possible developments within the different sub-areas and wards that make up the highland area. These results are shown in Table 4.1 and Table 4.2 overleaf.

Figure 4.2 and Figure 4.3 show the relationships between generating cost, planning approval probability and power output. Figure 4.2 shows that onshore wind developments have a low generating cost (less than 1 pence per kWh). It also shows that overall the greatest amount of generating potential from onshore wind lies in areas that have a 0 to 10% chance of obtaining planning approval and that there is very little potential above a 40% chance of obtaining planning approval.

Figure 4.2 Cumulative power output for each cost and constraint combination for onshore wind

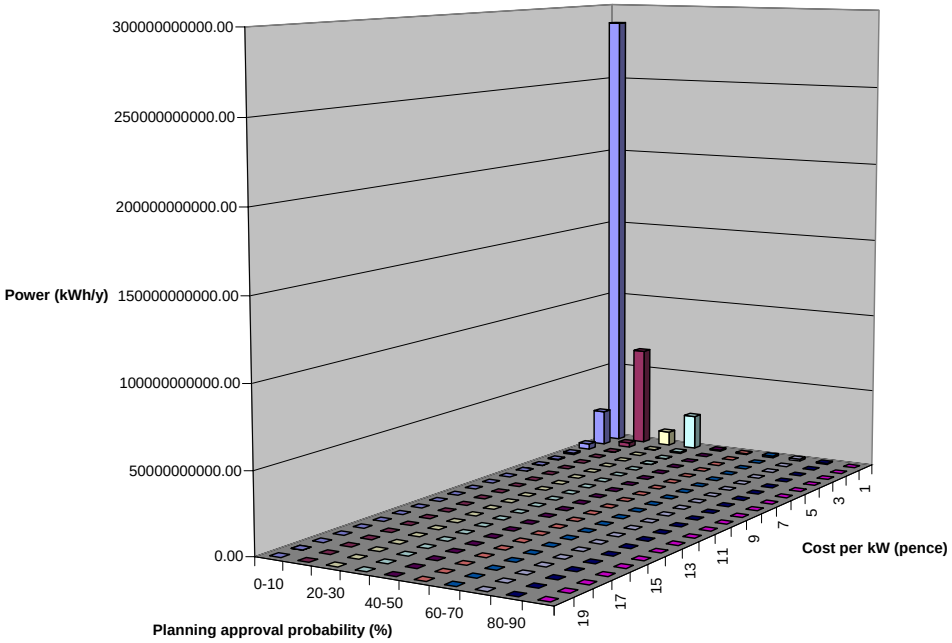


Figure 4.3 again shows that the majority of onshore wind developments have generating cost of less than 1 pence per kW hour. Potential generating power is fairly constant throughout the area with no particular constraint of land having a significantly higher potential power output.

Figure 4.3 Average power output for each cost and constraint combination for onshore wind

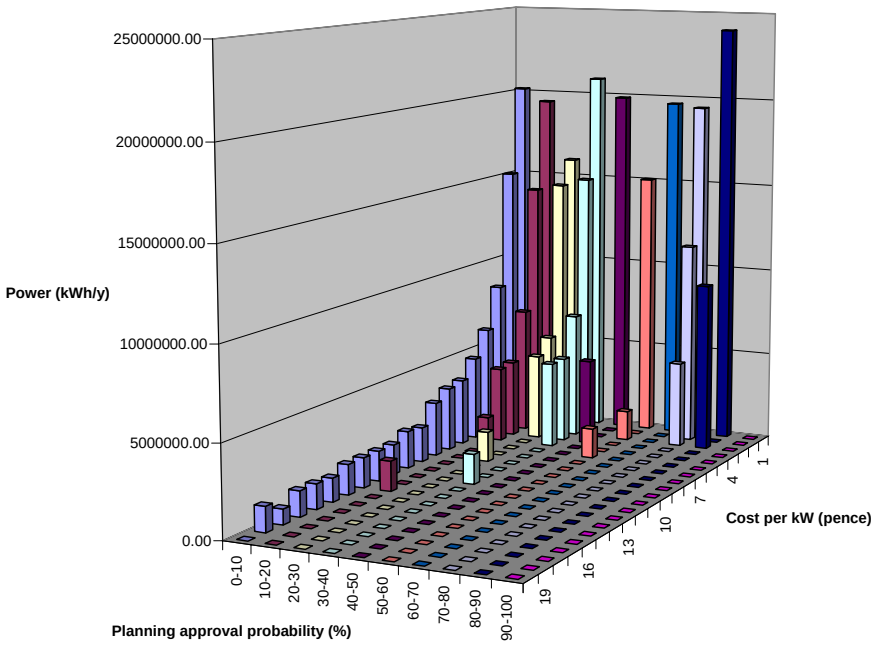


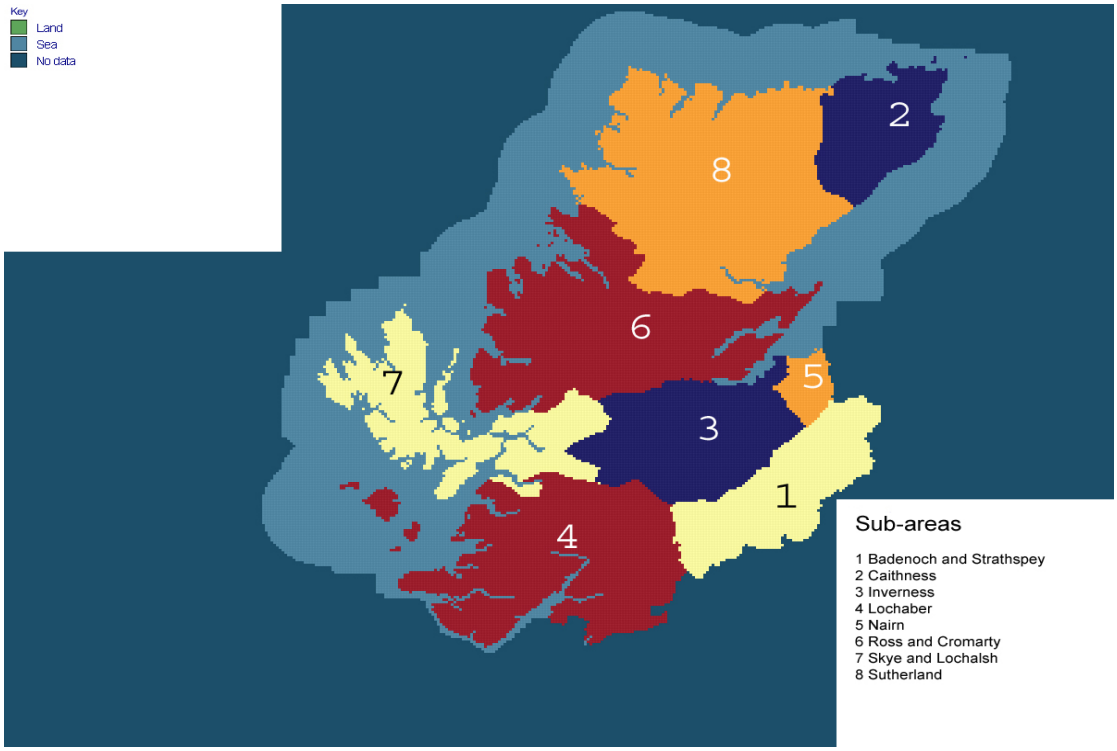
Table 4.1 Power outputs from onshore wind developments in various wards of the highland area under different levels of planning constraint. (All predictions made for 6 p wholesale energy price).

Ward	Energy output (GWh)		
	Highly constrained	Moderately constrained	Lightly constrained
Caithness North West	0	0	339
Thurso West	0	0	0
Thurso Central	0	0	10
Thurso East	0	0	0
Caithness Central	0	92	1151
Caithness North East	0	27	300
Wick	0	0	41
Wick West	0	0	0
Pulteneytown	0	0	0
Caithness South East	16	178	1301
Sutherland North West	0	0	1328
Tongue & Farr	21	74	2737
Sutherland Central	112	112	2130
Golspie & Rogart	0	65	991
Brora	182	219	3778
Dornoch Firth	145	231	1144
Lochbroom	0	0	0
Alness & Ardross	123	218	1278
Tain West	0	0	27
Tain East	0	0	0
Seaboard	0	0	5
Invergordon	0	0	0
Rosskeen & Saltburn	0	119	261
Gairloch	0	0	83
Lochcarron	0	4	1865
Ferindonald	0	26	194
Strathpeffer & Strathconon	36	36	381
Dingwall South	0	0	0
Dingwall North	0	11	38
Muir of Ord	0	0	5
Conon & Maryburgh	0	0	0
Knockbain & Killearnan	0	0	20
Black Isle North	0	0	139
Avoch Fortrose	0	0	75
Snizort & Trotternish	27	27	793
Skye West	109	136	1580
Portree	0	0	204
Skye Central	0	0	740
Kyle & Sleat	34	175	1868
Kinlochshiel	0	0	251
Beauly & Strathglass	0	72	1301
Kirkhill	0	0	43
Scorguie	0	0	0
Muirtown	0	0	0
Inverness Central	0	0	0
Culloden	0	0	0
Ardersier, Croy & Petty	0	0	5
Loch Ness West	0	0	2488
Inverness West	0	0	0
Ballifeary	0	0	0
Lochardil	0	0	0
Hilton	0	0	0
Crown	0	0	0
Raigmore	0	0	0
Loch Ness East	0	0	519
Culduthel	0	0	21
Inshes	0	0	0
Drumossie	0	279	4153
Westhill & Smithton	0	0	0
Balloch	0	0	0
Nairn Alltan	0	0	0
Nairn Ninian	0	0	16
Nairn Cawdor	0	11	76
Nairn Auldearn	0	46	905
Badenoch West	10	108	2006
Badenoch East	0	37	1056
Strathspey South	0	0	310
Strathspey North East	0	19	1406
Grantown on Spey	0	0	0
Mallaig & Small Isles	0	0	5
Kilmallie & Invergarry	0	5	382
Claggan & Glen Spean	0	10	768
Ardnamurchan & Morvern	802	1219	7193
Caol	0	0	0
Fort William North	0	0	0
Fort William South	0	0	15
Glencoe	25	100	649
Total	1642	3656	48374

Table 4.2 **Power outputs from onshore wind developments in various sub regions of the highland area under different levels of planning constraint. (All predictions made for 6 p wholesale energy price).**

Sub region	Energy output (GWh)		
	Highly constrained	Moderately constrained	Lightly constrained
1 Badenoch and Strathspey	10	164	4779
2 Caithness	16	296	3143
3 Inverness	0	352	8530
4 Lochaber	827	1332	9013
5 Nairn	0	57	998
6 Ross and Cromarty	159	414	4371
7 Skye and Lochalsh	170	338	5436
8 Sutherland	461	701	12109
Total	1643	3654	48379

Figure 4.4 **Sub-areas of the Highlands**



4.2 Offshore wind

The matrix below presents the build up of possible offshore wind capacity as planning pressures decrease and whole sale energy prices increase. Generally there should be a trend of lowest capacity and power levels in the bottom left quadrant and highest capacity and power outputs in the top right quadrant.

Figure 4.5 Cumulative energy production matrix for offshore wind given certain planning and wholesale price scenarios

Percentage probability of obtaining planning permission	Generating cost (pence kWh $^{-1}$) excluding transmission cost									
	0 to 1	0 to 2	0 to 3	0 to 4	0 to 5	0 to 6	0 to 7	0 to 8	0 to 9	0 to 10
10 to 100 %	1.53	59.35	62.20	62.42	62.45	62.52	62.55	62.55	62.55	62.55
	340	5980	9400	11660	14020	14200	16740	18440	18520	18900
20 to 100 %	0.96	31.07	32.72	32.72	32.74	32.78	32.78	32.78	32.78	32.78
	140	3040	5620	6700	7600	7700	8620	9560	9600	9720
30 to 100 %	0.29	14.82	15.40	15.40	15.42	15.42	15.42	15.42	15.42	15.42
	0	1440	2820	3320	3700	3760	3900	4280	4280	4300
40 to 100 %	0.00	7.44	7.89	7.89	7.91	7.91	7.91	7.91	7.91	7.91
	0	820	1220	1700	1980	2020	2040	2220	2220	2220
50 to 100 %	0.00	5.31	5.35	5.35	5.37	5.37	5.37	5.37	5.37	5.37
	0	800	1100	1120	1380	1400	1420	1420	1420	1420
60 to 100 %	0.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
	0	500	520	540	600	600	600	600	600	600
70 to 100 %	0.00	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07
	0	480	480	480	480	480	480	480	480	480
80 to 100 %	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	0	20	20	20	20	20	20	20	20	20
90 to 100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0	0	0	0	0	0	0	0	0	0
100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0	0	0	0	0	0	0	0	0	0

Total available power for scenario (TW hrs yr $^{-1}$)
Installed capacity (MW)

The results show that for offshore wind both planning constraints and costs can have a strong limiting influence. Offshore wind only becomes viable above 1p per unit for wholesale prices and planning consent for a significant scale of development only kicks in at the less than 80% likelihood level.

Figure 4.6 and Figure 4.7 show the relationships between generating cost, planning approval probability and power output. Figure 4.6 shows that offshore wind developments have a low generating cost (less than 3 pence per kWh). It also shows that overall the greatest amount of generating potential from offshore wind lies in areas that have a 0 to 10% chance of obtaining planning approval and that there is very little potential above a 40% chance of obtaining planning approval.

Figure 4.6 Cumulative power output for each cost and constraint combination for offshore wind

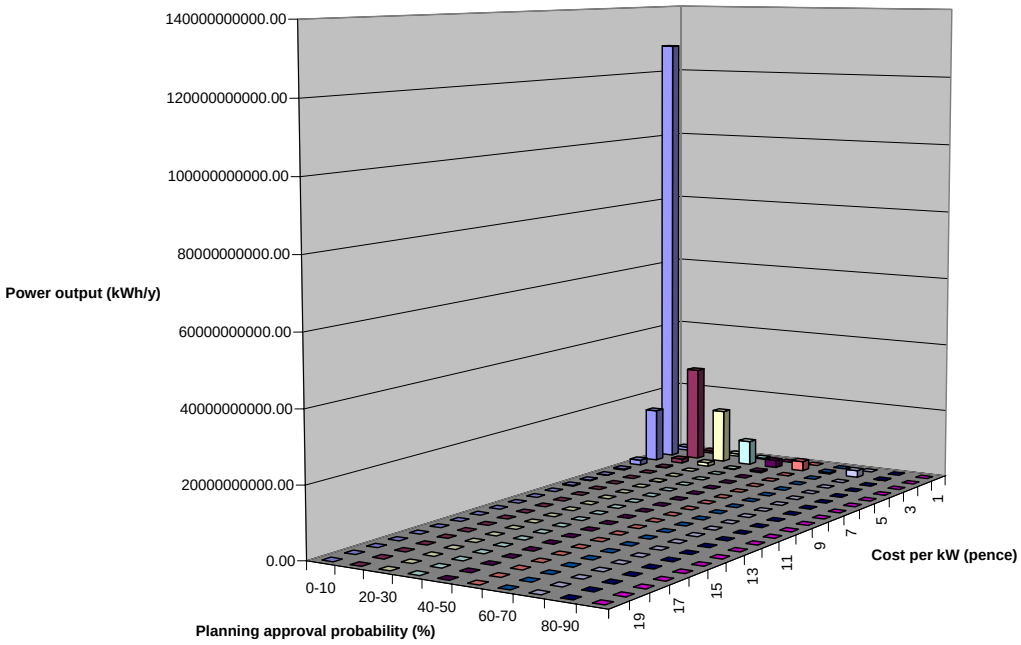
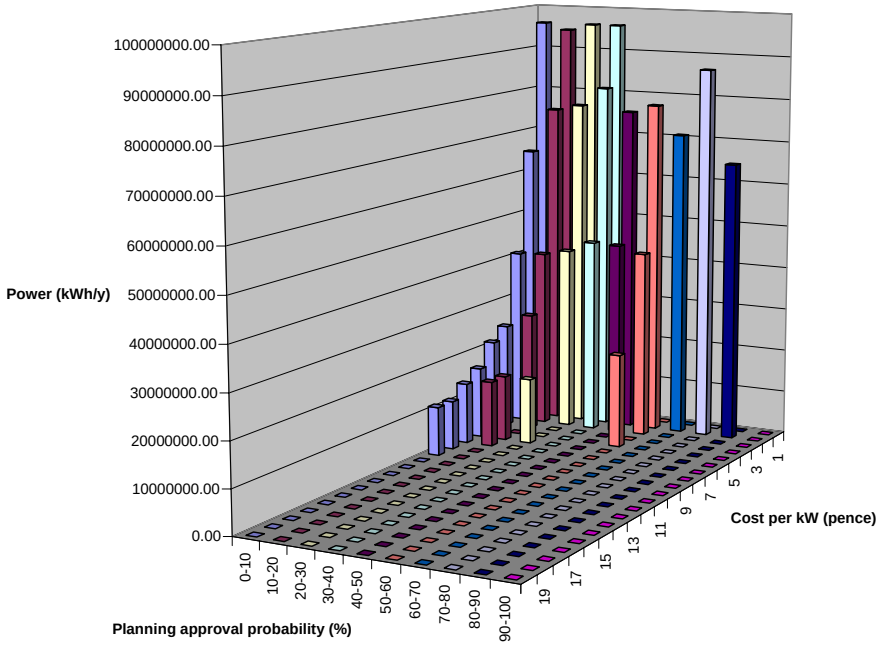


Figure 4.7 again shows that the majority of offshore wind developments have generating cost of less than 3 pence per kW hour. Potential generating power is fairly constant throughout the area with no particular constraint of sea having a significantly higher potential power output.

Figure 4.7 Average power output for each cost and constraint combination for offshore wind



4.3 Offshore wave

The potential development pattern for offshore wave technologies is complicated by fact that each device has the potential to interfere with the energy regime of devices next to it to a far greater degree than is the case for wind. This relates to the fact that with wave energy the devices are for the most part going to exploit the most energetic part of the wave, whereas for wind turbines work only in the bottom boundary layer of the atmosphere. The build up of capacity has therefore been expressed in terms of development area available in square kilometres. It can be seen from the results that even in the most highly constrained circumstances there is considered to be potential to develop wave farms over 42 km2 of sea area. However, in relation to the cost model the cheapest generation price anticipated in the waters of the Highland area is 12p per kWh. Based upon the assumptions used in the models it would suggest that wave energy may be uneconomic at current energy prices in the area. It is interesting to note that in similar studies in Orkney and Shetland more competitive costs were achieved due mainly to the higher levels of wave energy.

Figure 4.8 Cumulative energy matrix for offshore wave

		Generating cost (pence kWh $^{-1}$) excluding transmission cost									
		0 to 2	0 to 4	0 to 6	0 to 8	0 to 10	0 to 12	0 to 14	0 to 16	0 to 18	0 to 20
Percentage probability of obtaining planning permission	10 to 100 %	0	0	0	0	0	0	1116	1116	3331	3344
	20 to 100 %	0	0	0	0	0	0	536	536	2576	2582
	30 to 100 %	0	0	0	0	0	0	365	365	1627	1627
	40 to 100 %	0	0	0	0	0	0	364	364	1431	1431
	50 to 100 %	0	0	0	0	0	0	364	364	1128	1128
	60 to 100 %	0	0	0	0	0	0	364	364	1078	1078
	70 to 100 %	0	0	0	0	0	0	364	364	912	912
	80 to 100 %	0	0	0	0	0	0	323	323	821	821
	90 to 100 %	0	0	0	0	0	0	282	282	704	704
	100 %	0	0	0	0	0	0	42	42	42	42

Total area available for development (km^2)

Figure 4.9 and Figure 4.10 show the relationships between generating cost, planning approval probability and power output. Figure 4.9 shows that offshore wave developments have higher generating costs than wind developments (greater than 12 pence per kWh). It also shows that potential power developments are scattered throughout.

Figure 4.9 Cumulative power output for each cost and constraint combination for offshore wave

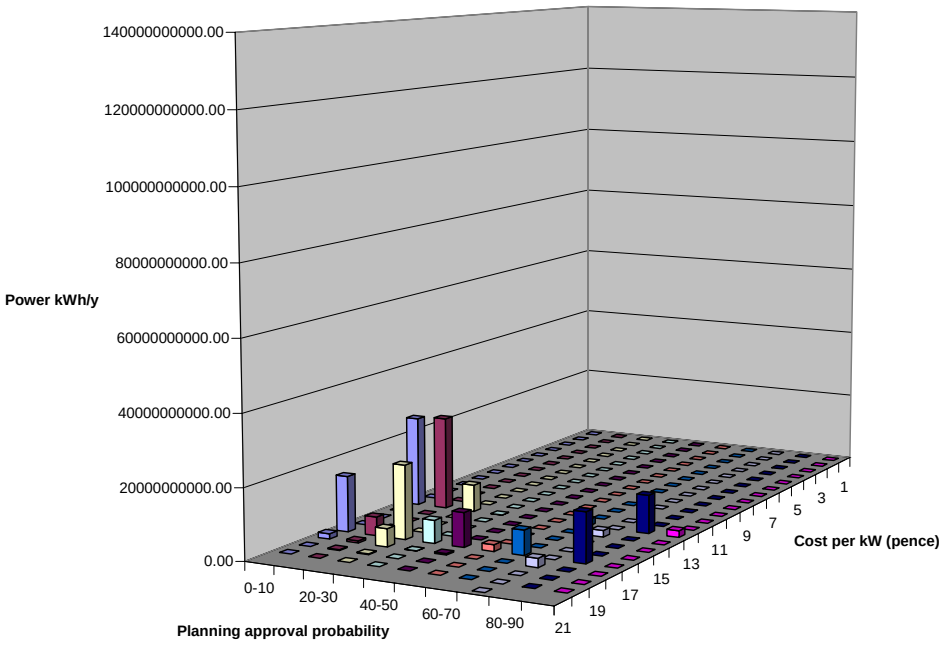
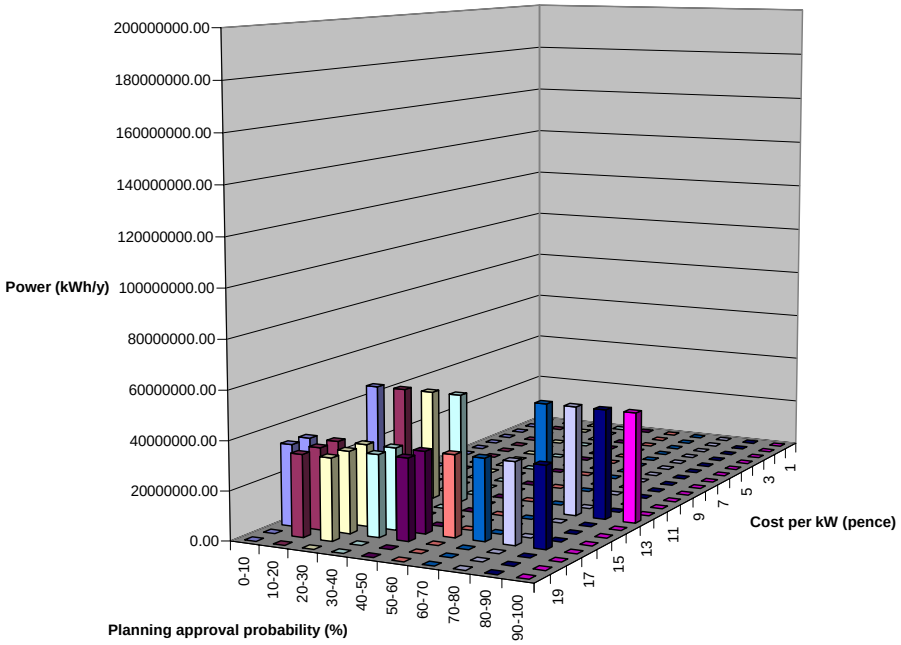


Figure 4.10 again shows that the majority of offshore wave developments have generating cost of greater than 12 pence per kW hour. Potential generating power is fairly constant throughout the area with no particular constraint of sea having a significantly higher potential power output.

Figure 4.10 Average power output for each cost and constraint combination for offshore wave



4.4 Tidal current

The matrix below presents the results for possible tidal current developments in the highland area. In this case a slightly different approach was used. Each individual tidal stream was considered on its own merits and its potential established. The matrix therefore shows how the various tidal stream area could come on stream given certain cost and constraint factors.

Figure 4.11 Cumulative energy matrix for tidal current (Letters in subscript indicate where tidal streams start to contribute to the energy production total, refer also to the tidal stream key below)

		Generating cost (pence kWh $^{-1}$) excluding transmission cost									
		0 to 1	0 to 2	0 to 3	0 to 4	0 to 5	0 to 6	0 to 7	0 to 8	0 to 9	0 to 10
Percentage probability of obtaining planning permission	10 to 100 %	2.50	4.76	4.76	4.76	4.76	9.18	9.18	9.18	9.18	9.18
		207	607_g	607	607	607	3539_h	3539	3539	3539	3539
	20 to 100 %	2.50	4.58	4.58	4.58	4.58	8.58	8.58	8.58	8.58	8.58
		207_d	571_e	571	571	571	3230_f	3230	3230	3230	3230
	30 to 100 %	0.00	0.19	0.19	0.19	0.19	0.32	0.32	0.32	0.32	0.32
		0	36	36	36	36	127_c	127	127	127	127
	40 to 100 %	0.00	0.19	0.19	0.19	0.19	0.21	0.21	0.21	0.21	0.21
		0	36	36	36	36	55_b	55	55	55	55
	50 to 100 %	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
		0	36	36	36	36	36	36	36	36	36
	60 to 100%	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
		0	36_a	36	36	36	36	36	36	36	36
	70 to 100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0	0	0	0	0	0	0	0	0	0
	80 to 100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0	0	0	0	0	0	0	0	0	0
	90 to 100 %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0	0	0	0	0	0	0	0	0	0
	100%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0	0	0	0	0	0	0	0	0	0

Total available power for scenario (TW hrs yr $^{-1}$)
Installed capacity (units)

Table 4.3 Tidal development key (to be used in conjunction matrix for tidal current)

Letter referred to in table	*Name of Development*
A	*Kyle Rhea*
B	*Inverness*
C	*Chanonry Point (Moray Firth)*
d	*Pentland Firth*
e	*North Stroma (Pentland Firth), John o' Groats*
f	*The Minch 1 to 9, Loch Eil, Corran Narrows, Sound of Mull 2*
g	*Loch Leven*
h	*The Minch 10, Sea of the Hebrides 1*

The results show that the optimal tidal stream in the highland area in terms of cost and constraint is Kyle Rhea. This is primarily due to the fast currents and low shipping levels that prevail in the area.

Figure 4.12 and Figure 4.13 show the relationships between generating cost, planning approval probability and power output. Figure 4.12 shows that tidal current developments generally have low generating costs. It also shows that potential power developments are mainly in high constraint (low planning approval probability) areas scattered throughout.

Figure 4.12 Cumulative power output for each cost and constraint combination for tidal current

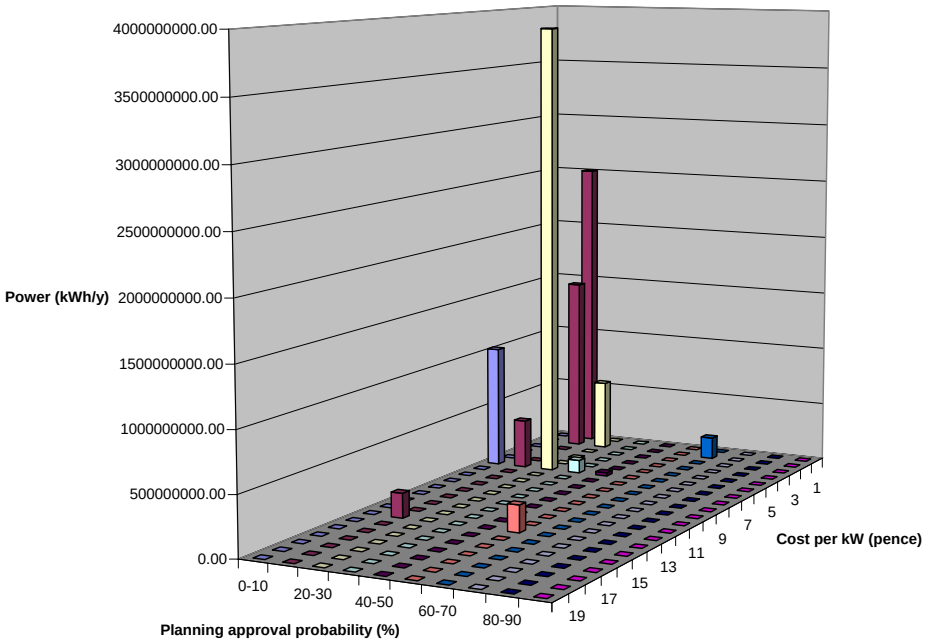
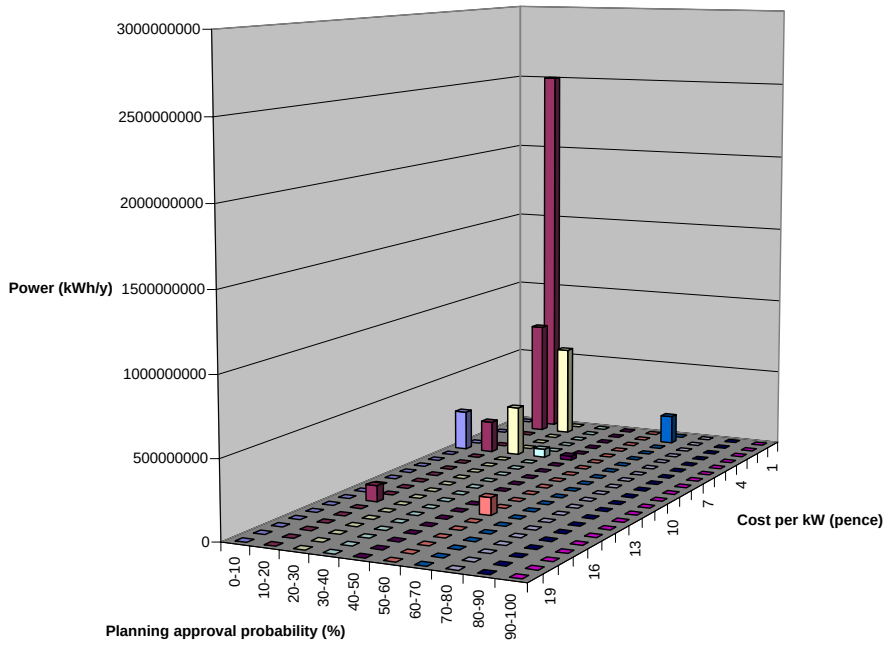


Figure 4.13 again shows that the majority of tidal current developments have generating costs of less than 2 pence per kW hour. Potential generating power is again limited to the high constraint areas.

Figure 4.13 Average power output for each cost and constraint combination for tidal current



4.5 Coastal wave

The matrix below shows the pattern of capacity build up for coastal wave developments. The scale of capacity for this technology is somewhat lower than for the other marine technologies and results are presented in GWh rather than TWh. It can be seen from the results that coastal energy schemes are predicted to be viable at current energy prices. It can also be seen that there is a predicted gradual build up in capacity as the threshold for planning approval is lowered.

Figure 4.14 Cumulative energy matrix for coastal wave

		Generating cost (pence kWh $^{-1}$) excluding transmission cost									
		0 to 1	0 to 2	0 to 3	0 to 4	0 to 5	0 to 6	0 to 7	0 to 8	0 to 9	0 to 10
Percentage probability of obtaining planning permission	10 to 100 %	0	0	0	0	2.9	5.9	35.7	56	62.8	69.6
		0	0	0	0	2	4	24	40	46	52
	20 to 100 %	0	0	0	0	2.9	5.9	35.7	50.0	56.8	63.7
		0	0	0	0	2	4	24	36	42	48
	30 to 100 %	0	0	0	0	2.9	5.9	26.7	35.8	42.7	49.5
		0	0	0	0	2	4	18	26	32	38
	40 to 100 %	0	0	0	0	2.9	5.9	20.8	27.6	32.2	36.7
		0	0	0	0	2	4	14	20	24	28
	50 to 100 %	0	0	0	0	2.9	5.9	17.8	24.6	29.2	33.7
		0	0	0	0	2	4	12	18	22	26
	60 to 100 %	0	0	0	0	2.9	2.9	14.8	19.4	21.7	23.9
		0	0	0	0	2	2	10	14	16	18
	70 to 100 %	0	0	0	0	2.9	2.9	11.9	14.1	14.1	16.4
		0	0	0	0	2	2	8	10	10	12
	80 to 100 %	0	0	0	0	0	0	0	2.2	2.2	4.5
		0	0	0	0	0	0	0	2	2	4
	90 to 100 %	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
	100 %	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0

Total available power for scenario (GW hrs yr $^{-1}$)
Installed capacity (MW)

4.6 Hydro

A number of new hydro schemes are being planned for the area. The capacity and possible power outputs from these schemes under differing constraint thresholds are shown below

Table 4.4 Possible annual energy and capacities for hydro schemes in the Highland area

	Highly constrained	**Moderately constrained**	***Lightly constrained***
Annual Energy (GWh)	36.7	64.3	*224.3*
Capacity (MW)	*8.1*	*14.1*	*49.0*

4.7 Biomass

The capacity for biomass production within the Highland area has been assessed on a different basis to the previous energy sources. The tables below present the key factors that have been used to develop an estimate for biomass related energy production. No cost factors have been established for this resource. Estimates have been made separately for biomass crops and for bio-digestion of slurries etc.

4.7.1 Crops

Details for crop production are provided below.

Anticipated production of cultivated crops

Poplar/willow	= 500 – 1000 tonnes per km ^{2}
Straw	= 500 tonnes per km^2
Generic crop production	= 500 tonnes per km^2
Energy output from biomass crops	= 1 kg biomass crop produces 1 kWh of energy

Table 4.5 Farmland areas and possible crop production

Category	*Highlands*
Arable / cultivated land	*999 km^2*
Grassland	*2493 km^2*
Commercial woodland	*1583 km^2*
Total area for growing crops	*3492 km^2*
Potential crop production	*1746000 tonnes*
Lower acceptability threshold area for growing biomass crops 50% of total	*1746 km^2*
High acceptability threshold areas for growing crops 10 % of arable	*99.9 km^2*
Lower acceptability crop production	*873000 tonnes*
High acceptability crop production	*49950 tonnes*
Maximum feasible production	*1746 GWh*
Lower acceptability energy output	*873 GWh*
High acceptability energy output	*50 GWh*

4.7.2 Wood fuel

Anticipated figures are shown below

Table 4.6 Wood fuel potential 2020

Forestry District	***Oven dried tonnes***	***GWh***
Dornoch	188,270	*790.734*
Inverness	270,943	*1,137.961*
Fort Augustus	170,884	*717.713*
Lochaber	136,726	*574.249*
Lorne	211,235	*887.187*
Total	*978,058*	*4,107.844*

4.7.3 Bio-digestion

Details for bio-digestion from slurry waste are provided below.

Table 4.7 Livestock wastes and possible associated energy production

	Holdings	Number	No/Holding	Volume Manure Litres/day	% Total Solids	Biogas Yield m3/tonne	No of animals to produce 1t/day	tonnes/day	tonnes/year	Energy Value of gas MJ/m3	Electricity MWh*	Heat MWh*
Dairy cattle	239	5002	20.93	55	12	25	30	166	30,012	25	1,594	1,876
Beef cattle	2071	90586	43.74	24	12	25	30	3,019	543,516	23	26,564	31,252
Other cattle (6 mnth - 1yr)	795	15164	19.07	19	8.7	20	40	379	68,238	23	2,668	3,139
Other cattle (under 6 mnth)	1447	33634	23.24	19	8.7	20	40	840	151,353	23	5,918	6,962
Bulls	958	2262	2.36	24	12	25	30	75	13,572	23	663	780
Total cattle	2114	146648	69.37						806,691		37,408	44,009
Sheep	3213	1156810	360.04								0	0

Pigs	99	24707	249.57	4	9.5	26	275	89	16,171	24	858	1,009
Poultry	974	244479	251.01	0.9	20	90	12,500	19	3,520	27	727	855
Overall total											76,400	89,882
10%											7,600	
20%											15,000	
50%											38,000	

4.8 Waste

Household and commercial wastes can be used in a number of ways to generate energy. Some 150,000 tonnes of waste are produced from these sources annually. Planned waste management strategies suggest that 30,000 tonnes could be organic waste suitable for bio-digestion, leaving perhaps 120,000 tonnes for incineration.

The Shetland district heating plant outputs 20-25 GWh of energy for a waste input of 17,500 tonnes annually. With 120,000 tonnes available energy from domestic and commercial waste in the Highland area could be in the range of 140 GWh.

4.9 Civil infrastructure

The possibility of using existing civil infrastructure as a base for renewables developments has often been suggested as an opportunity. The estimates below identify preliminary power output levels for three types of renewable technology. The first are small 20 kW wind turbines that could perhaps be fixed to or erected near existing structures such as bridges. The second are small scale tidal turbines that could be attached to bridge supports. The third is wave power generators attached to breakwaters.

Table 4.8 Potential areas and figures civil infrastructure developments

Description	Energy type	Resource level	Capacity	Capacity factors	Power production GWh
Ardersier works	Wind	7-8 m/s	500 m	20kW/50 m, @40%	0.7
Kessock bridge	Tidal stream	4 kts	2 supports	10kW/10m if>4kts	1.39
Cromarty bridge	Tidal stream	3 kts	30 supports	10kW/10m if>4kts	0
	Small wind	5-7 m/s	1000m long	20kW/50 m, @25%	0.9
Dornoch Bridge	Tidal stream,	3 kts	2 supports	10kW/10m if>4kts	0
	Small wind	5-7 m/s	800m long	20kW/50 m, @25%	0.7
Long pier into Cromarty Firth	Tidal stream	2 kts	10 supports	10kW/10m if>4kts	0
	Small wind	5-7 m/s	800m long	20kW/50 m, @25%	0.7
Helmsdale harbour	Wave	4 kW/m	100m long	40% availability, 40% conversion	0.6
Wick south pier	Wave	8.5 kW/m	200m length	X8700x0.4x0.4	2.4
Lybster pier	Wave	8.5 kW/m	50m length	40% availability, 40% conversion	0.6
Scrabster pier	Wave	8.5 kW/m	400m length	40% availability, 40% conversion	4,7
Kylesku Bridge	Tidal stream	2 kts	0 supports	0	0
	Small wind	5-7 m/s	100m long	20kW/50 m, @25%	0.09
Skye bridge minor span	Tidal stream,	4 kts	200m length	10kW/10m if>4kts	0.7
	Small wind	5-7 m/s	200m length	20kW/50 m, @25%	0.2
Skye bridge main span	Tidal stream	4 kts	300m	10kW/10m if>4kts	1.04
Mallaig harbour wall	Coastal wave	4 kW/m	300m length	40% availability, 40% conversion	1.4
Ballachulish Bridge	Tidal stream	6 kts	0 supports	10kW/10m if>4kts	0.7
White corries ski centre	Wind	9-10 m/s	1 km	20kW/50 m, @50%	1.7
Blackwater reservoir dam	Wind	5-7 m/s	500 m long	20kW/50 m, @25%	0.4
Anoch More ski centre	Wind	9-10 m/s	1 km	20kW/50 m, @50%	1.7
Overall total					**26.92**
Cautious (10%)					2.7
Moderate (20%)					5.4
Ambitious (50%)					13.5

Other options for utilising infrastructure for energy production relate to investing in bridges of barrages to replace ferry services and including power generation systems within the new structures. The potential energy available is outline where appropriate in Table 4.10.

Table 4.9 Possible ferry routes with the potential to generate tidal stream energy

Ferry replacement	Options	Speed	Available energy
Tobermory/Bunavulin	Tidal bridge/ barrage	2 kts	Stream too slow
Corran narrows	Tidal bridge/ barrage	5 kts	30 GWh
Kyle Rhea	Tidal bridge/ barrage	6 kts	27 GWh
Rassay sound	Tidal bridge/ barrage	3 kts	Stream too slow
Pentland Firth crossings	Tidal bridge/ barrage	7 kts	4000 GWh

4.10 Utility infrastructure

There are also possibilities of using existing utility infrastructure to generate power. Small turbines could be fixed to telegraph poles and larger turbines may be able to be incorporated into electricity pylons. Estimates of possible energy output are given below.

Table 4.10 Lengths of power lines in the Highland region and their potential to incorporate power production technologies

Powerline category	Length	Unit size	Units per km	Capacity (MW)	Capacity factor	*Output (GWh)*
11 kV	5333 km	1 kW	15	80	25	*208*
33 kV	2198 km	1 kW	10	22	25	*48*
132 kV	1229 km	200 kW	5	1230	30	*3,210*
Overall technical limit						*3,466*
Highly constrained (10%)						*350*
Moderately constrained (20%)						*700*
Lightly constrained (40%)						*1,400*

4.11 Micro generation

There are a number of micro energy generation units available now, particularly for wind and hydro. Such devices are easily incorporated into a domestic energy supply and their capacity potential has been based upon the percentage uptake by householders. The values are based on the figure of 90,000 dwellings in the Highland area.

Table 4.11 Potential micro wind generation under different technology types and varying levels of uptake

Turbine capacity	1% uptake	5% uptake	*10% uptake*
0.5kW	0.979 GWhrs	4.89 GWhrs	*9.79 GWhrs*
	450kW	2250kW	*4500kW*
1kW	1.96 GWhrs	9.79 GWhrs	*19.6 GWhrs*
	900kW	*4500kW*	*9000kW*

4.12 Energy efficiency

As with micro generation, energy efficiency has been assumed to operate at a per household basis in terms of the percentage saving on energy bills.

Table 4.12 Potential domestic energy savings in the Highland region

	5% savings	10% savings	*20% savings*
Potential energy savings (GWhrs)	*134.0*	*268.1*	*536.1*

The above values are based on the figure of 90,000 dwellings in the Highland region and the annual energy use of detached properties shown in Table 4.13.

Table 4.13 Domestic energy performance indicators

	Fossil fuel use due to space heating and domestic hot water (kWh/dwelling)	*Electricity use[1] (kWh/dwelling)*
Detached	25,875	*3,910*
Semi-detached	19,210	*3,145*
Terraced	16,929	*2,916*
Purpose built flats	9,086	*1,947*
Converted flats	10,140	*2,340*
Not self contained[2]	5,070	*1,170*
Other household spaces not self contained[2]	*5,070*	*1,170*

Notes: [1] includes lights, appliances and electric cooking
[2] 'Not self contained' and 'Other household spaces not self contained' have been assumed to consume half as much energy as one 'Converted flat'

An indication of the energy savings that could be achieved from larger community facilities can be seen from the figures for large schools in the Highland area presented below.

Table 4.14 Energy performance indicators for 60 selected larger schools in the Highlands

	Fossil fuel use due to space heating and domestic hot water* (GWh)	*Electricity use (GWh)**
Total	57.0	*8.22*
5% saving	2.85	*0.411*
10% saving	5.70	*0.822*
20% saving	*11.4*	*1.64*

* The UK potential for community heating with combined heat & power (Carbon Trust)

4.13 Research & development

As well as commercial production of energy there is also potential for research and development projects to provide important generation capacity. In adjacent areas such as Orkney where there are wind wave and soon tidal test facilities, research and development activities have provided important input to overall renewables development. In the Highland areas the Beatrice offshore wind scheme is starting in an experimental phase. Other part funded development projects are being, and will be developed, in the area. These developments could perhaps reach 20MW in total capacity with a power output of around 52,200 GWh.

4.14 Overall combined power outputs

The table below collates all of the results for each of the individual energy sources under each development scenario.

Table 4.15 Levels of energy production (GWh) under different development scenarios

Resource type	Highly constrained	Moderately constrained	*Lightly constrained*
Onshore wind	1,644	3,655	*48,378*
Offshore wind	65	5,350	*32,716*
Offshore wave	0	0	*0*
Coastal wave	0	3	*3*
Tidal stream	0	190	*8,580*
Tidal head	0	0	*0*
Tidal barrage	0	0	*0*
Biomass (crops)	50	879	*1746*
Biomass (wood fuel)	1027	2054	*3081*
Biomass (slurry)	7.6	15	*38*
Waste	40	60	*100*
Hydro	36.7	64.3	*224.3*
Civil infrastructure	2.7	5.4	*13.5*
Utility infrastructure	350	700	*1400*
Micro generation	1.96	9.79	*19.6*
Energy efficiency (saving)	134	268	*536*
Research & development	13	26	*52*
Overall total	3,371.96	13,279.49	*96,887.40*

Existing wind (inc approved)	713	713	*713*
Existing hydro (capacity MW)	*1,800*	*1,800*	*1,800*

It can be seen from these results that the wind related resources are likely to dominate highland area energy production under any of the possible development scenarios. Offshore wind holds particularly good development potential under both moderately and lightly constrained scenarios.

Appendices: Specific resource parameters

The following sub sections detail the factors that were applied to each of the resource types

Appendix A - Onshore wind

Constraints

Raster	Subset	Default	*Comments*
Visibility from Munros & Corbetts	1	0.9	*Each km^2 was scored depending on the number of Munros & Corbetts seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.*
	2	0.7	
	3	0.5	
	4	0.4	*(Source: Macaulay Institute)*
	5	0.3	
	6	0.2	
	7	0.1	
Visibility from dwellings	1	1	*Each km^2 was scored depending on the number of dwellings seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.*
	2	0.9	
	3	0.8	
	4	0.7	*(Source: Macaulay Institute)*
	5	0.6	
	6	0.5	
	7	0.4	
	8	0.3	
	9	0.2	
	10	0.1	
	11	0	
Visibility from tourism & recreation centres	1	0.8	*Each km^2 was scored depending on the number of tourism & recreation centres seeing a point. Two distances were also introduced with the closest distance band scoring greatest.*
	2	0.7	
	3	0.5	*(Source: Macaulay Institute)*
	4	0.3	
	5	0.2	
	6	0.1	
Visibility from The West Highland Way	1	0.9	*Each km^2 was scored depending on the number of km^2 points along the West Highland Way seeing a point. Three distance bands were also introduced with the closest distance band scoring greatest.*
	2	0.7	
	3	0.5	*(Source: Macaulay Institute)*
	4	0.4	
	5	0.3	
	6	0.2	
	7	0.1	
Visibility from designated viewpoints	5 km	0.2	*Concentric bands of up to 5km, 5 to 10km and 10 to 15km were plotted. Any squares falling in these bands were assigned the relevant values.*
	10 km	0.4	
	15 km	0.6	*(Source: Macaulay Institute)*
Airport exclusion zones	All development	0	*Airport exclusion data was used to constrain development in various areas around the two major airports in the Highlands. Any developments that exceeded the heights listed for that square were prohibited. The 30km buffer is the recommended exclusion for turbine developments due to radar interference.*
	All exceeding 10.7m	0.7	
	All exceeding 15.2m	0.7	*(Source: Highlands Council GIS)*
	All exceeding 45.7m	0.7	
	All exceeding 91.4m	0.7	
	30km buffer	0.8	
Telecommunications	Mast	1	*Locations of telecommunication masts and microwave links. (Source Highlands Council)*
	Microwave link	0	
International Biological Conservation	Ramsar	0.2	*Locations of Internationally recognized conservation areas.*
	SPA	0.2	*(Source: Highlands Council GIS)*
	SAC	0.2	
National Biological Conservation	SSSI	0.3	*Locations of Nationally recognized conservation areas.*
	NNR	0.3	*(Source: Highlands Council GIS)*
	National Park	0.3	
Local Biological Conservation	Local Nature Reserve	0.5	*Locations of locally designated conservation areas.*
	RSPB	0.5	*(Source: SWT, RSPB, SNH, Macaulay Institute)*
	SWT	0.5	
	Private Nature Reserve	0.5	
Onshore wildlife outside designated sites	Montane	0.2	*Areas which are likely to have special wildlife value, but which lie outside the existing designations listed above.*
	Moorland	0.4	
	Semi-natural woodland	0.2	*(Source: Macaulay Institute)*
	Commercial woodland	0.8	
	Wetland	0.2	
	Grassland	0.7	
	Arable / Cultivated	0.9	
	Coastal grassland	0.2	
	Loch and freshwater	0.2	
	Urban	1	
	Quarries and Airports	0.9	
	Cliffs	0.3	

	Recreational land	0.9	
Remoteness	2 to 5 km from track	0.5	*Classification of remoteness developed by SNH, which takes account of the distance from a road or track. (Source: SNH, Macaulay Institute)*
	5 to 8 km from track	0.4	
	> 8 km from track	0.2	
Geological Conservation	Geological conservation	0.8	*Locations of geological SSSIs (Source: Highlands Council GIS)*
Landscape conservation	NSA	0.2	*The distribution of various levels of designated areas that may be protected from development due to their scenic appeal. (Source: Highlands Council GIS)*
	Designated viewpoints	0.2	
	AGLV	0.2	
	Designed landscape	0.2	
Archaeological conservation	World Heritage	0	*Locations of designated archaeological sites*
	World Heritage Buffer	0.1	*(Source: Highlands Council GIS, RCAHMS)*
	Scheduled site	0.5	
Film and prestige locations	Film	0.7	*Distribution of existing filming locations and prestige resort locations. (Source: relevant web sites)*
	Prestige	0.1	
MoD Training areas	Bombing	0.1	*Distribution of military exercise and training areas. (Source: Navigational charts and Macaulay Institute)*
	Torpedo & gunnery	0.1	
	Tactical flying	0.4	
Aquaculture	Aquaculture	1	*Locations of all fin and shell fish farms. (Source: Crown Estate)*
Cables	Cables	1	*Locations of submarine cables. (Source: Admiralty charts and Kingfisher charts)*
Oil & Gas	Pipeline	0.8	*Locations of oil & gas pipelines. (Source: DTI)*
Hazardous areas	3 km	0	*Distribution of classified hazardous areas around the Highlands. (Source: Highlands Council GIS)*
	5 km	0	
	8 km	0	

Technical

Category	Sub category	Defaults
Turbine Specifications	Rated Power (MW)	2

Costs

Type of cost	Category	Sub category	Defaults	Comments
CAPEX	Non geographic	Total Estimate	£387,000	Capital costs not affected by any geographic variables.
	Turbine towers	Class I (£ per unit)	£1090,000	Cost of individual towers.
		Class II (£ per unit)	£1024,600	
		Class III (£ per unit)	£893,800	
	Foundations	Wet bed (£ per unit)	£150,000	Cost of building foundations for each turbine depending on soil type.
		Dry bed (£ per unit)	£100,000	
		Rock (£ per unit)	£70,000	
		Loch (£ per unit)	£500,000	
		Built up area (£ per unit)	£50,000	
	Cabling to GSP	Poled (£ per km)	0	Cost of laying cable between site and national grid.
		Buried (£ per km)	£17,000	
		Estimated % poled	0	
		Estimated % buried	100	
OPEX	OPEX	% of total CAPEX	1.8	
	Operating conditions multiplication factor	Extreme	1.75	Factor to be applied to base operating costs depending on operating conditions.
		Severe	1.5	
		Adverse	1.25	
		Acceptable	1	
	Land fees	% of wholesales	2	
	Selling price	p/kWh	1.2	
	Capital Recovery Factor	Number of years	20	
		Rate of Return	8	

Appendix B - Offshore wind

Constraints

Raster	Subset	Default	*Comments*
Visibility from Munros & Corbetts	1	0.9	*Each km² was scored depending on the number of Munros & Corbetts seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	0.7	
	3	0.5	
	4	0.4	
	5	0.3	
	6	0.2	
	7	0.1	
Visibility from dwellings	1	1	*Each km² was scored depending on the number of dwellings seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	0.9	
	3	0.8	
	4	0.7	
	5	0.6	
	6	0.5	
	7	0.4	
	8	0.3	
	9	0.2	
	10	0.1	
	11	0	
Visibility from tourism & recreation centres	1	0.8	*Each km² was scored depending on the number of tourism & recreation centres seeing a point. Two distances were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	0.7	
	3	0.5	
	4	0.3	
	5	0.2	
	6	0.1	
Visibility from The West Highland Way	1	0.9	*Each km² was scored depending on the number of km² points along the West Highland Way seeing a point. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	0.7	
	3	0.5	
	4	0.4	
	5	0.3	
	6	0.2	
	7	0.1	
Visibility from designated viewpoints	5 km	0.2	*Concentric bands of up to 5km, 5 to 10km and 10 to 15km were plotted. Any squares falling in these bands were assigned the relevant values.* *(Source: Macaulay Institute)*
	10 km	0.4	
	15 km	0.6	
Airport exclusion zones	All sea development	0	*Airport exclusion data was used to constrain development in various areas around the two major airports in the Highlands. Any developments that exceeded the heights listed for that square were prohibited. The 30km buffer is the recommended exclusion for turbine developments due to radar interference.* *(Source: Highlands Council GIS)*
	30km buffer	0.8	
Telecommunications	Mast	1	*Locations of telecommunication masts and microwave links. (Source Highlands Council)*
	Microwave link	0	
International Biological Conservation	SAC	0.2	*Locations of Internationally recognized conservation areas. (Source: Highlands Council GIS)*
Local Biological Conservation	MCA	0.5	*Locations of locally designated conservation areas.* *(Source: SWT, RSPB, SNH, Macaulay Institute)*
Offshore wildlife outside designated sites	High	0.3	*Various parameters were used to select sites outside designated areas which had the particular wildlife value of relevance to marine renewables and renewables in general. Features taken into consideration include: cetacean distribution and numbers, seal haul outs, seabird breeding colonies, wintering sea duck and other water fowl, sensitive seabed habitats and frontal mixing zones in the sea.* *Source: Derived from a variety of literature sources*
	Medium	0.5	
	Low	0.7	
Landscape conservation	NSA	0.2	*The distribution of various levels of designated areas that may be protected from development due to their scenic appeal. (Source: Highlands Council GIS)*
	AGLV	0.2	
Archaeological conservation	World Heritage	0	*Locations of designated archaeological sites* *(Source: Highlands Council GIS, RCAHMS)*
	World Heritage Buffer	0.1	
	Wrecks	0.5	
Marine Recreation	Marine Recreation	0.6	*Distribution of marine recreation centres. (Source: Tourist Board)*
Film and prestige locations	Film	0.7	*Distribution of existing filming locations and prestige resort locations. (Source: relevant web sites)*
	Prestige	0.1	
MoD Training areas	Submarine exercise	0.1	*Distribution of military exercise and training areas. (Source: Navigational charts and Macaulay Institute)*
	Bombing range	0.1	
	Diving	0.4	
	Torpedo and gunnery	0.1	
	Tactical flying	0.4	
	Tactical flying & submarine exercise	0.4	
Creeling areas	Creeling	0.9	*Distribution of creeling activity.* *(Source: SEERAD data from occasional papers)*
Dredging areas	Dredging	0.8	*Distribution of dredging activity.* *(Source: SEERAD data from occasional papers)*
Aquaculture	Aquaculture	0.8	*Locations of all fin and shell fish farms. (Source: Crown Estate)*
Cables	Cables	0.8	*Locations of submarine cables. (Source: Admiralty charts and Kingfisher charts)*

Oil & Gas	Oil or gas field	0.6	*Locations of oil & gas pipelines.* *(Source: DTI)*
	License area	0.9	
	Pipeline	0.5	
	Major find	0.6	
Shipping concentration	< 0.05	0.9	*Distribution of shipping densities.* *(Source: Scottish Executive Renewable Resource Assessment for Scotland. Appendices)*
	0.05 to 0.5	0.9	
	0.5 to 1	0.8	
	1 to 2	0.7	
	2 to 5	0.6	
	> 5	0.5	
Ferries	*Ferry route*	0.5	*Distribution of ferry routes.* *(Source: Ordnance Survey maps)*

Technical

Category	Sub category	Defaults
Turbine Specifications	Rated Power (MW)	5

Costs

Type of cost	Category	Sub category	Defaults	Comments
CAPEX	Non geographic	Total Estimate	£5,517,000	Capital costs not affected by any geographic variables.
	Marinised turbine	Class I (£ per unit)	£2,000,000	Cost of individual turbines.
		Class II (£ per unit)	£1,800,000	
		Class III (£ per unit)	£1,600,000	
	Marinised tower		£230,000	Cost of marinised tower.
	Foundations	Monopile (£ per unit)	£180,000	Cost of building foundations depending on seafloor geology.
		Dry-bed	£100,000	Cost of building foundations on dry bed
		Rock	£70,000	Cost of building foundations on rock
	Cabling to GSP	Submarine (£ per km)	£17,000	Cost of laying cable between site and national grid.
	Vessel hire	£ per day	10000	Cost of hiring works vessel for 24 hrs
OPEX	OPEX	% of total CAPEX	1.8	
	Operating conditions multiplication factor	Exposed	1.75	Factor to be applied to base operating costs depending on operating conditions.
		Semi exposed	1.5	
		Sheltered	1.25	
	Land fees	% of wholesales	2	
	Selling price	p/kWh	1.2	
	Capital Recovery Factor	Number of years	20	
		Rate of Return	8	

Appendix C - Offshore wave

Constraints

Raster	Subset	Default	*Comments*
Visibility from Munros & Corbetts	1	1	*Each km^2 was scored depending on the number of Munros & Corbetts seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	0.8	
Visibility from dwellings	1	1	*Each km^2 was scored depending on the number of dwellings seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	1	
	8	1	
	9	1	
	10	0.9	
	11	0.8	
Visibility from tourism & recreation centres	1	1	*Each km^2 was scored depending on the number of tourism & recreation centres seeing a point. Two distances were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	1	
	3	1	
	4	1	
	5	0.9	
	6	0.8	
Visibility from The West Highland Way	1	1	*Each km^2 was scored depending on the number of km^2 points along the West Highland Way seeing a point. Three distance bands were also introduced with the closest distance band scoring greatest.* *(Source: Macaulay Institute)*
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	0.9	
Visibility from designated viewpoints	5 km	0.9	*Concentric bands of up to 5km, 5 to 10km and 10 to 15km were plotted. Any squares falling in these bands were assigned the relevant values.* *(Source: Macaulay Institute)*
	10 km	1	
	15 km	1	
Airport exclusion zones	All sea development	0.8	*Airport exclusion data was used to constrain development in various areas around the two major airports in the Highlands. Any developments that exceeded the heights listed for that square were prohibited. The 30km buffer is the recommended exclusion for turbine developments due to radar interference.* *(Source: Highlands Council GIS)*
International Biological Conservation	SAC	1	*Locations of Internationally recognized conservation areas.* *(Source: Highlands Council GIS)*
Local Biological Conservation	MCA	0.2	*Locations of locally designated conservation areas.* *(Source: SWT, RSPB, SNH, Macaulay Institute)*
Offshore wildlife outside designated sites	High	0.2	*Various parameters were used to select sites outside designated areas which had the particular wildlife value of relevance to marine renewables and renewables in general. Features taken into consideration include: cetacean distribution and numbers, seal haul outs, seabird breeding colonies, wintering sea duck and other water fowl, sensitive seabed habitats and frontal mixing zones in the sea.* *Source: Derived from a variety of literature sources*
	Medium	0.4	
	Low	0.6	
Landscape conservation	NSA	0.5	*The distribution of various levels of designated areas that may be protected from development due to their scenic appeal. (Source: Highlands Council GIS)*
	AGLV	0.6	
Archaeological conservation	World Heritage	0.1	*Locations of designated archaeological sites* *(Source: Highlands Council GIS, RCAHMS)*
	World Heritage Buffer	0.2	
	Wrecks	0.5	
Marine Recreation	Marine Recreation	0.6	*Distribution of marine recreation centres.* *(Source: Tourist Board)*
MoD Training areas	Submarine exercise	0.1	*Distribution of military exercise and training areas.* *(Source: Navigational charts and Macaulay Institute)*
	Bombing range	0.1	
	Diving	0.2	
	Torpedo and gunnery	0.1	
	Tactical flying	0.9	
	Tactical flying and submarine exercise	0.1	
Creeling areas	Creeling	0.9	*Distribution of creeling activity.* *(Source: SEERAD data from occasional papers)*
Dredging areas	Dredging	0.7	*Distribution of dredging activity.* *(Source: SEERAD data from occasional papers)*
Aquaculture	Aquaculture	1	*Locations of all fin and shell fish farms.* *(Source: Crown Estate)*
Cables	Cables	0.8	*Locations of submarine cables.* *(Source: Admiralty charts and Kingfisher charts)*
Oil & Gas	Oil or gas field	0.6	*Locations of oil & gas pipelines.* *(Source: DTI)*
	License area	0.9	
	Pipeline	0.5	
	Major find	0.6	
Shipping concentration	< 0.05	0.9	*Distribution of shipping densities.*
	0.05 to 0.5	0.9	

	0.5 to 1	0.8	*(Source: Scottish Executive Renewable Resource Assessment for Scotland. Appendices)*
	1 to 2	0.7	
	2 to 5	0.6	
	> 5	0.5	
Ferries	*Ferry route*	0.2	*Distribution of ferry routes.* *(Source: Ordnance Survey maps)*

Technical

Category	Sub category	Defaults
Unit capacity	Rated Power (kW)	750
	Number of units per km^2	40
Nominal Wave Power	kW/m	55
Annual output (estimate)	GWh	2.7

Costs

Type of cost	Category	Sub category	Defaults	Comments
CAPEX	Non geographic	Total Estimate	£740,000	Capital costs not affected by any geographic variables.
	Cost of hiring vessel		£10,000	Cost of hiring works vessel for 24 hrs
	Pelamis	Price per unit	£980,000	Cost of individual Pelamis unit
	Installation	Price per unit	£10,000	Cost of installing individual Pelamis usnit
	Moorings	Price per unit	£15,000	Cost of moorings for one Pelamis unit
	Cabling to GSP	Submarine (per km)	£30,000	Cost of laying cable between site and national grid.
OPEX		% of total CAPEX	1.8	
	Operating conditions multiplication factor	Exposed	1.5	Factor to be applied to base operating costs depending on operating conditions.
		Semi exposed	1.25	
		Sheltered	1	
	Land fees	% of wholesales	0	
	Selling price	p/kWh	1.2	
	Capital Recovery Factor	Number of years	20	
		Rate of Return	8	

Appendix D - Coastal wave

Constraints

Raster	Subset	Default	Comments
Visibility from dwellings	1	1	Each km^2 was scored depending on the number of dwellings seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	0.9	
	8	0.8	
	9	0.7	
	10	0.6	
	11	0.5	
Visibility from tourism & recreation centres	1	1	Each km^2 was scored depending on the number of tourism & recreation centres seeing a point. Two distances were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	0.9	
	6	0.8	
Visibility from designated viewpoints	15km	1	Concentric bands of up to 5km, 5 to 10km and 10 to 15km were plotted. Any squares falling in these bands were assigned the relevant values. (Source: Macaulay Institute)
	10km	1	
	5km	0.8	
Airport exclusion zones	All development	1	Airport exclusion data was used to constrain development in various areas around the two major airports in the Highlands. Any developments that exceeded the heights listed for that square were prohibited. The 30km buffer is the recommended exclusion for turbine developments due to radar interference. (Source: Highlands Council GIS)
	All above 10.7m	1	
	All above 15.2m	1	
	All above 45.7m	1	
	All above 91.4m	1	
	30km buffer	1	
Telecommunications	Mast	1	Locations of telecommunication masts and microwave links. (Source Highlands Council)
	Microwave Link	1	
International Biological Conservation	Ramsar	0.8	Locations of Internationally recognized conservation areas. (Source: Highlands Council GIS)
	SPA	0.7	
	SAC	0.8	
National Biological Conservation	SSSI	0.8	Locations of Nationally recognized conservation areas. (Source: Highlands Council GIS)
	NNR	0.8	
	National park	0.8	
Local Biological Conservation	LNR	0.8	Locations of locally designated conservation areas. (Source: SWT, RSPB, SNH, Macaulay Institute)
	RSPB	0.9	
	SWT	0.7	
	Private nature reserve	0.8	
	MCA	0.8	
Onshore wildlife outside designated sites	Montane	0.6	Areas which are likely to have special wildlife value, but which lie outside the existing designations listed above. (Source: Macaulay Institute)
	Moorland	0.8	
	Semi-natural woodland	0.6	
	Commercial woodland	0.9	
	Wetlands	0.6	
	Grassland	0.8	
	Arable/cultivated	1	
	Coastal grassland	0.8	
	Lochs and freshwater	0.5	
	Urban	1	
	Quarries and airports	1	
	Cliffs	0.8	
	Recreational land	1	
Remoteness	2 to 5 km from track	0.5	Classification of remoteness developed by SNH, which takes account of the distance from a road or track. (Source: SNH, Macaulay Institute)
	5 to 8 km from track	0.4	
	> 8 km from track	0.2	
Geological conservation	Geological conservation	0.6	Locations of geological SSSIs (Source: Highlands Council GIS)
Landscape conservation	NSA	0.8	The distribution of various levels of designated areas that may be protected from development due to their scenic appeal. (Source: Highlands Council GIS)
	Designated viewpoint	0.9	
	AGLV	0.6	
	Designed landscape	0.9	
Archaeology	World heritage	0	Locations of designated archaeological sites (Source: Highlands Council GIS, RCAHMS)
	World heritage buffer	0	
	Scheduled site	0.8	
	Wrecks	1	
Film locations and prestige locations	Film locations	0.8	Distribution of existing filming locations and prestige resort locations. (Source: relevant web sites)
	Prestige locations	0.8	
	Tactical flying	1	
Aquaculture		1	Locations of all fin and shell fish farms. (Source: Crown Estate)
Oil and gas	Oil or gas field	1	Locations of oil & gas pipelines. (Source: DTI)
	License area	1	
	Pipeline	1	
	Major find	1	
Hazardous areas	3km buffer Dounreay	0.9	Distribution of classified hazardous areas around the Highlands. (Source: Highlands Council GIS)
	5km buffer Dounreay	1	
	8km buffer Dounreay	1	

Appendix E - Tidal current

Constraints

Raster	Subset	Default	Comments
Visibility from munros and corbetts	1	1	Each km^2 was scored depending on the number of Munros & Corbetts seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	0.8	
Visibility from dwellings	1	1	Each km^2 was scored depending on the number of dwellings seeing the square. Three distance bands were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	1	
	8	1	
	9	1	
	10	0.9	
	11	0.8	
Visibility from tourism and recreation centres	1	1	Each km^2 was scored depending on the number of tourism & recreation centres seeing a point. Two distances were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	0.9	
	6	0.8	
Visibility from the West Highland Way	1	1	Each km^2 was scored depending on the number of km^2 points along the West Highland Way seeing a point. Three distance bands were also introduced with the closest distance band scoring greatest. (Source: Macaulay Institute)
	2	1	
	3	1	
	4	1	
	5	1	
	6	1	
	7	0.9	
Visibility from designated viewpoints	15km	1	Concentric bands of up to 5km, 5 to 10km and 10 to 15km were plotted. Any squares falling in these bands were assigned the relevant values. (Source: Macaulay Institute)
	10km	1	
	5km	0.9	
Airport exclusion zones	All sea development	0.8	Airport exclusion data was used to constrain development in various areas around the two major airports in the Highlands. Any developments that exceeded the heights listed for that square were prohibited. The 30km buffer is the recommended exclusion for turbine developments due to radar interference. (Source: Highlands Council GIS)
International Biological Conservation	SAC	1	Locations of Internationally recognized conservation areas. (Source: Highlands Council GIS)
Local Biological Conservation	MCA	0.2	Locations of locally designated conservation areas. (Source: SWT, RSPB, SNH, Macaulay Institute)
Offshore wildlife outside designated sites	High	0.2	Various parameters were used to select sites outside designated areas which had the particular wildlife value of relevance to marine renewables and renewables in general. Features taken into consideration include: cetacean distribution and numbers, seal haul outs, seabird breeding colonies, wintering sea duck and other water fowl, sensitive seabed habitats and frontal mixing zones in the sea. Source: Derived from a variety of literature sources
	Medium	0.4	
	Low	0.6	
Landscape conservation	NSA	0.5	The distribution of various levels of designated areas that may be protected from development due to their scenic appeal. (Source: Highlands Council GIS)
	AGLV	0.6	
Archaeology	World heritage	0.1	Locations of designated archaeological sites (Source: Highlands Council GIS, RCAHMS)
	World heritage buffer	0.2	
	Wrecks	0.5	
Marine recreation		0.6	Distribution of marine recreation centres. (Source: Tourist Board)
MoD training areas	Submarine exercise and noise ranging	0.1	Distribution of military exercise and training areas. (Source: Navigational charts and Macaulay Institute)
	Bombing range	0.1	
	Diving	0.2	
	Torpedo and gunnery	0.1	
	Tactical flying	0.9	
	Tactical flying and submarine exercise	0.1	
Creeling areas	Creeling area	0.6	Distribution of creeling activity. (Source: SEERAD data from occasional papers)
Dredging areas	Dredging area	0.7	Distribution of dredging activity. (Source: SEERAD data from occasional papers)
Aquaculture	Aquaculture	1	Locations of all fin and shell fish farms. (Source: Crown Estate)
Cables	Cables	0.8	Locations of submarine cables. (Source: Admiralty charts and Kingfisher charts)
Oil and gas	Oil or gas field	0.6	Locations of oil & gas pipelines. (Source: DTI)
	License area	0.9	
	Pipeline	0.5	

	Major find	0.6	
Shipping concentration	< 0.05	0.9	Distribution of shipping densities. (Source: Scottish Executive Renewable Resource Assessment for Scotland. Appendices)
	0.05 to 0.5	0.9	
	0.5 to 1	0.8	
	1 to 2	0.7	
	2 to 5	0.6	
	> 5	0.5	
Ferry route	Ferry route	0.2	Distribution of ferry routes. (Source: Ordnance Survey maps)