Renewable energy sustainability study – impacts and opportunities for the Isle of Man

Final Report – Executive summary

Report for Department of Environment, Food and Agriculture

Restricted Commercial
ED46657
Issue Number 1
Date 19/11/2010

Customer:

Department of Environment, Food and Agriculture

Customer reference:

Final report v1

Confidentiality, copyright & reproduction:

AEA reference:

ID: AEAT/ENV/R/46657

Ref: ED46657- Issue Number 1

Contact:

Mark Johnson
AEA Technology plc
Gemini Building, Harwell, Didcot, OX11 0QR

t: 0870 190 6748

f: 0870 190 6933

e: Mark_Johnson@aeat.co.uk

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001 and ISO14001

Authors:

Mark Johnson, Erika Rankin, James Craig, Colin McNaught, Martin Williams, Nigel Griffiths and other project team members

Approved By:

Mark Johnson

Date:

19 November 2010

Signed:

Executive summary

Objectives and approach

The Government of the Isle of Man has recognised that climate change and energy security are critical issues for the Island in the short, medium and long term. The energy system is currently undergoing a significant transformation and the government has committed to further additional changes. The relatively new CCGT plant, energy from waste installation and plans to expand the natural gas network will all have a long term impact on the shape of the Island's future carbon emissions and energy dependency. What's more, the Island has adopted a short term renewable electricity target of 15% by 2015, which if to be achieved will require significant additional investment in new generating capacity.

The Isle of Man, as co-signatory to the Kyoto Protocol (with the UK) and an active participant in the international climate change process, has committed to reviewing the potential for developing additional renewable energy sources with a long term view on the role that they could play in meeting climate change and energy security objectives. As such, the Government commissioned AEA to carry out a systematic review of the potential for renewable energy on the Island and to provide the evidence base to inform future decisions regarding a long term renewables target and the measures it may need to put in place to achieve that target. This report contains the results of that analysis.

There are certain important environmental and socio-economic factors that will have an important influence on the direction of future energy policy for the Isle of Man. The Island is a small and close community, so any developments would need to be sized to meet those energy needs. High tech and internet business are strongly promoted on the Island, and require a stable and low cost energy supply if this area is to expand as the Government would wish. As a small economy, the Island cannot provide the asset infrastructure for many new developments without reliance on imports. Consequently the employment prospects afforded by an expansion in renewable energy are specific to the Island.

GDP per capita is higher on the Isle of Man than in the UK, yet this does not mean increased energy prices can be readily accommodated. The Office of Fair Trading regularly undertakes price enquiries and the general awareness of energy prices on the Island is high. In this context the cost of renewables may be considered in two ways. Against current prices it is important that renewable projects would not increase the overall cost of energy – an aspect examined in this report – but also when the potential for future increases in global fossil fuel prices to an unacceptable level is considered, renewables must be viewed as an opportunity to keep costs down, by reducing dependence on international energy markets.

The objectives of the study are to:

- Map current primary and secondary energy needs so that future decisions regarding energy generation can be made in the context of energy need.
- Examine the potential for reducing future energy demand through improved energy efficiency and review the impact these measures could have on overall demand, to signal the importance of energy efficiency within the policy spectrum.
- Assess the state of technology readiness for a wide range of possible renewable and low carbon options for the Isle of Man, with specific reference to the resources available and scope for deployment on the Island. This will provide an evidence base for future energy and climate change policy developments.
- Assess the relative attributes of future energy options to provide an independent view on the priority order for the technologies.
- Analyse the impacts of each option so this can inform future policy development.
- To make recommendations on how the Isle of Man should take forward its longer term renewable energy strategy.

Energy policy

The Government Strategic Plan and IoM Strategic Plan have been reviewed, as well as supporting policies with an influence on energy system (Building regulations, 2006 Report by the Council of Ministers on Energy Policy, Energy Policy Group proposal for an energy policy plan, Clean Tech sector brochure and 2008 energy policy consultation documents).

The Council of Minister's energy policy and the IoM government strategy documents set out a useful policy framework with numerous aims and objectives related to sustainable energy production and consumption. The documents make clear the Government's aspirations. However, the documents do not express targets (other than for renewables) and objectives in a quantified manner and detailed implementing measures are not defined in the energy policy.

It is found that existing strengths lie in building energy efficiency measures, implementation of a biomass strategy and the setting of targets for renewable energy.

Further fiscal or economic, regulatory, information or behaviour change measures need to be established to enable the IoM government to realise its aims and objectives. Transparent quantified targets should also be set to help the government and citizens to monitor progress towards targets.

At present, there would appear to be no fiscal or economic incentives to promote renewables on the IoM. The Department of Economic Development's (DED's) clean tech brochure makes a good case for sustainable energy developments on the Island but more needs to be done to set up specific measures to attract investment.

While the IoM government is committed to reduce GHG emissions from its estate, no policy seems to be in place for businesses to reduce their energy consumption. Further policy initiatives could include flexible mechanisms such as domestic carbon trading or voluntary agreements, coupled with the promotion of smart metering. There is a role for government in driving improved product standards, possibly through regulation.

Future demand and energy efficiency take-up

Whilst business as usual energy demand is expected by suppliers to slowly increase, it is believed that there are pressures which could lead to a reduction in overall demand, most noticeably increasing consumer awareness and the Government's policy towards aspects such as building regulations and vehicle emissions tax.

Significant emissions reduction opportunities lie with improved building energy efficiency. For the domestic sector the greatest potential space heating savings lie with increased loft insulation, cavity wall insulation, draught proofing and boiler upgrades. Electricity savings through better lighting and use of appliances can also be significant. Total savings of around £6 million/year are estimated, but the programme to achieve this would be large and require long term planning. The results for domestic buildings are shown below. These are the best known because of the current housing condition survey, and could give the greatest total energy savings. For comparison, the retail prices including VAT are 16.38p/kWh for electricity and 5.86p/kWh for domestic natural gas[1]. Without VAT these are 15.60p/kWh and 5.58p/kWh respectively. Savings to individuals will include the VAT saving but for the Isle of Man economy the ex VAT figures are the appropriate comparators.

Measure	Total energy saving (kWh/year)	Unit cost of achieving saving (p/kwh heat or electricity
Loft Insulation	13,961,160	2.4
Cavity Wall Insulation	17,941,500	3.4
Solid Wall Insulation	2,155,500	18.2
Double Glazing	5,262,000	26.5
Draught Proofing	13,799,652	4.52

[1] All prices correct as of October 2010

Measure	Total energy saving (kWh/year)	Unit cost of achieving saving (p/kwh heat or electricity
Boiler upgrade	30,913,200	7.45
Heating controls	7,728,300	2.74
Total: space heating savings 75% of total to allow for measures interaction	**68,820,984**	**9.13**
Hot water use	5,100,678	2.7
Lighting	5,718,942	8.3
Appliances	3,746,680	14.4
Total for all measures	**83,387,284**	**-**

In the absence of accurate up to date information on the thermal performance of public buildings, and given the relatively small numbers involved (approximately 500 buildings), it would be cost-effective to commission a detailed survey of public buildings, possibly making use of thermal imaging. This would produce the most productive building-specific recommendations.

There is no data available to form a firm view on the potential for energy efficiency savings within the commercial and industrial sectors. However, finance and IT are significant sectors for the economy and it is believed there is potential for government to play a role in encouraging energy efficiency within data centres, possibly akin to the UK Carbon Trust Data centre Strategic Design Advice service.

Energy infrastructure

The energy infrastructure is well positioned to meet the current energy needs of the Island's population in a safe and economic manner, through the gas and diesel electricity generating plant and plans to extend the natural gas network.

Even if demand continues to grow at the current rate, the Pulrose CCGT and IoM-UK interconnector assets can be expected to continue to be able to meet Island demand through to 2030, supported by the Island's operational diesel stations. However, current short term operating reserve contracts often involve the allocation of significant interconnector capacity, therefore if significant amounts of new renewable generation were to come on line, and be exported to the GB market new interconnector capacity may be required. A number of options exist for implementation of new interconnector capacity. These include direct connection of renewable generation to the UK/Irish networks, bypassing any possible detrimental effects posed by connecting substantial amounts of intermittent generation to the IOM network.

Several interconnector projects are expected to come online in the future that will be serving the UK/Irish markets. Given that there is not a pressing need for additional interconnector capacity at this time, this affords the IOM Government time to observe how this new market develops before pursuing a particular course of action.

Even with expected gas growth demand continues to sit below the design capacity of the NG interconnector (130,000scm/h) well beyond the scope of this study therefore no additional interconnector capacity should be required to meet demand in the medium to longer term.

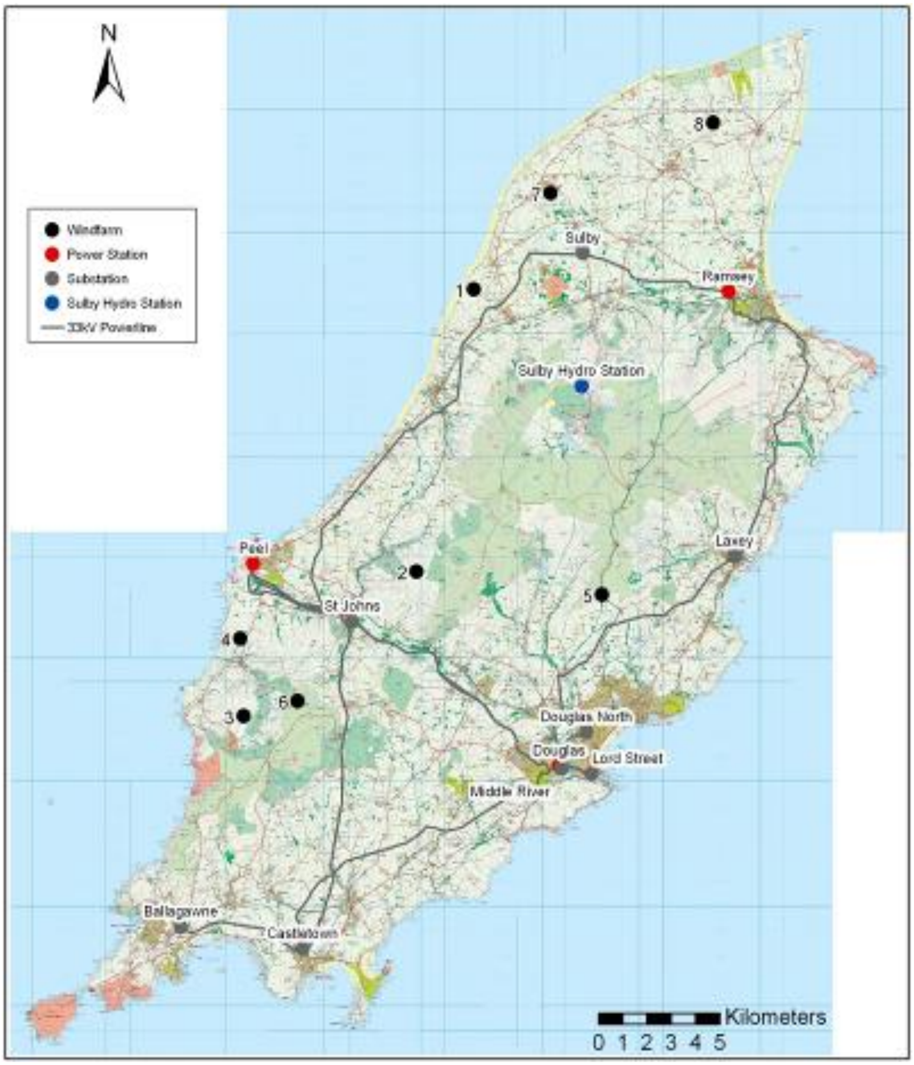
Large scale renewable energy options

This section summarises the technology status and applicability of large scale renewables to the Isle of Man. Subsequent sections review all technologies for their relative economics, carbon benefit and other key factors.

Onshore wind

Onshore wind is an established technology ready for deployment on the Island. In addition to the technology, sophisticated resource modelling and landscape visualisation capabilities have become established.

Eight potential 10MW wind farm locations have been identified, each capable of generating between 16.7 and 27.3GWh per year. They are located in the central and northern parts of the Island, shown below in relation to the existing electricity infrastructure.



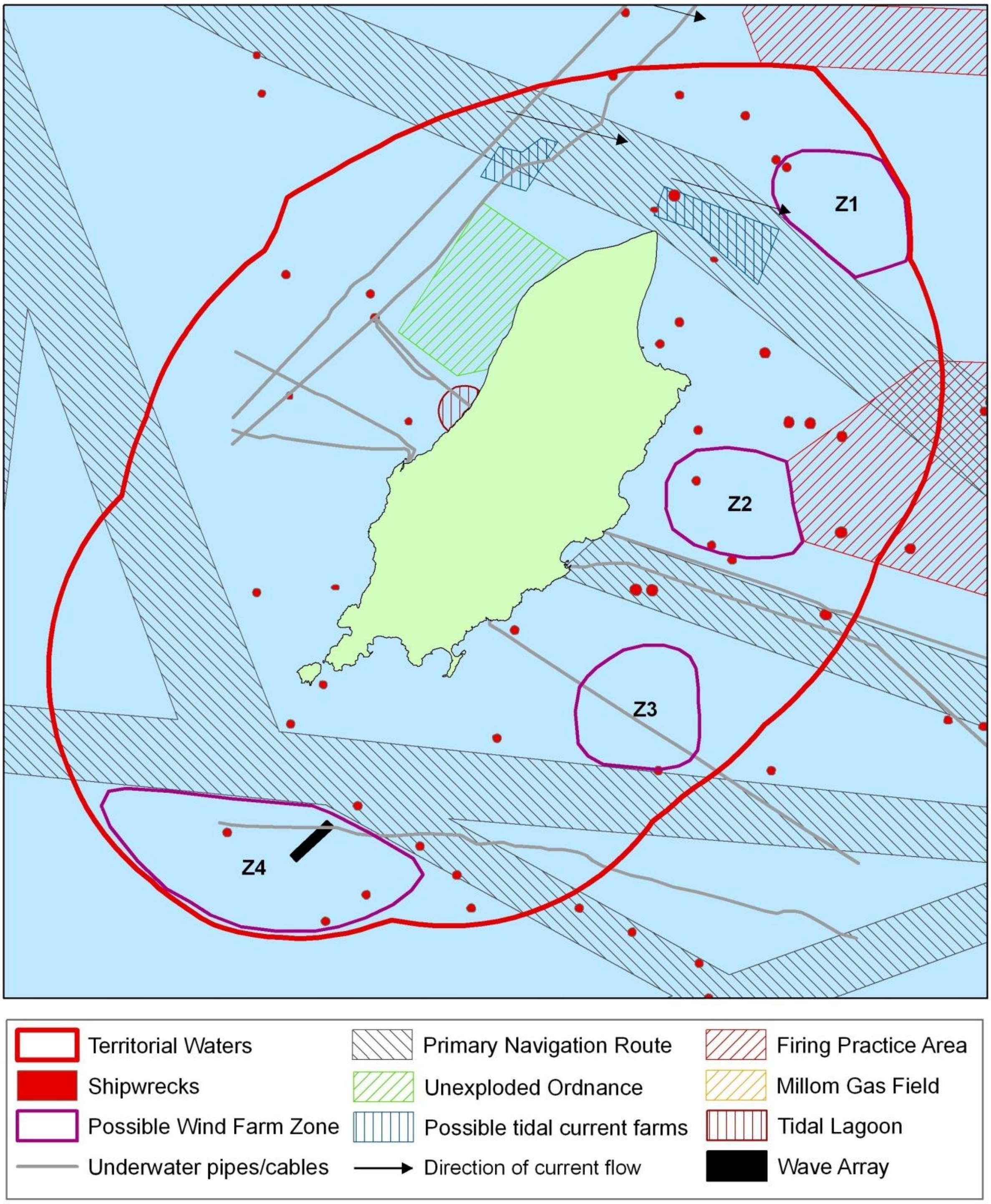
1. Ballacooiley
2. Beary Mountain
3. Dalby Mountain
4. Gordon
5. Keppel Gate
6. Snuff the Wind
7. Jurby
8. Cronk

The levelised cost for onshore wind generation at a discount rate of 10% is around 8p/kWh, for the most cost effective sites. The cost of generation from onshore wind depends on the exact level of resource at a given site and whether cabling is to be above or underground. We have examined illustrative sites in this report; further work would be necessary to determine the full potential of any future developments, and the exact costs associated with them.

Offshore wind

Offshore turbines are in long term operation in the marine environment. 13 arrays are reported to be in full commercial operation in UK waters.

The offshore wind resource for the Isle of Man in this study is based on four large arrays in different locations on the north-east, east and south of the Island. These are large arrays intended for the export of power to the UK. They would be arrays of between 100 and 200 turbines generating between 1,000GWh/y and 3,500GWh/y. The zones for these arrays are shown in the following figure:



Environmental and fishery constraints have been considered in the review for each of the four zones. Three of the four zones for offshore wind farm development avoid identified sensitive species habitats, although one (Z3) is close to a recognised scallop dredging area and, consequently, impacts would need to be carefully assessed. The IoM Government is currently progressing with a Marine Spatial Planning exercise to map data sets of the IOM Territorial Waters in order to identify key issues in different areas. This will support robust decisions on what uses areas could have covering navigation routes, wildlife designations/value, fishing interests, telecom routes, MOD zones and other uses.

The levelised cost for offshore wind generation at a discount rate of 10% is around 18p/kWh, for the most cost effective sites. We have examined the potential to earn UK Renewable Obligation Certificates for export of offshore wind power to the UK market. It is far from certain that this benefit could be realised, and even so it does not make the case for offshore development compelling. However, offshore wind is an emerging market and costs can be expected to decline.

Biomass

Biomass is a viable, low risk renewable energy option for the Isle of Man that is most economic in larger public buildings and commercial/industrial settings. Options are reviewed for the application of biomass to domestic (wood pellet), and small medium and large scale uses (all wood chip). These last three can be characterised as follows:

Category	Applications	Boiler size (max rated output) kW
Small	Primary schools, public offices	200
Medium	Leisure centres, shopping centres	1000
Large	Diaries, creameries, hospitals	2000

The resource assessment for biomass is based on the use of indigenous resources. The fuel potential from these sources was calculated as:

- Government forestry estate (current resources): 6.5k oven dry tonnes
- Energy crops: 25.3k oven dry tonnes per year - using willow coppice making use of 10% (7.9kacres) of the suitable land that is currently used for cereals or grassland and hay
- Total indigenous potential: 31.8k oven dry tonnes per year

This study examines the contribution that these sources could make to Island energy needs. If only the forestry estate were utilised, then the benefits would be a factor of five smaller. The option to import biomass would need to be considered further, although opportunities to import wood pellets from the UK are identified. The levelised cost for biomass at a discount rate of 10% ranges from 3.4p/kWh heat for large scale applications to 11.8p/kWh heat for domestic uses.

Anaerobic Digestion

Anaerobic digestion (AD) involves the conversion of biodegradable organic matter to energy by microbiological organisms in the absence of oxygen. The biogas produced in the process is a mixture of methane and carbon dioxide, and can be used as fuel source for heating and/or electricity production. The most feasible AD plant is a farm enterprise model at Santon, which could be based at or close to the large dairy farm with approximately 340 cattle. The estimated quantity of waste, from creamery and farm is 19,100tonnes/year, which could generate annually 1.4GWh electricity and 1.2GWh heat for export.

Sewage sludge is normally very dilute, between 2-4 wt% solids, and requires a safe and secure outlet. Currently, it is dewatered, dried to 92% dry matter and pelleted for either land application or sent to EfW plant. Therefore, no sewage sludge has been taken into account in the considerations related to AD plants.

The levelised cost for AD at a discount rate of 10% is 6.4p/kWh heat and 12.8p/kWh electricity, apportioning costs on a 1/3 heat 2/3 electricity basis by analogy with common carbon accounting practice.

Wave

Wave energy is the extraction of useful energy from the motion of water in surface waves on the sea. Wave energy devices are usually designed to generate electricity. Wave energy has achieved a number of full scale prototype tests of short duration, up to a few weeks, but with no continuously operating prototype yet in place. The most promising location for the Isle of Man is 4-16 km south of the Calf of Man, which is in the area with the highest energy density, although this would have implications for current fishing patterns requiring a new exclusion zone. An array of 40 machines could generate about 21GWh/y.

However, the technology is in the developmental stage and is costly. The unit cost of generation at a discount rate of 10% is 79p/kWh. Surveys would be necessary to gather better information on the wave resource around the Island, and more detailed consideration of environmental impacts would be required.

Tidal current

A number of different tidal current generator concepts have been proposed in recent years. Tidal-current energy is the direct extraction of energy from naturally occurring tidal currents. This is done in much the same way as wind turbines extract energy from the wind. The leading device concept is the SeaGen turbine. However, this device is limited to locations with a water depth up to 30m, while much the Isle of Man's tidal current resource is somewhat deeper than this, with only limited potential areas in the 20-30m depth range. For locations deeper than 30m, alternative designs must be used in which the rotor occupies a smaller proportion of the water column. Such design concepts are less advanced.

The most favourable locations are identified off the north of the Island; an array of 30 devices generating up to 18GWh/y.

Since this technology is in a development stage, and because the natural resource around the Isle of Man is relatively low, this option is one of the most expensive technologies considered. The levelised cost of tidal current is 50p/kWh at a 10% discount rate. If it is to be considered then it would need to be treated as a research and development programme. Sampling of tidal current resource would be necessary to take this option forward as the power output, and hence economics, are extremely sensitive to the flow velocities, which are themselves very uncertain. It is an emerging market and technological developments should be watched closely as costs would be expected to decline in years to come.

Tidal lagoon

Tidal lagoons use the same technology as tidal barrages. Several examples of tidal barrages are currently operating around the world, including the Rance barrage in Brittany, Annapolis Royal in Canada and a few small plants in Russia and China.

Barrages are typically built across the mouths of estuaries and impound an area of water bounded by the barrage embankment and the banks of the estuary on the landward side of the barrage. Lagoons, on the other hand, enclose an area of water that is not a whole estuary. Although no tidal lagoons have yet been built components of tidal lagoon, such as the turbines, have been demonstrated as individual sub-systems. As there has been no complete system test, this technology can be considered to be in the development stage.

The most promising location is a few km north of Peel, for a large scheme of diameter 4.6km. It could generate 90GWh/y. However, the unit cost of generation would be 43p/kWh at a 10% discount rate.

Small scale renewable options

This section summarises the technology status and applicability of small scale renewables to the Isle of Man. Subsequent sections review all technologies for their relative economics, carbon benefit and other key factors.

Small scale wind

Small scale wind systems are turbines rated up to 50kW, which can be sub divided into two categories, micro-wind turbines (0kW – < 1.5kW) and small wind turbines (1.5kW – 50kW). The Isle of Man has wind speeds ranging from 5 – >10 m/s and therefore some areas offer good potential for wind energy generation. With the small scale wind resource on the Isle of Man it is likely that isolated micro wind systems would be distributed across the Island. Micro 5kW would be suitable for farms especially in open exposed locations. It is assumed that a maximum of 200 could be deployed. A smaller number of 25 kW turbines would be used by commercial companies, assumed to be 50 for the assessment.

The amount of energy generated from these schemes could total about 4,400MWh/y, at a unit cost of between 30p/kWh and 40p/kWh. Public opposition is another significant barrier to the deployment of this technology.

Solar photovoltaics

Solar photovoltaic (PV) materials and devices convert light energy into electrical energy. Commonly known as solar cells, individual PV cells are electricity-producing devices made of semiconductor materials (silicon, polycrystalline thin film or single-crystalline thin film) and are the basic building block of a PV (or solar electric) system. There are many commercial arrays and schemes in place across the world. We have assumed take-up of PV at 50 residential properties and 20 public sector buildings and estimate that small scale residential and public sector schemes could generate about 10MWh/y. The unit cost of generation at a 10% discount rate is around 60-80p/kWh.

Solar thermal

A solar (thermal) water heating system uses solar collectors (panels), normally mounted on a roof, to capture the energy released by the sun to heat water. These collectors contain liquid, which once heated travels to a coil in the hot water cylinder and transfers heat to the water store. So over a period of time a full tank of hot water is created.

There are many domestic and commercial schemes in place across the world. We have assumed take-up of retrofit solar thermal at 200 residential properties and 20 public sector buildings and estimate that small scale residential and public sector schemes could generate a heat output of about 20MWh/y. The unit cost of generation at a 10% discount rate is around 23p/kWh heat, for retrofit application. New build applications would be cheaper, although the total potential would be less, due to the slow turnover of building stock.

Heat pumps

Ground source heat pumps are increasingly deployed in the UK as a means of space and water heating and could have application on the Isle of Man. Similarly Air source heat pumps could have application. They are generally most economic off the gas grid, and do require electricity use to operate, at around 1/3 of the amount of heat supplied.

It is estimated that there is a maximum potential for around 4,700 heat pumps on the Isle of Man. The unit cost of generation at a 10% discount rate is around 15p/kWh heat.

Micro CHP

Combined Heat and Power (CHP), or cogeneration, technology uses a prime mover (an engine, turbine or fuel cell) to convert the chemical energy in a fuel to mechanical or electrical energy and recovers residual thermal energy (heat) from the same process for use where there is a demand for heat, thus reducing the fuel consumption in separate boilers. Overall the amount of fuel used by a CHP plant is usually less than the total used to generate the same amount of heat and power separately. Not a renewable option, micro CHP could have small scale commercial or public sector application more efficiently than separate supplies of electricity and gas. It has been assumed that there is the potential to employ small non domestic CHP schemes (of electrical output <50kW) at about 60 locations the Island (in addition to the relatively small number that currently exist). By attributing 2/3 of the cost to electricity and 1/3 to heat, the unit costs at a 10% discount rate are 14p/kWh and 7p/kWh respectively.

Small scale hydro power

Hydropower is the exploitation of kinetic energy from a flow of water either from a natural water course, an artificial water storage facility, such as a reservoir or where barrier such as a weir has impounded water. Hydropower on the Isle of Man could therefore be developed in two different settings – either high head run-of-river type developments or within the existing water supply infrastructure. There is currently a 1MW device in operation at Sulby, and a project under development by the Water Authority for an energy recovery turbine at Sulby Water Treatment works for use by the works. An additional four potential river flow schemes and three reservoir schemes have been identified. The most promising two locations (on the Sulby and Glass rivers) could generate a total of about 2,200MWh/y at a unit cost of 17p/kWh.

District heating

District Heating (DH, also known as Community Heating) refers to the provision of heat where the heat is generated centrally and then distributed to users within a locality by means of a network of pipes. The heat distribution network will typically consist of a two-pipe pumped circulation arrangement. One pipe carries high temperature water away from the heat station while the second returns the water at lower temperature back to the station, having first given up heat to consumers.

The potential for a district heating on the Island has been reviewed, by matching demand to potential heat supply. The principal DH network opportunity identified is the use of heat from the Richmond Hill EfW plant to supply the following heat demands:

- Commercial Premises on the IoM Business Park and Spring Valley Trading Estate
- New properties on the 20ha package of land on Cooil Road, which has been ear-marked for commercial development.
- Former Ballakinnish Nurseries glasshouse complex situated opposite Richmond Hill EfW plant.
- For this scheme the unit cost of heat at a 10% discount rate is 9.6p/kWh heat.

Electric vehicles

We have considered the potential for electric vehicles (EV) and plug-in hybrid electric vehicles (PHEVs) on the Island. We have taken as our starting point the marginal abatement cost curve work carried out for the UK Committee on Climate Change, and developed a deployment model applicable to the isle of Man. We have then examined the impact that this could have on electricity demand, using a pessimistic charging scenario during a mid winter period of high demand.

Indications are that in the short term, to 2015 or perhaps 2020, the small numbers of EV and PHEV likely to be purchased in the Isle of Man mean that no particular measures need to be taken to compensate for any increased load on the grid. Rather, the IoM Government and MEA should investigate available technologies such as intelligent metering to determine a way forward to better administrate and manage the demand as it increases, negating the need to increase generation or supply capacity. By 2025 the impact of EV charging on Island electricity demand could be significant enough to make demand management measures desirable.

It is recommended that as EVs/PHEVs penetrate the transport market on the Island, monitoring programmes should be carried out to assess and characterise how consumers use their vehicles, in order to promote the best infrastructure capable of taking on the extra grid load with the least amount of disruption to the current system.

Technology assessment

Economics

In the main report cost-resource curves for heat and electricity have been presented, showing the contribution to energy supply that each measure could make, and at what cost. On these curves energy efficiency measures are also shown for comparison. This analysis feeds into the multi-criteria analysis described later in this executive summary. In summary, the levelised costs and resource potential of each electricity generating measure is shown below for a 10% discount rate, with new build CCGT included for comparison (the main report also shows units costs at a 15% discount rate). Of course the true price will lie within a range, and we have in many instances examined a number of possible projects to understand those ranges. The costs stated below are the most favourable for each technology.

Technology	Maximum potential electricity generated(GWh/y)	p/kWh generated
New build CCGT	-	6.9
Onshore Wind - 2 lowest cost 10MW sites	54.5	7.7*
Small Hydro (2 most favoured sites)	2.2	16.6
Offshore Wind (all 4 zones)	7,709	17.7
Small Wind Commercial	2.63	32.7
Small Wind Domestic	1.75	39.2
Tidal Lagoons	90.5	43.0
Tidal Current	18.2	49.8
Solar PV	0.30	71.0
Wave	21.8	78.7

** assumes overground cabling. For underground cabling, higher discount rates or less favoured sites the levelised costs would be higher*

The levelised costs for heat generation in the same way are as follows:

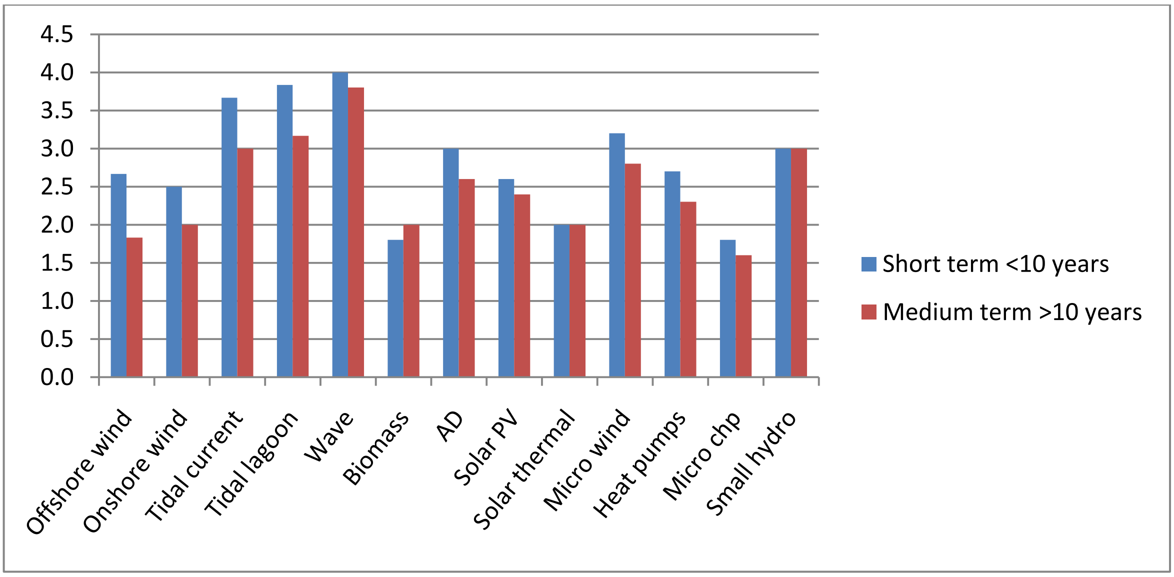
Technology	Maximum potential heat output (GWh/y)	p/kWh heat
Biomass Large scale	36.8	3.5
Biomass Medium scale	15.8	4.7
Biomass Small scale	21.0	5.1
District Heating	17.8	9.6
Biomass Domestic	44.1	12.1
Heat Pumps (air & ground)	56.3	15.4
Solar Thermal	0.7	23.0

The levelised cost for cogeneration has been calculated by attributing 2/3 of the cost to electricity and 1/3 for heat, by analogy with the common approach for treatment of greenhouse gas emissions.

Technology	Maximum potential heat /electricity output (GWh/y)	p/kWh heat / electricity
AD heat	1.2	6.5
AD electricity	1.4	13.1
Small CHP (<50 kWe) heat	24.2	6.8
Small CHP (<50 kWe) electricity	15.0	13.6

Barriers assessment

The renewable technology options considered in this project all have barriers to deployment, to some extent, and when applied to the Isle of Man will be specific to the local circumstances. These barriers are often the most significant factors affecting development prospects or take-up rates, therefore an approach has been developed to rank and compare the barriers across the technologies using a scoring system that ranges between 1 (low barrier) and 5 (high barrier) for a series of attributes. The average values are shown below, for 2 different timeframes:



Smaller heat options, namely biomass, solar thermal and micro CHP do score well, principally because the barriers for deployment of smaller equipment within existing developments are lower. Heat pumps score a little less well than these technologies. Regarding the remaining electricity generating options, small hydro, micro wind and AD (which incorporates CHP) do not score as well as onshore and offshore wind, even though on an individual project basis they may be easier to deploy. Large scale marine technologies do not score well, although modest improvements may be expected in the longer term, as these technologies mature.

Carbon footprint

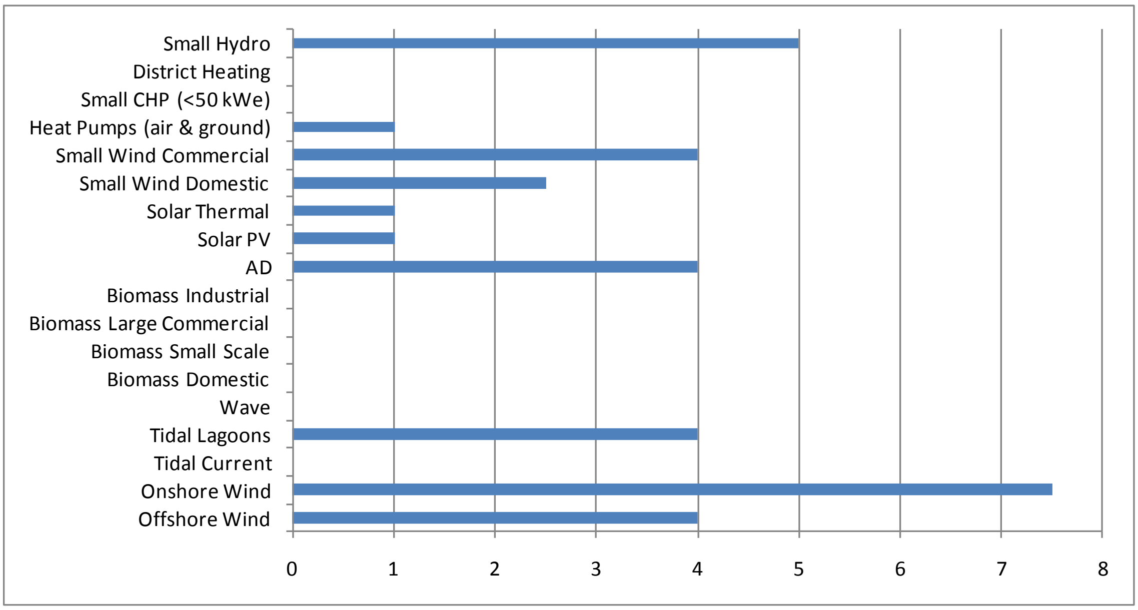
The renewable technology options described in this report could make a significant beneficial difference to the greenhouse gas emissions of the Island. The carbon benefit for each measure has been assessed, with assumptions regarding avoided use of existing energy supplies. Offshore wind has not been included as it is assumed to generate electricity that is exported to the UK and therefore has no impact on the carbon footprint of the Isle of Man. Overall, this carbon assessment highlights the importance large scale electricity generation as the most significant options to deliver the greatest carbon savings. Domestic and large scale biomass also provide large benefits.

Technology	Energy generated (MWh/year)		Carbon saved (tCO_2e / year)
	Electricity	Heat	
Onshore Wind - 2 lowest cost 10MW sites	54,520		23,444
Tidal Current	18,180		7,817
Tidal Lagoons	90,460		38,898
Wave	21,760		9,357
Biomass Domestic		44,150	10,150
Biomass Small scale		21,024	4,833
Biomass Medium scale		15,768	3,625
Biomass Large scale		36,792	8,458
AD	1,434	1,205	903
Solar PV	298		128
Solar Thermal		740	220
Small Wind Domestic	1,752		753
Small Wind Commercial	2,190		942
Heat Pumps (air & ground)		56,261	4,870
Small CHP (<50 kWe)	14,995	24,192	2,140
District Heating		17,800	4,092
Small Hydro	2,208		949

Visual impact

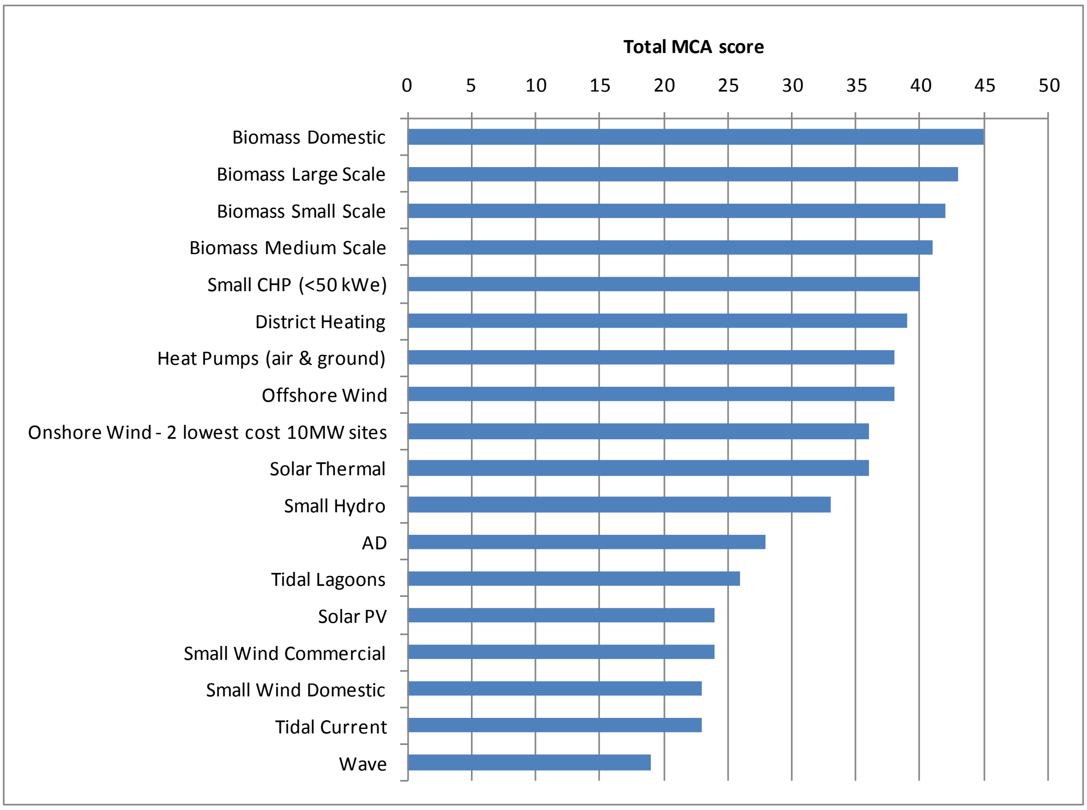
Visual impact is an area of public concern for developments in general and for wind farms in particular. Hence planning regulations often include visual impact as a criterion that will influence local plans and the assessment of specific planning applications. With regards Marine developments, the IoM Government has employed an Officer to progress Marine Spatial Planning for IoM Territorial Waters. A methodology for ranking the measures according to visual impact has been developed, which ranks technologies from zero to nine[2]. The highest impact technologies are offshore, onshore and small scale wind, AD and small hydro, shown below.

[2] Note: the visual impact scale is specific to the methodology applied for this issue, such that each technology is scored between zero and three for its visual impact and for the sensitivity of the locations where it would be most likely to be deployed, and the scores are multiplied together. The collation of all issues in the MCA normalises them all to a scale of 1 to 6.



Multi criteria analysis

A powerful tool to enable the ranking of technology options is the use of Multi Criteria Analysis (MCA). The purpose of the MCA is to bring together each of the technology attributes, including economics, carbon barriers and visual impact in a way that gives an appropriate ranking to each criterion. MCA involves the systematic assessment of each technology against a set of criteria against a quantitative scale. The criteria are then weighted according to perceived importance, and the scores combined to give an overall technology score, on a scale from zero to 50.



Overall, it is clear that biomass applications score the best in this assessment. Small non-domestic CHP schemes, the district heating option identified in this study and heat pumps (both ASHP and GSHP) perform well. Offshore and onshore wind achieve the next highest scores.

Solar thermal and small hydro score next, although are very modest in terms of energy generated, and hence carbon saved. AD is medium to low ranking. Of the remainder, small scale wind and solar PV score less well primarily because of their costs and more modest deployment potential. Marine generation technologies also score low, but because of their costs and technology immaturity.

It is important to note that of the technologies shown in the above figure, we consider tidal current, tidal marine and wave to be below TRL9, i.e. not at a stage for commercial deployment.

Scenario analysis

The purpose of the scenarios is to develop different views of the future. The potential role and development of each renewable energy technology is then assessed in each of these futures. This provides an understanding how renewable energy could develop under different views of what the future might hold. Four scenarios have been developed, corresponding to a matrix of low (current) and high energy prices and low (current) and high take up of energy efficiency measures on the Isle of Man. The scenarios are shown below:

Energy Prices

		Low	High
Energy Efficiency	**High**	**ORANGE** • Low financial incentive for energy efficiency as the savings and case for investment is weak. • Instead regulations or public opinion drive demand down • Consumer bills lowest • Energy costs are an incentive for inward investment • Lowest market incentive for RE, requires most Govt incentive for RE	**BLUE** • Strongest market incentive for energy efficiency • Backed by regulations • Lowest energy demand • Strong case for efficiency and renewable solutions. • Lowest energy imports • Renewable energy generation for export
	Low	**PURPLE** • Low efficiency buildings • Low efficiency appliances • Highest energy demand • Weak case for efficiency and renewable solutions. • Building in long term high energy use in new homes etc. • Highest energy imports (100%).	**YELLOW** • Market incentive ineffective to overcome barriers to EE • Lack of investment as other priorities attract funds • Consumer bills highest • Energy costs are a disincentive for inward investment • Highest incentive for RE – but low investment • Would need financial support

As a reference to future energy price scenarios, we take the latest UK Department of Energy and Climate Change (DECC) price projections. These forecasts are produced annually and take information from current studies as well as representing the best view from DECC internal modelling. In the latest issue, June 2010[3], real gas prices for the central case have an annual growth rate of 1.2% to 2020, whereas the corresponding increase in oil price is about 1.4% per annum. In our methodology we take these prices as representative of the low energy price scenario – i.e. the current position. The high energy price scenario would need to be materially different and we consider that the DECC high price scenario is appropriate for this. In the DECC high price scenario the annual rate of increase of oil and gas prices is around 4% in the next few years, reducing to a rate of increase of 3% by 2020.

Similarly energy efficiency is assumed not to fall from current levels, hence low energy efficiency is intended to represent the current situation, where high levels of efficiency are not widespread buildings, appliances or other energy using equipment. In this outcome energy efficiency will continue to improve but at a slow, gradual, rate.

[3] http://www.decc.gov.uk/assets/decc/Statistics/Projections/67-updated-emissions-projections-june-2010.pdf

High energy efficiency is a much more rapid improvement. This could be driven by regulation (e.g. much more stringent building regulations) or through better financial returns (due to high energy prices or incentives). In this outcome energy demand falls, which will reduce opportunities for some of the renewable energy technologies. In our appraisal of domestic energy efficiency savings, we identified that in principle up to 9MWh of annual energy for space heating could be saved from current levels of around 12MWh. As an indication, our high energy efficiency scenarios would correspond to the realisation of these benefits in over 20% of private households.

The assessment has looked at how each of the technologies would be favoured, or otherwise, in each scenario. In conclusion it is found that biomass and onshore wind are very resilient to each scenario, so would be attractive in a wide range of future conditions. Offshore wind is favoured in high energy price scenarios. On the heat side, district heating, heat pumps and solar thermal fair reasonably well, especially in the high energy prices high energy efficiency scenario.

Energy prices

The adoption of renewables on the Island, if they are more expensive than conventional alternatives, will put an upward pressure on energy prices. This impact has been modelled and it is found that for electricity, onshore wind has the smallest impact on energy costs for the Island, at an average price increase of about 0.4p/kWh for the lowest cost onshore wind projects (assuming overground cabling but excluding other connection costs and the increase to MEA operational costs necessary to manage the effects of intermittent generation). However, it is important to note that we have derived a range of costs for onshore wind, depending on location and method of connection (underground or overground cabling). At a 10% discount rate costs vary between 7.7p/kWh to 13.7p/kWh. Our simplified model indicates that for every 1p/kWh cost increase for 20MW of onshore wind generation the average electricity price would increase by 0.12p/kWh, so it is clear that if more expensive onshore wind projects were developed then the impact on electricity prices could be more significant.

The other large centralised generating options have a significant impact on the economy, most noticeably the tidal options, because of their size and high levelised costs. The smaller projects implemented by individual consumers have a much smaller impact on the Island cost of energy, principally because of their modest size. With the exception of small CHP though, the unit cost for the consumer/developer is substantially increased over the current grid supply costs. In general, the benefit from avoided gas imports for the electricity measures is more than outweighed by the higher overall technology cost.

For heat, the non-domestic biomass and CHP deliver a net energy cost saving to the Island and to individual consumers. For the other options the total Island cost is relatively modest, but this generally reflects the small scale of deployment of these measures.

Employment

Investment in renewable energy is likely to create direct jobs as well as indirect jobs across the entire supply chain of the renewable industry including environmental monitoring, development design, commissioning and procurement, manufacturing, installation, project management, transport and delivery and operations and maintenance. In order to determine the potential job generation from each technology option a renewable supply chain gap analysis carried out by the UK Department of Trade and Industry (DTI) was drawn upon and modified for the Isle of Man. The results are shown below.

Technology	Total jobs	Direct jobs	Indirect jobs
Offshore Wind	n.a.	n.a.	n.a.
Onshore Wind (2 most favoured 10MW farms)	5.1	3.7	1.4
Tidal Current	1.5	1.1	0.4
Tidal Lagoons	14.0	9.9	4.1
Wave	10.5	7.4	3.1
Biomass Domestic	72.8	40.4	31.5
Biomass Small scale	23.1	12.8	10.0
Biomass Medium scale	18.0	9.2	8.7

Technology	Total jobs	Direct jobs	Indirect jobs
Biomass Large scale	18.0	9.2	8.7
AD (EFW)	0.6	0.0	0.0
Solar PV	0.2	0.0	0.0
Solar Thermal	50.7	27.5	23.2
Small Wind Domestic	0.3	0.0	0.0
Small Wind Commercial	0.3	0.0	0.0
Heat Pumps (air & ground)	na		
Small CHP (<50 kWe)	na		
District Heating	na		
Small Hydro	0.8	0.0	0.0
Total	**216**	**123**	**93**

A qualitative review of the supply chain capability for the Isle of Man for supporting the renewable technologies suggests that jobs created or retained would mainly be related to:

- Small vessels for installation,
- Constructing access roads,
- Undertaking plumbing work,
- Undertaking electrical work, and
- Civil work

Community investment

Investment in renewable energy requires an investable project. This is true of community and commercial developments. To fund a renewable or low carbon energy project requires:

- A stable and known source of renewable or low carbon energy input.
- An affordable and appropriate source of capital funding.
- A stable and known source of revenue for the energy outputs.

This wider consideration of funding reflects the fact that all capital funding relies on a business case which in turn depends on the operating costs and revenues. In other words the project needs to be fundable in order to attract funding. Potential ways for community involvement in new renewable projects have been examined and case studies that are believed to have potential interest for the Isle of Man have been provided.

The case studies show some of the potential roles and funding opportunities for community bodies. There are also a wide range of roles for a public body in the funding and delivery of renewable energy. The table below summarises these:

Stage	Role
Fuel Inputs	Providing fuel (e.g. food waste) Providing Land (suited to wind farms) Providing Buildings (for solar installations)
Capital Funding	Investment Access to grants targeted at the key technologies Gearing from credit rating Community Infrastructure Levy
Energy Outputs	Long term energy supply contracts

The role of a public body in an individual project will vary greatly and the public body may have more than one role. Hence the role of public bodies can only be specified in more detail when the details of the projects are known.

Conclusions and recommendations

This study has assessed the potential for energy efficiency, renewable and low carbon energy generation on the Isle of Man. The following conclusions have been reached:

Policy and targets

Further fiscal or economic, regulatory, information or behaviour change measures need to be established to enable the IoM government to realise its aims and objectives. Transparent quantified targets should also be set to help the government and citizens to monitor progress to targets.

Energy efficiency

There are great opportunities for improved energy efficiency and unit costs lower than the current retail price of energy. Specifically in the domestic sector these include loft insulation, cavity wall insulation, draught proofing, improved heating controls and improved lighting. These measures are cheaper than current energy generation and new renewables so should be pursued as a policy priority.

There are likely to be significant energy savings opportunities within the public non-domestic building stock, but the opportunities have not been characterised for specific buildings. It would be cost-effective to commission a detailed survey of public buildings, possibly making use of thermal imaging.

Further work should be undertaken to determine opportunities for energy savings within the commercial and industrial sectors. It has not been possible to assess the opportunities as part of this study.

Energy infrastructure

The energy infrastructure is well positioned to meet the current energy needs of the Island's population in a safe and economic manner, through its gas and diesel electricity generating plant and plans to extend the natural gas network, although there is heavy reliance on imported fossil fuels. There is no short to medium term need to extend either the gas or electricity interconnector capacities to meet Island needs.

Heat-only technologies

Biomass technologies represent the best renewable option overall, for scales ranging from domestic through to large scale applications, using indigenous resources in the first instance. It is the cheapest heat option; although for domestic consumers would be significantly higher than conventional gas generation. It has the lowest barriers to deployment and without the visual impact concerns that affect some other technologies. The carbon saved could be over 20,000tCO_2/y so it offers potential to make a significant contribution to the Island's climate change ambitions. The technology is fairly robust to future energy price and energy efficiency scenarios and has the potential to generate jobs on the Isle of Man. More widespread development of biomass should be a priority for the Isle of Man Government. This should focus initially on non domestic applications but potentially also extend to domestic uses, for which some capital subsidy may be necessary.

There is potential for a district heating scheme making use of heat from the Richmond Hill EfW plant and serving the Isle of Man Business Park, Spring Valley Trading Estate and involving reuse of the former Ballakinnish Nurseries glasshouse complex. The Isle of Man Government should engage with affected business and the plant operator to determine the appetite for such a project. The cost of heat could be comparable with conventional sources, but with high capital expenditure. There may be a role for the Isle of Man Government in facilitating the development process and providing support for the capital requirements.

Domestic ground and air source heat pumps could also play a major part in meeting future Island energy needs, although the greatest barrier is cost. Some degree of capital subsidy, grant or loan may be appropriate to contribute to the cost of establishing these technologies in the domestic sector, which can amount to approaching £10k per application. It could be taken forward on a trial basis.

Solar thermal should not be pursued as a policy priority due to its high cost relative to other heat generation options.

Electricity-only generation technologies

Onshore wind should be pursued as a priority option for meeting short and longer term domestic renewable energy targets. It is the cheapest renewable electricity generating option and its increased cost relative to conventional CCGT is relatively small. It can deliver large amounts of energy, save significant carbon dioxide emissions and reduce the need for gas imports. The greatest barrier is public opposition and the Isle of Man Government should engage with local communities on the prospects for onshore wind generation.

The Island has significant offshore wind generation resource and four possible zones for large wind farms have been identified. These projects could generate large amounts of electricity (between 1,000GWh and 3,500GWh per year) although would only be viable under a scenario of direct connection to the UK in which Renewable Obligation certificates or similar are earned.

There is potential for additional small hydro generation, although the amount of electricity that could be generated would be small, and the cost of generation is around three times that of CCGT. It is recommended that the Isle of Man Government does not pursue small hydro as part of its renewable energy strategy.

Wave, tidal lagoon and tidal current technologies are at development or demonstration stages and as a consequence any application for the Isle of Man would be risky and expensive in economic terms. It is not recommended that the Isle of Man Government pursues any of these technologies as part of its medium term energy strategy. There could be benefits to the Island economy from the support of research and development projects on small scale, with the objective of establishing new clean tech enterprises that could benefit the Island through longer term exports or eventual commercial application on the Island. However, this would need to be viewed as a research project and not one that would provide a cost effective means of meeting short or medium term energy needs.

Small scale wind and solar PV are expensive options that have not scored well in the overall assessment. As well as price there are barriers over visual impact and consequently it is judged that the potential of these technologies to meet Island energy needs and contribute to cutting emissions is relatively small.

Cogeneration technologies

Small scale CHP applied to non-domestic buildings offer the potential for a cost effective way to cut carbon emissions and fossil fuel imports through the more efficient use of natural gas. Unit cost to consumers would be comparable with retail costs, although a barrier would be the capital investment cost. The Isle of Man Government could consider funding measures to support the supply and take-up of these technologies, possibly as part of a trial.

The potential for anaerobic digestion has been reviewed and the most promising option identified. It is judged that it could be cost effective, however, it would be on a very small scale relative to other technologies, and there would be concerns over its technical success (given previous experience on the Island). The multi criteria analysis ranks this technology low and it is considered that it should not form a significant part of a long term energy strategy.

Overall

In this study the potential for improved energy efficiency and the application of renewable and low carbon technologies on the Isle of Man has been systematically reviewed. The assessment has considered the state of technology readiness and the resources available on and around the Island to identify candidate projects for each. These have then been assessed to determine their costs, potential carbon benefits, contribution to improved energy security and the extent to which there are barriers or visual impact concerns associated with them. The impact that the technologies could have on employment and energy prices have then been considered, and examples provided of how local communities may benefit from the involvement in such projects. On the basis of this work we have identified those measures that we recommend should form part of a long term energy strategy for the Island, and those that should not. For technologies that it is recommended that the Isle of Man pursues, the type of support that may be applicable has been identified. It is recommended that the Isle of Man develops a long term energy strategy focusing on the most promising measures that are identified in the above conclusions.

AEA

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 0870 190 1900
Fax: 0870 190 6318

www.aeat.co.uk