Powering the Island through Renewable Energy

Cost Benefit Analysis For

A Renewable Energy Strategy for the Isle of Wight to 2010

Intermediate Technology Consultants (ITC) Ltd
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Intermediate Technology Consultants Ltd, Bourton Hall, Bourton-on-Dunsmore, Warwickshire, UK, CV23 9QZ.
Tel: 01788 661103 Fax: 01788 661105 Email: itc@itdg.org.uk
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List of Tables

List of acronyms and abbreviations

Abbreviation	Meaning
GOSE	Government of the South East
RES	Renewable Energy System
BWEA	British Wind Energy Association
IRESSI	Integrated Renewable Energy Systems for Small Islands
ETSU	Energy Technology Support Unit

1 Executive Summary

1. This report is part of a project to prepare a renewable energy strategy for the Isle of Wight, and is part of a larger project called "IRESSI" – Integrated Renewable Energy Systems for Small Islands.

2. A Background Analysis for A Renewable Energy Strategy for the Isle of Wight to 2010, was presented in March 2002. This report discussed options for the Isle of Wight in terms of renewable energy potential and gave the **technical** potential for various options. It also stated the possible lower and upper bounds for the contribution renewable energy could make to the Island by the year 2010.

3. This report presents a cost benefit analysis of the renewable energy strategy for the Isle of Wight and looks in detail at the **non technical** parameters concerned with the various options. These cover:

- *Economic* issues- including market costs and prices
- *Environmental* issues- both in terms of national effects such as global warming and atmospheric pollution, but also local environmental effects such as noise, and visual intrusion
- *Social* issues- concerning level of employment, regional development and overall attitude of the population towards the technologies and specific options proposed

4. The Background Analysis considered each renewable energy technology included in the respective targets to achieve a lower and upper bound of renewable energy supply. The table below is repeated from this analysis for clarity.

Table 1: Summary of potential contribution of different renewable energy options for meeting electricity and total energy demand on the Isle of Wight, by 2010

Type of Renewable Energy	Practicable Resource (MW)		Practicable Annual Energy Output Electricity (GWh)		Practicable Annual Energy Output Heat (GWh)		% Achievable Contribution to 2010 Electricity Demand		% Achievable Contribution to 2010 Total Energy Demand	
	LB	**UB**	**LB**	**UB**	**LB**	**UB**	**LB**	**UB**	**LB**	**UB**
Wind										
on-shore wind	12.0	18.0	30.0	44.9	n/a	n/a	5.1%	7.7%	0.9%	1.3%
off-shore wind	0.0	50.0	0.0	159.9	n/a	n/a	0.0%	27.2%	0.0%	4.6%
Biomass:										
Anaerobic digestion using dairy cow manure	0.2	0.5	1.7	4.3	0.5	1.3	0.3%	0.7%	0.1%	0.2%
Centralised CHP Plant, using SRC and forestry residues as fuel	2.8	5.3	21.0	39.3	31.5	59.0	3.6%	6.7%	1.5%	2.8%
OR Up to 5 decentralised heat only biomass systems, using forestry residues and SRC	1.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tidal Currents	0.0	3.0	0.0	9.4	n/a	n/a	0.0%	1.6%	0.0%	0.3%
Existing RDF/CHP Plant	1.7	1.7	6.6	6.6	not used	not used	1.1%	1.1%	0.2%	0.2%
Liquid biofuel (biodiesel)	n/a	n/a	n/a	n/a	0.0	21.9	n/a	n/a	0.0%	0.7%
Solar water heating	n/a	n/a	n/a	n/a	0.2	0.5	n/a	n/a	0.01%	0.01%
PV	0.0	0.1	0.0	0.1	n/a	n/a	0.00%	0.02%	0.00%	0.00%
Totals	**18.2**	**78.6**	**59.3**	**264.6**	**32.2**	**82.7**	**10.1%**	**45.1%**	**2.6%**	**10.0%**

LB = LOWER BOUND
UB = UPPER BOUND
n/a = not applicable

This study uses the figures above in the development of the cost benefit analysis for the strategy and considers the non-technical issues for each strategy within both the upper and lower bounds. The table below is a summary of the **local** environmental and social impact indicators that are of particular relevance to the specific technology and a summary of the specific economic costs. More detail is given in sections 3 and 7.

Renewable Technology	**Specific Environmental Impact Indicators**	**Specific Social Impact Indicators**	**Specific Economic Costs (with assumptions)**
Wind- on shore	• Noise • Visual • Impact on landscape • Effect on birds • Planning process • Use of land	• Community cohesion • Tourism • Political • Employment • Education • Self reliance	Economic: 2.9-3.6 p/kWh
Wind off shore	• Noise • Visual • Impact on landscape • Effect on birds • Planning process • Recreational	• Tourism • Political • Employment	Economic: ~3.6 p/kWh
Biomass- anaerobic digestion	• Noise • Visual • Use of land • Transport of fuel	• Community cohesion • Tourism • Political • Employment • Education • Self reliance	Economic: 4.7-8.2 p/kWh (Electricity only) Economic: 3.6-6.3 p/kWh (Heat and Electricity)
Biomass-centralised CHP	• Noise • Visual • Use of land • Transport of fuel • Planning process	• Employment • Education • Tourism	Economic: 2.6-2.9 p/kWh
Biomass- de-centralised heat only	As above	• Community cohesion • Tourism • Political • Employment • Education • Self reliance	Economic: ~1.8 p/kWh
Tidal Currents	• Visual • Impact on landscape • Effect on marine life • Planning process • Recreational	• Tourism • Political • Employment • Education	Economic: ~7 p/kWh
Solar water heating	• Visual	• Employment • Education • Self reliance	Economic: 13.9-20.9 p/kWh
Solar PV	• Visual	• Employment • Education • Self reliance	Economic: 78.5-104.7 p/kWh
Biodiesel	• Use of land • Transport of fuel	• Employment	Economic: ~82p per litre

5. In terms of the economic analysis the costs and prices were taken from data collected during the background analysis and from other available information. The costs included capital, fuel and Operation and Maintenance (O&M) costs. The capital costs were annuitised - using specific lifetime figures and discount rates. The annual costs of fuel and O&M were added to this capital cost to give a total energy cost. The direct economic cost in p/kWh is then calculated based on the energy output of the system. A simple rate of return (average annual return divided by capital cost)- ROR- has also been calculated to provide a pseudo measure of profitability, ignoring discounting.

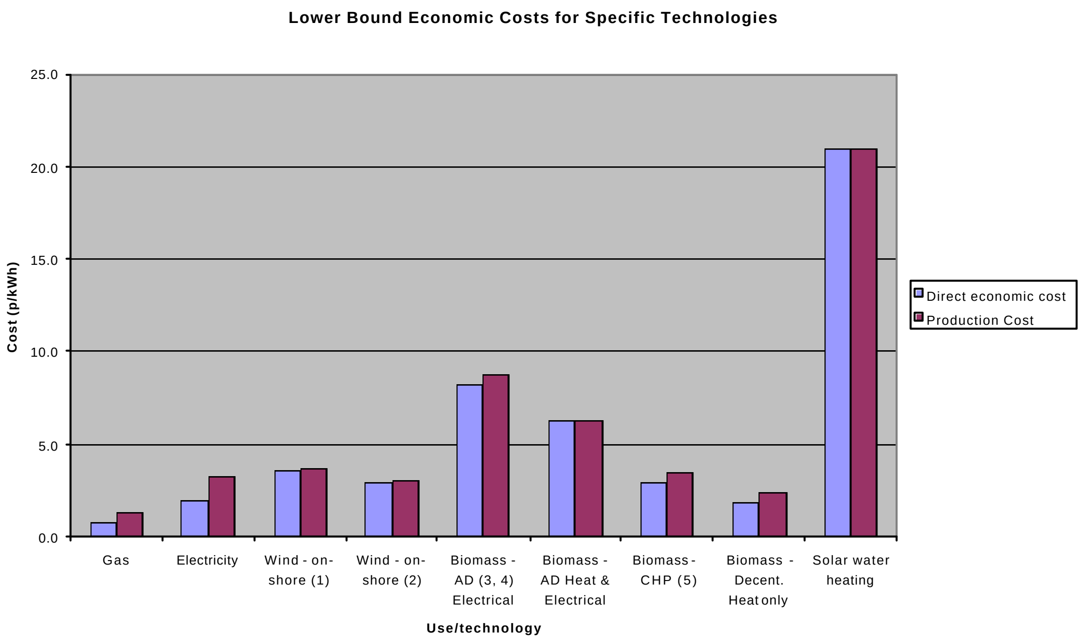
6. The economic figures can, by their very nature, be quantified, whereas the social and environmental indicators are generally hidden impacts and may be viewed either as

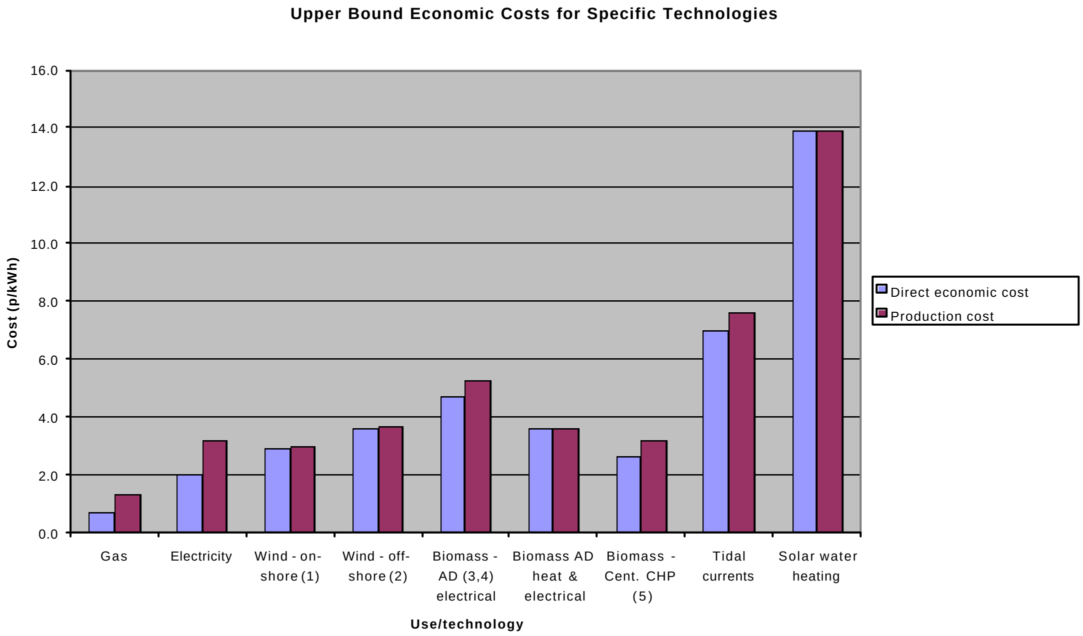
external costs (i.e. to the environment – local and/or global) or as external benefits (i.e. job creation). The social and environmental indicators have been quantified using data from an EU project, ExterneE that researched these costs in detail for a wide range of electricity producing technologies. A range has been given for these costs and an average taken in order to calculate the final production cost including all of these externalities.

7. A list of the social and environmental impact indicators is included in the report- as although a quantitative figure has been given overall, many of these are qualitative and need to be considered further in a Strategy.

8. A simple ROR for the production cost was calculated- including the economic cost and the average social and environmental cost. The increase in the ROR when social and environmental costs are included was then calculated.

9. The following two graphs show the economic costs and the total production costs (i.e. including the social and environmental costs) - section 8 of the report gives these in more detail. Please note solar PV is not shown as its costs are very high and distorted the graphs.





10. The on-shore wind option considered three alternatives - the lower bound considered 5 clusters of 4 small machines (600kW) and one larger farm with 8 machines (1.5MW). The lower overall capital cost of the second option makes it cheaper per kWh, but the social and environmental impacts would needed to be carefully considered. The upper bound considers a cluster of six machines in two windfarms.

11. The off-shore wind option is only included in the upper bound and would consist of 25 machines of 2MW. It is expected that the capital cost of these installations will fall as the industry develops, hence reducing the final electricity cost.

12. The options for biomass using anaerobic digestion, for the lower bound target, considered five farm based systems of approximately 40kW each. A direct economic cost of 8.2 p/kWh was calculated when only electricity was considered and a cost of 6.3 p/kWh when both thermal and electrical energy were considered. The upper bound target looked at one large centralised system of 500 kW. Again the option considered only electric and both thermal and electrical. Especially for the former it may be that the heat available would be difficult to utilise bearing in mind the location (on single farms) without considerable additional costs being incurred, hence the consideration of cost based only on the electrical output.

13. The option for biomass using forestry and short rotation coppicing looked at achieving the lower bound using a number of small systems- to produce both heat and electricity- and to just produce heat.

14. The solar water heaters for the lower bound were calculated on the assumption that they were only being used for domestic water heating on single retrofit properties. The upper bound was based on the assumption that they would also be used for new buildings and with bulk purchase. Additional savings and hence an overall lower price for the energy output would be achieved if a significant number of systems were used to heat swimming pools.

15. The Solar PV targets were based on small domestic installations of 1.5 kWp. The high capital cost for the relatively low amounts of electrical power make the economic cost very high. However these systems have very low social and environmental costs.

16. The tidal current turbine is still at the development stage so all costs were not available - the economic cost was thus quite high at 7p/kWh. This was provided by the companies involved in its development and cannot, at this stage, be easily verified by independent analysis which would be based on known costs for previous installations.

17. The biodiesel option has not been included in the two graphs as it is based on the production of fuel for transport rather than for electricity or heating. However an economic cost analysis was performed and showed that the costs for biodiesel on the Island would be approximately 82 p/litre (compared with around 75 p/litre for ordinary diesel at the pumps).

18. The baseline costs of gas and grid electricity were calculated (as these are the main fuels that the renewable technologies will be substituting).

19. This report will allow the development of a Renewable Energy Strategy- the technical options have already been discussed and these can be viewed alongside indicative economic costs for each technology. Quantitative costs have also been calculated for the social and environmental factors. However some of these social and environmental impact indicators are qualitative and will need to be considered in a Strategy.

2 Introduction

A Background Analysis for A Renewable Energy Strategy for the Isle of Wight to 2010, was presented in March 2002. This report discussed options for the Isle of Wight in terms of renewable potential and gave the **technical** potential for various options. It also gave the possible lower and upper bounds for the contribution renewable energy could make to the Island by the year 2010.

A **Cost-Benefit Analysis** has been prepared, using these options, and considering the economic, environmental and social costs and benefits.

An *Economic* analysis is based on market prices and conditions. The economic indicators are the universally recognised market indicators, which are the usual dictates on whether or not a project will move forward. The key economic indicators for any project are likely to be based on capital costs, project development costs, running or operation and development costs, and potentially training costs. In addition the revenue flow which affects the economic viability can be made up of many different components.

The *social* and *environmental* analysis is concerned with externalities which are perceived by the particular society but are not valued in the market place, such as environmental impacts on health or impact on local employment. They include damage to the natural and built environment, such as effects of air pollution on health, buildings, crops, forests and global warming; occupational disease and accidents; and reduced amenity from visual intrusion of plant or emissions of noise. Traditional economic assessment of fuel cycles has tended to ignore these effects. However, there is a growing interest in adopting a more sophisticated approach involving the quantification of these environmental and health impacts of energy use and their related external costs.

The report briefly describes the approach taken, gives an overview of the impact indicators used in that analysis and then gives details of the economic, social and environmental indicators for each technology.

3 Methodology/approach

The approach taken towards producing a Cost-Benefit Analysis has been to construct a list of the economic, environmental and social indicators. The economic figures can, by their very nature, be quantified, whereas the social and environmental indicators are generally hidden impacts and may be viewed either as external costs (i.e. to the environment – local and/or global) or as external benefits (i.e. job creation). The social and environmental indicators have been quantified using data from a EU project, ExterneE, that researched these costs for a wide range of technologies.

The table below summarises the impact indicators for all energy technologies- both the Renewable Energy Technologies and the conventional technologies that they are replacing. Some of these are obviously relevant to some technologies and not to others (i.e. the cost of crop cultivation is pertinent to biomass but not to wind technologies). These are discussed in further detail in the latter sections detailing the cost benefit analyses.

It should be noted that many items are effectively combined and reviewed together, i.e. under the economic impact indicators resource extraction, resource transportation, materials processing for any fuel are reflected in the fuel price.

Table 2: Summary of all impact indicators for all the technologies considered

Impact indicators		
Economic	**Environmental**	**Social**
Resource extraction	Emissions - climate change – acid rain	Community benefits
Resource transportation	Noise	Education
Materials processing	Visual	Employment
Establishment of crop	Effect on wildlife/biodiversity/soil structure and/or erosion, local hydrology	Health
Cultivation of crop	Landscape	Political
Harvesting	Planning – issues	Tourism
Collection (of crop or waste)	Planning process costs – including Environmental Impact Assessment	Energy diversification and security of supply
Transportation (of crop or waste)	Recreation	
Processing (of crop or waste)	Risk abatement	
Component manufacture	Loss of agricultural land	
Component transportation	Energy pay-back	
Plant construction	Transport of primary fuel, equipment, crops, etc – local and global issues	
Plant O&M	De-commissioning	
Duty	Product/by product disposal	
Potential sources of funding		

4 Economic impact indicators

The Economic analysis uses the commonly recognised market indicators which include the following:

4.1 Capital costs

This is the main expense for renewable energy projects. It includes the costs associated with actually purchasing and installing the project hardware.

4.2 Project development costs

These can be very significant and may include (depending on the project type/technology involved):

- Technical, legal and planning consultants' fees, and the farmer or developer's own time, in negotiations with legal and statutory bodies (for example in obtaining planning permission and consulting the Environment Agency)
- Financing and legal costs, including the costs of arranging finance
- Electrical connection costs
- Costs of licenses (for example, if imported food processing residues are used, a Waste Management License will be required, which will involve an initial charge and an annual fee)

4.3 Running and operation and maintenance costs

The running costs vary enormously for different technologies and projects depending on variations in design and operating circumstances. Running costs will include:

- Fuel costs, if applicable, it can include direct costs, or collection, (i.e. of biomass).
- Staff costs
- Insurance
- Transport costs
- Annual fees for licenses and pollution control measures
- General maintenance and operating costs, of plant, equipment, site, etc.

4.4 Training costs

Training is an often forgotten or ignored part of the overall project cost. The people who run energy projects/plants, of whatever size and technology, need to be fully trained in the safety, financial and environmental implications of the project. These skills will need to be updated as technology and knowledge develops.

4.5 Income

The key income will be from the sale of energy (including avoided cost and sales), often in the form of electrical energy. However it should be remembered that by-products can contribute to the overall income, i.e. for anaerobic digestion the fibre sales can produce a significant income. Markets for all the products will need to be developed and balanced for the project to be economically viable. The way the project develops depends on the priority product for the developer (that is for biomass anaerobic digestion systems, energy, fibre or liquor), which will have implications for the technology which should be chosen.

In summary, income streams are likely to include:

- Electricity sales (or displaced purchases); energy from renewable sources is likely to continue to command premium rates
- Heat sales (or displaced purchases)
- By product sales (or displaced costs)
- Savings i.e. for anaerobic digestion on slurry handling and other waste management costs.

4.6 Financing the project

Most renewable energy systems will require a large amount of capital investment and, in most cases, developers will require finance from an external source.

There are two types of loan: those secured against the developer's existing assets (on-balance sheet financing), and those secured against future cash flows (limited recourse project financing). It is unlikely that a lender will finance 100% of a project's costs. Between 20% - 40% may have to be funded by the developer.

Traditional investors do not recognise the environmental benefits and sustainability of renewable energies and view it in the same way as any other high-risk commercial project, demanding high security and high returns on invested capital, leaving less for other investors and shareholders. Ethical or 'green' banks and funds are beginning to appear. They take a more sympathetic view of renewable energy in general and seem willing to invest on less onerous terms. These could be sought by renewable energy project developers, particularly those whose projects fall into the financing gap described earlier. Certain Regional Electricity Companies (RECs) may be interested in supporting (through investment) alternative renewable energy sources in some areas.

Other potential sources of funding include:

- Enhanced Capital Allowances –incentives to buy *green* as part of the Climate Change Levy (basically tax breaks for large companies paying corporation tax)[1]
- New opportunities fund – lottery
- Landfill Tax Credit Scheme
- Environmental Innovation and Improvement Grant – European Regional Development funded grant
- Other EC Regional Policy and Structural Funds
- EC ALTENER and SAVE programmes
- EC ENERGIE 6th Framework
- DEFRA – Rural Development Programme
- PIU – Performance and Innovation Unit – government funds
- DTI – research and development programmes
- Renewables Obligation (RO)
- MAFF – for certain related issues

5 Social impact indicators

It is important to consider that the social aspects of any project especially in gaining local support and acceptance of a particular project. Social assessments are used to evaluate the local (or regional or national) implications of implementing particular strategy. Some of these can be quantified in terms of local employment gains and income increases. However many of them are particular to an individuals or communities perception and are difficult to quantify. Table 3 gives a range of indicators, with the group who will benefit and the effect it could have on this group.

5.1 Employment

According to the 1996 European Commission's Green Paper on renewable energies[i] the development of renewables can bring positive and tangible effects on regional development and employment. It can bring *employment to regions which are otherwise deprived of industrial development,* as well as a supply of energy resources necessary for development.

[1] www.eca.gov.uk

The renewable energy industry consists predominantly of small and medium sized enterprises (SMEs) which are recognised as being a major source of new job opportunities in the EU. Furthermore, renewables are of particular interest for development in tourist areas, where energy demand in increasing.

5.2 Education

Having systems "to hand" provides young people to learn about renewable energy sources and introduce sustainable development, first hand.

5.3 Tourism

There have been numerous cases of renewable energy developments being used to simulate "green" tourism. In Cornwall a visitor's centre was set-up at a newly developed wind farm which received 55,000 visitors over 18 months[ii].

5.4 Self-reliance

This applies not only to individual systems rather than those that supply directly to the grid on a specific small plant and local level. It refers to the benefit of not relying solely on the grid but having the option and security of other sources of energy. This is equally true on an extended level for the whole island.

5.5 Community benefits

These are interrelated with the benefits of self-reliance but also, for specific projects, include involvement of the community in areas such as:

- financial return – this can be for the individual but also for the community for community based schemes
- diversification of rural incomes
- an increase in local employment as discussed above
- a contribution towards environmental sustainability – minimising Ecological Footprint, and contributing to Local Agenda 21 strategy. And potential for combining with Green Tourism.
- some degree of control over the scheme for the community, for community based schemes.
- a sense of satisfaction for those involved, and building capacity and strength of community

5.6 Health

Health hazards relate not only to the operation of the plant and associated equipment but also to all interrelated factors – such as air quality due to crop choice, i.e. oil seed rape for biodiesel production.

5.7 Political

There may be costs/savings associated with objections/support from local groups, i.e. planning processes may need to be extended and include public consultation.

5.8 Summary

Table 3: Summary of social impacts

Impact indicator	Receptor	Effect	Suggested? Prioritisation	Impact level
Employment	Public	Increased employment		
Education	Local			
Tourism	Local people	Income/publicity		
Community benefits	Local people	Local cohesion/ownership benefits		L, M, H
Self-reliance - individual system	Local groups/industry			
Self-reliance - Energy diversification and security of supply	Whole island	Added security		
Health	Industry workers	Accidents		
Political				

Just ordering them to be the same as above headings

6 *Environmental impact indicators*

The environmental analysis concerns the impact of the technology on:

- Local and regional emissions of greenhouse gases
- Local landscape and nature conservation
- Risk abatement

As with the social indicators, some of these can be quantified in terms of emissions. However many of them are particular to an individuals or communities perception and are difficult to quantify. Table 3 gives a range of indicators, with the group who will benefit and the effect it could have on this group.

6.1 Emissions

Emissions from Renewable Energy technologies are negligible during the actual generation stage. However emissions do occur during other stages of their Life Cycle (such as during the manufacturing, transporting and constructing of the plant). The emissions looked at include emission of SO2, Nox, CO2 and other particulates.

6.2 Visual Impact

The visual impact of a renewable energy scheme is highly particular to perception. Two impacts are considered:

'Objective impact'- visual image of technology to observers in line of sight depends on land form and visibility and number of observers
'Perceived impact'- depends on attitudes to existing land and scenery, and general attitudes technology

6.3 Noise

Noise from the technology is mainly from the operation of the plant

6.4 Effect on flora, fauna

The effect on wildlife, biodiversity, soil and local water sources on the whole process

6.5 Site selection/landscape

Including
- the planning process costs
- Siting- on land used for other purposes
- Effect on land use

6.6 Risk abatement

This refers to the risks that could be averted if a renewable energy technology substitutes for a conventional fuel, i.e. diesel spills

Table 4: Summary of Environmental impacts

Impact indicator	Receptor	Suggested? Prioritisation	Impact level
Emissions - climate change – acid rain	Local/Regional		
Noise	Local		
Visual			
Effect on wildlife/biodiversity/soil structure and/or erosion, local hydrology	Local		
Landscape	Local		
Planning - issues	Local		
Recreation	Local		
Risk abatement	Local		
Loss of agricultural land	Local		
Energy pay-back	Local		
Transport of primary fuel, equipment, crops, etc – local and global issues	Local		
De-commissioning	Local		
Product/by product disposal			

7 Technology and Impact of Indicators

7.1 On-shore wind energy

7.1.1 Economic impact indicators

The table below summaries the economic analysis for three possible on-shore wind scenarios
The systems modelled are:
System 1: For the lower bound target of 12 MW the analysis considered 20 off 600kW machines in 4 clusters of 5
System 2: For the lower bound target of 12 MW the analysis considered 8 off 1.5MW machines in one larger windfarm
System 3: For the upper bound of 18 MW the analysis considered 12 off 1.5MW machines in 2 off clusters of 6

Table 5: Economic indicators for on-shore wind

Technology	**On-shore wind energy**		
Bound	Lower	Lower	Upper
System description	1	2	3
Machine size (MW)	0.6	1.5	1.5
Total capital cost (£, millions)	10.0	8.0	12.0
Fuel costs/annum (£ k)	0	0	0
O&M costs/annum (£ k)	68	44	74
Annuitised capital cost/annum (£ k)	1,019	815	1,222
Life time	20		
Total annual energy production (GWh)			
Electricity	30.0	30.0	45.0
Simple energy cost (p/kWh)			
Electricity only	**1.9**	**1.5**	**1.5**
Energy cost (p/kWh)			
Electricity only	**3.6**	**2.9**	**2.9**

7.1.2 Environmental impact indicators

In terms of Energy payback, the average wind farm in the UK pays back the energy used in its manufacture within three to five months, and over its lifetime a wind turbine will produce over 30 times more energy than was used in its manufacture.

In local terms the most important externality is the perceived noise and visual intrusion. As discussed in the background report and at the subsequent workshop these can be significantly reduced through good site planning, with criteria as to the acceptable range.

Other negative environmental impacts with wind turbines can be birds affected by injury/death through colliding with the turbine or disturbance to breeding/nesting. However these are generally low (less than those colliding with over head transmission lines are)

Wind turbines can have dual land use- the capture of wind energy requires turbines to be spread over a large area. However the base of a wind turbine uses less than 0.2% of the land it occupies. The remaining land can be used for agriculture.

7.1.3 Social impacts indicators

There are potential good community benefits with wind turbines. These have already been discussed in the determination of the flagship projects, although these apply specifically to the lower bound option utilising appropriate implementation of small clusters of smaller wind generators:

- A financial return for the community, landowners and investors
- Diversification of rural incomes
- An increase in local employment as discussed below
- A contribution towards environmental sustainability and for combining with Green Tourism.
- Some degree of control over the scheme for the community.
- A sense of satisfaction for those involved, and building capacity and strength of community

In terms of employment numerous studies find that wind power compares favourably in its job creating capacity with coal and nuclear generated electricity. A 1995[2] report on the status of employment in the UK wind industry concluded that the job creation for operation and maintenance – essentially local in nature – are significantly higher than for coal powered and combined gas cycle turbine power stations, even taking into account mining and extraction of the latter. Of 1300 jobs estimated for the UK in 1995 8% were in operation and maintenance and 14% in construction.

Under 1997 European market conditions the installation of 1MW of wind power was estimated to create jobs for between 15-19 people[3]. Even accounting for the increasing size of wind turbines and the growing economies of scale for the industry in general estimates can be made for the number of jobs created by the planned scenario for the IoW. Hence 12MW (lower bound figures) installed on the IoW could be expected to produce 150 – 200 jobs, an estimated 12-16 in operation and maintenance and 21-28 in construction. Obviously not all of these would necessarily be on the IoW and not all would be from local people but it would certainly be of a net gain for the island since it would not be replacing any existing jobs.

The figures discussed above are only direct employment gain and do not include indirect and induced employment, there would be additional employment figures in these groups.

[2] Survey of Employment in the UK wind energy industry 1993-1995, North Energy Associates, DTI ETSU Rep No. ETSU/W/13/00354/47/REP, 1995.

[3] European Commission Directorate General for Energy, *Wind Energy – The Facts; Volume 3 – Industry and Employment*, EWEA, 1997

Accidents to the public are extremely unlikely. There is a minute risk of accidents if part or all of the turbine blade detaches from the turbine whilst operating, although the risk of such accidents is very small indeed. There is no known occurrence of injury to a member of the public due to the operation of wind turbines. The risk of occupational accidents is likely to be greatest during the manufacturing and construction phase.

Wind turbines can produce a "shadow flicker" effect as sunlight passes through the rotating blades, which can produce a visual impact and could (potentially) induce attacks in epilepsy sufferers. However, this is highly unlikely and in any case these effects are minimised by keeping rotation rates below 50 r.p.m. for three-bladed machines.

There is no evidence to suggest that wind farms detract tourists, indeed many wind farms have themselves become tourist attractions

7.2 Off-shore wind energy

7.2.1 Economic Impact Assessment

The table below summaries the economic analysis for a possible off-shore wind system
The systems modelled is to achieve an upper bound of 50 MW with a total 25 of 2MW machines in one windfarm

Table 6: Economic indicators for off-shore wind
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Technology	**Off-shore wind energy**
Bound	Upper
System description	1
Machine size (MW)	2.0
Total capital cost (£, millions)	49.7
Fuel costs/annum (£ k)	0
O&M costs/annum (£ k)	621
Annutised capital cost/annum (£ k)	5,062
Life time	20
Total annual energy production (GWh)	
Electricity	160.0
Simple energy cost (p/kWh)	
Electricity only	1.9
Energy cost (p/kWh)	
Electricity only	3.6

7.2.2 Environmental impact indicators

Most of the same issues apply to off-shore wind turbines in terms of visual impact. Recreational activities could also be affected and navigational routes.

7.2.3 Social impacts indicators

There would be fewer community benefits from the installation of large-scale off-shore wind energy that for smaller land based systems.
The development of the offshore wind industry is on now beginning with the development of this new branch of the technology there is the involvement of companies from the offshore energy field. Recent investigations by the BWEA off-shore group member estimate that a 75MW off-shore installation would create 245 jobs[4]. Some jobs will certainly be created away from the main centres of industry.

7.3 Biomass – Anaerobic digestion

7.3.1 Economic Impact Indicators

The table below summaries the economic analysis for upper and lower bound biomass AD systems:
System 1: To achieve lower bound of 0.2 MW and based on 5 off farm based systems of 40kWe each
System 2: To achieve upper bound of 0.5 MW and based on 1 large centralised system of 500kWe
Note that the slurry is already collected so there are no fuel costs associated and an allowance is made for transportation costs for large-scale system

Table 7: Economic indicators for biomass anaerobic digestion

Technology	**Biomass - Anaerobic digestion**	
Bound	Lower	Upper
System description	1	2
Plant size (MWe)	0.04	0.50
Total capital cost (£, millions)	1.2	1.5
Fuel costs/annum (£ k)	0	10
O&M costs/annum (£ k)	15	50
Annutised capital cost/annum (£ k)	122	153
Life time	20	
Total annual energy production (GWh)		
Electricity	1.7	4.3
Heat	0.5	1.3
Simple energy cost (p/kWh)		
Electricity only	4.5	3.1
Heat and electricity	3.4	2.4
Energy cost (p/kWh)		
Electricity only	8.2	4.7
Heat and electricity	6.3	3.6

[4] www.BWEA.com

7.3.2 Environmental impact indicators

The environmental impact issues concerned with anaerobic digestion include noise, the perceived cleanliness of the 'fuel' and the alternative use of land.

7.3.3 Social impacts indicators

Community benefits would include:

- Diversification of incomes for farmers
- Anaerobic digestion can reduce the odour from farm slurries and food residues by up to 80%.
- There are increasingly regulatory and public pressures on farmers and others to ensure that residues are dealt with in new ways which are more environmentally sound, and carry less risk to human and animal health than traditional methods. Properly managed anaerobic digestion schemes will help farmers meet these pressures.

7.4 Biomass – Wood based (SRC and/or forestry residue)

7.4.1 Economic impact indicators

The main economic costs for wood based biomass systems are the plant and the fuel price. There are grants which can contribute to growing SRC these include:

- Woodland management & establishment, equipment

The table below summaries the economic analysis for three possible biomass/SRC scenarios

The systems modelled are:

System 1: To achieve lower bound of 1.5 MW based on thermal only heating systems using 5-7 systems of 200-300 kWt plant size

System 2: To achieve lower bound of 2.8 MW, thermal and electrical using a number of installations ranging from 50-500KWe

System 3: To achieve Upper bound of 5.3 MW, thermal and electrical, using a large centralised single size system

Table 8: Economic indicators for biomass SRC/Forestry residue

Technology	Biomass - SRC/forestry residue		
Bound	Lower	Lower	Upper
System description	1	2	3
Plant size (MWe or MWt)	0.2	0.05-0.5	5.3
Total capital cost (£, millions)	0.3	6.0	9.3
Fuel costs/annum (£ k)	88	825	1,561
O&M costs/annum (£ k)	101	74	82
Annutised capital cost/annum (£ k)	35	606	945
Life time	15	20	
Total annual energy production (GWh)			
Electricity	0.0	20.8	39.5
Heat	7.5	31.3	59.2

Simple energy cost (p/kWh)			
Electricity & heat		2.3	2.1
Heat only	1.6		
Energy cost (p/kWh)			
Electricity & heat		2.9	2.6
Heat only	1.8		

7.4.2 Environmental impact indicators

The environmental benefits of SRC/forestry residue can be summarised as:

- Production of energy with no net increase in atmospheric carbon, other than the small amount released in the manufacture of the plant and equipment used in this process;
- Fuel can be supplied from an area close to the plant thus reducing transportation needs;
- SRC plantations can provide landscape variety and a habitat for many species of plants, birds and other wildlife;
- Use of agricultural chemical is low in comparison to agricultural land.

The costs could be the noise, the change of land use and the visual impact

7.4.3 Social impacts indicators

As discussed the local Forest Enterprise (FE) warden has already expressed an interest in finding an alternative use for the forestry softwood thinnings. At present, the main contractor, who takes the harvested logs to the mainland for processing, is obliged to take the thinnings as well. This depresses the price that FE get for the logs.

If the softwood thinnings could be put to productive use on the Island, this would benefit FE. It would also have the benefit of "closing the loop" – i.e. what would normally be regarded as a waste product, grown on the Island, could be put to good use – it would reduce the Island's Footprint by displacing the use of fossil fuel for heating.

The growing of short rotation energy crops (SRC), would provide a much needed alternative source of income for local farmers on the Island. The extent to which the community would be affected would depend on the nature and scale of the project(s).

Community concerns which must be addressed early are likely to include:

- Timing of construction and disturbance to local area during construction;
- Traffic routes;
- Air emissions and monitoring;
- Public access to SRC plantation

In terms of employment work on SRC plantation can provide employment for agricultural workers. In addition jobs will be created at the power production plants. A similar example (to that indicated as possible in the upper bound of systems) of a new 5.8MW plant (yet to be installed) estimates that the precise number of jobs created will be:

- 15 new permanent jobs (plant operation and provision of wood fuel);
- 18 jobs provided indirectly in the procurement of goods and services required by the plant;
- 35 jobs created by an increase in expenditure on the local economy;
- 75 workers employed during the 18 month construction phase.

Plantations and power plants can be promoted as visitor attractions and to provide educational opportunities, i.e. because they are local projects links can be made with local schools' environmental programmes.

7.5 Tidal currents

7.5.1 Economic Impact Indicators

The table below summaries the economic analysis for a possible tidal current scenario
The system is to achieve an upper bound of 3.4 MW and is based on a 3MW machine

It should be noted that many costs not available due to developmental nature of the technology

Table 9: Economic indicators for Tidal current turbines

Technology	**Tidal currents**
Bound	Upper
System description	1
Machine size (MW)	3.0
Total capital cost (£, millions)	3.0
Fuel costs/annum (£ k)	0
O&M costs/annum (£ k)	n/a
Annutised capital cost/annum (£ k)	n/a
Life time	25
Total annual energy production (GWh)	
Electricity	9.4
Simple energy cost (p/kWh)	
Electricity only	n/a
Energy cost (p/kWh)	
Electricity only	7.0

7.5.2 Environmental impact indicators

- Hydrodynamics - effects on the wave and tidal dimate. This could influence the shore, estuary and shallow sub-tidal areas and the communities of plants and animals they support.
- Navigation - potential hazards to shipping and fishing activity
- Disruption to marine recreation e.g. sailing
- Landscape and visual impact of shoreline and near shoreline devices
- Installation of support structures and associated impact on marine & tidal ecology
- Power transmission infrastructure– visual impacts

7.6 Biodiesel

7.6.1 Economic impact indicators

As a supporting project to this work a study has been completed by an MSc student at Reading University into the viability of the use of biodiesel on the IoW. This also included a detailed economic assessment.

As part of this economic evaluation the costs and prices of each of the inputs were identified and have been inputted at their current values. The capital costs of items such as the plant, filtering equipment and crushing equipment have been charged at an annual rate using an annuity formula, the write-off period is ten years in all cases and the interest rate is assumed to be 10%.

The report showed that about 1.7 million litres of waste cooking oil is produced on the Island each year. Presently, about 250,000 (15% of total) litres per year is collected for recycling, where it is taken to the mainland, to be converted into animal feed.

The current annual diesel consumption of the combined fleets of Wightbus, Southern Vectis and Biffa waste collection vehicles is about 2.4 million litres per year. RVO (Recycled Vegetable Oil) could meet about 28% of this demand, assuming 50% can be collected. The remainder could come from rapeseed and linseed to be grown on the Island. Currently, there is 570ha of rapeseed grown on the Island (1999), and 621ha of linseed. If all the oil for these crops were converted into biodiesel, it would produce about 1.9 million litres of fuel.

This would require a biodiesel production plant with an output capacity of just over 2000 tonnes of biodiesel per annum. The capital cost of a 2000tpa biodiesel production plant is likely to be in the order of £1 million.

The study indicates that the costs for biodiesel produced in this volume could be:

	Biodiesel[5]	Fossil fuel based diesel
Basic fuel production cost	37	
Margin and distribution costs	12	
Total incl. duty[6]	82	75

The economics of production are highly dependent on 2 factors:

i) the level of fuel duty applied to biodiesel
ii) the price that can be obtained for the sale of the by-products

Biodiesel has recently received a tax break such that the duty on this fuel is now approximately 33p/litre[7]. There is pressure for this to be further reduced to the rate currently applied to the alternative fossil transport fuels, such as LPG and CNG, which are taxed at 9.8p/litre. At this level biodiesel production is likely to become economic, even at the small scale being proposed on the Island.

A biodiesel plant could be successful on the Isle of Wight, however a detailed feasibility study would be required to carefully identified and monitor all variables. This will ensure that the success of the project must not lie solely on one particular factor, such as the market price for a specific by-product.

[5] Fuel production cost based on limited/zero sale of by-products and incorporating contingency 10% into spread sheet costs.
[6] Biodiesel duty 33p/litre
[7] Once the duty reduction comes into force at the Royal Assent of the Finance Bill (expected July).

7.6.2 Environment impact indicators

The environmental impacts of biodiesel production on the Isle of Wight range from the reduction in greenhouse gas emissions due to the use of biodiesel rather than petroleum diesel to the effects on local biodiversity due to the growth of large quantities of oilseed crops.

In terms of the environmental impact from the production facility, this would be minimal as the proposed site is in a non-residential area at the wharf in Cowes. The area is already industrialised and is not highly visible except from the water. The location will allow easy access by road and sea and will help to minimise transport costs.

Th environmental impact of the large-scale growth of one type of crop, particularly rapeseed, is largely unknown. The growth of oilseed rape requires large amounts of inorganic nitrogen and could possible lead to higher concentrations of nitrates in the water supply, however this is unlikely because rapeseed has a long taproot allowing it to absorb more nitrogen.

The growth of any crop also requires the use of agrochemicals the application of which, is covered by various legislative documents such as:

- Control of Substances Hazardous to Health (COSHH), 1998
- Health and Safety at Work Act, 1974
- Control of Pesticide Regulations (COPR), 1986

Certain restrictions apply to the use of specific chemicals particularly during flowering season and the toxicity of these chemicals for insects must be minimal especially during this season.

There is potential for the displacement of certain species in habitats adjacent to sites where rapeseed is grown. Hedgerows are a particularly common habitat and house many species of birds, insects and small mammals that could be effected. There is however, the fact that rapeseed can only been grown on the same area of land for one year before it must be replaced by another crop. This will reduce the impact of rapeseed on biodiversity of particular areas.

7.6.3 Social impact indicators

The social impacts of this project can effect most islanders and in various ways. For farmers there is the benefit of additional income through the CAP Reform: Arable Areas Payment Scheme.[1] Under this scheme farmers are entitled to payments for crops grown, particularly relevant is the payments for crops grown on set-aside land. Depending on the amount of extra land used for oilseed crops, there may also be an increase in employment opportunities on farms.

The biodiesel plant may also encourage employment is several areas. For instance, there will be employment in construction while the plant is built, there will be jobs in the operation of the plant although these will vary depending on the plant size. Employment will also be created due to the need to collect the RVO and the delivery and transportation of the biodiesel and the by-products.

On the negative side, when there is strong public opposition to a particular industrial activity it can prove detrimental to the success of that activity. This is true of biodiesel in the sense that it is not the production of biodiesel that is the problem but the growing of large quantities of crops such as rapeseed that causes the public resistance.

Oilseed rape has been labelled ‘the yellow peril’ by the UK press due to the increase in health problems such as asthma and hay fever that are rumoured to be caused by rapeseed.

A recent report drawing conclusions from several experiments states that 'the consensus from these data is that rapeseed pollen forms only a minute fraction of the total atmospheric pollen load, but that it is more abundant during the flowering season and in the vicinity of rapeseed crops'.[2] Another recent report concludes that 'currently available data suggests that allergic responses to oilseed rape make very little contribution to the overall burden of allergy in the UK and diagnoses of pollen allergy should be considered in the context of an increasing prevalence of allergy in developed and developing countries'.[3] It is further concluded that 'rapeseed pollen does not contribute greatly to the total pollen load in the environment at the time of rapeseed flowering and that there was no direct evidence suggesting that rapeseed volatile organic compounds (VOCs) are implicated in adverse health effects'. [3]

Despite the suggestions from these reports that rapeseed does not induce significant health problems in humans, the idea of these problems is firmly embedded in the publics mind, it is therefore not a problem that can be easily dismissed. With this in mind it is necessary to assess the alternatives to oilseed rape, these are other oilseed crops such as linseed and sunflower. Linseed has been grown successfully on the Isle of Wight for many years and there is currently more of this crop grown than of rapeseed. Sunflower however has only recently undergone trials in the South of England and although successful, it has not been proven on the Isle of Wight and yields are not definite.

In order to minimise the effects of rapeseed on the publics health it is important to use a combination of these two crops, rapeseed and linseed, and also to import some of the raw crops from the mainland.

7.7 Solar water heating

7.7.1 Economic impact indicators

The table below summaries the economic analysis for two possible solar water heater scenarios:

System 1: To achieve the heat equivalent of 0.2 GWh per year. The capital cost is based only on use for domestic water heating in typical retrofit. The cost would be decreased if it involved significant use of SWH for swimming pool heating and/or bulk purchase, i.e. by housing associations

System 2: To achieve the heat equivalent of 0.5 GWh per year. Here it assumes some economies of scale for bulk purchase of domestic systems i.e. by housing associations/new build figures would also improve further if including significant use of SWH for swimming pool heating

Table 10: Economic indicators for Solar Water Heaters

Technology	**Solar water heating**	
Bound	Lower	Upper
System description	1	2
System size (m2)	3-4	3-4
Total capital cost (£, millions)	0.45	0.65
Fuel costs/annum (£ k)	0	0
O&M costs/annum (£ k)	1	2
Annutised capital cost/annum (£ k)	46	66

Life time	20	
Total annual energy production (GWh)		
Heat	0.23	0.49
Simple energy cost (p/kWh)		
Heat only	10.5	7.0
Energy cost (p/kWh)		
Heat only	20.9	13.9

7.7.2 Environmental impact indicators

The environmental effects are low for solar water heaters especially , in terms of visual impact or noise.

7.7.3 Social impacts indicators

The installation of a limited number of SWH systems (i.e. 150 as indicated in the lower bound) could contribute to the creation of one job on the IoW[8] , based on the increased penetration that this would represent and certainly installing a larger number of systems would require the availability of local plumbers, trained in such installations.

7.8 PV

7.8.1 Economic impact indicators

The table below summaries the economic analysis for two possible solar water heater scenarios:
System 1: To achieve lower bound based on small domestic installations 10 off 1.5kWp
System 2: To achieve Upper bound based on small domestic installations 40 off 1.5kWp plus one large commercial installation 50kWp

Table 11: Economic indicators for Solar PV

Technology	Solar PV	
Bound	Lower	Upper
System description	1	2
System size (kWp)	1.5	1.5-50
Total capital cost (£, millions)	0.12	0.65
Fuel costs/annum (£ k)	0	0
O&M costs/annum (£ k)	1	3
Annutised capital cost/annum (£ k)	11	61
Life time	25	
Total annual energy production (GWh)		
Electricity	0.01	0.08

[8] Active Solar Information Dissemination Activities, Solar Trade Association, ETSU S/P3/00264/REP, 1998

Simple energy cost (p/kWh)		
Electricty only	47.4	35.6
Energy cost (p/kWh)		
Electricity only	104.7	78.5

7.8.2 Environmental impact indicators
Environmental impacts are low although there can be a visual impact if the panels are not integrated into the design of the house.

7.8.3 Social impacts indicators

All PV schemes can pose a health hazard. Fires could release toxic materials (depending on the module and system construction) but conventional fire precautions and the low level of emissions caused by fire would make these risk low especially in comparison to the normal risks from fire in buildings[iii]. Occupational safety is an important issue for PV systems, direct current (DC) electricity is more dangerous than the equivalent alternating current (AC) output. This risk can be minimised by the use of good operating practices and equipment, i.e. plug-in connectors, appropriate warning labels.

8 Summary/Discussion of findings

Tables 11 and 12 shows the economic, social and environmental analysis for the potential different renewable energy options for meeting certain targets for electricity and total energy demand on the Isle of Wight.
Table 13 gives a summary of the **local** environmental and social impact indicators that are of particular relevance to the specific technology

Table 11 shows the possible lower bound where 10% of electricity demand comes from renewables and 2.6% of total energy demand is from renewables, by the year 2010.

The following assumptions have been made

1. The first on shore wind option refers to 600kW machines in 4 small farms each with 5 machines

2. The second on shore wind option refers to one larger windfarm incorporating eight 1.5MW machines

3. The biomass AD system is based on 5 farm based systems @ 40kWe each

4. With the biomass AD the first row of figures are based on electrical energy output only, the second row on electrical and thermal energy output

5. The figures for the biomass SRC/forestry CHP are based on electrical and thermal energy output

6. The direct economic cost includes no profit margin or transmission costs included (direct production costs only)

7. Direct economic cost is based on discount rate of 8%

8. The SWH is a domestic based cost based only on use for domestic water heating in typical retrofit

9. It should be noted that there are additional direct avoided costs and savings for Biomass AD

10. For the electricity direct economic cost the lower bound of production cost indicated for current supply mix from Scottish & Southern- upper bound approx. 2.5p/kWh

11. Comparison are made only to gas and electricity because these are the energies that would be substituted by renewable technologies

12. Gas and electricity prices based on rates for domestic and industrial supply weighted for IoW sector distribution

Table 12: Summary of Cost Benefit Analysis for Lower bounds for Renewable Targets for IoW

Lower Bound							Environmental & social cost		Total cost (average)			
Use / technology	Energy (heat) used / practicable output (GWh/annum)	Energy (electricity) used / practicable output (GWh/annum)	Capital cost (£ '000,000)	Direct economic cost (p/kWh) (6, 7, 8, 9, 10)	Price to consumer (p/kWh) (11, 12)	Simple ROR (rate of return)	Lower band (p/kWh)	Upper band (p/kWh)	Production cost (p/kWh)	Price to consumer (p/kWh)	Indicative ROR (simple)	ROR increase
Gas			n/a	0.7	1.1		0.4	0.8	1.3	1.7		
Electricity			n/a	2.0	5.0		0.8	1.5	3.2	6.1		
Wind - on-shore (1)		30.0	10.0	3.6		14.9%	0.1	0.1	3.7		18.4%	24%
Wind - on-shore (2)		30.0	8.0	2.9		18.6%	0.1	0.1	3.0		23.1%	24%
Biomass - AD (3, 4)	0.5	1.7	1.2	8.2		6.9%	0.6	0.6	8.8		8.6%	24%
				6.3		7.4%			6.3		9.3%	26%
Biomass - CHP (5)	31.3	20.8	6.0	2.9		23.2%	0.6	0.6	3.5		30.5%	31%
Biomass - Decent. Heat only	7.5		0.3	1.8		27.8%	0.6	0.6	2.4		42.8%	54%
Solar water heating	0.2		0.45	20.9		0.6%					0.9%	54%
PV		0.01	0.12	104.7		0.5%	0.2	0.6	105.1		0.6%	24%

Table 12 shows the possible upper bound where 45% of electricity demand comes from renewables and 10% of total energy demand is from renewables, by the year 2010.

The following assumptions have been made:

1. The on shore wind option refers to six 1.5MW machines in 2 clusters
2. The off shore wind option incorporates 25 machines of 2MW machines. Note that Prices for off-shore installations are expected to fall as experience is gained of installations
3. The biomass AD system is based on 1 large centralised system @ 500kWe
4. With the biomass AD the first row of figures are based on electrical energy output only, the second row on electrical and thermal energy output
5. The figures for the biomass SRC/forestry CHP are based on electrical and thermal energy output
6. The direct economic cost includes no profit margin or transmission costs included (direct production costs only)
7. Direct economic cost is based on discount rate of 8%
8. The SWH assumes some economies of scale for bulk purchase of domestic systems i.e. by housing associations/new build figures would also improve further if including significant use of SWH for swimming pool heating
9. It should be noted that there are additional direct avoided costs and savings for Biomass AD
10. The Tidal power direct economic costs as provided by company involved in the R&D development system as no similar size systems yet in place
11. For the electricity direct economic cost the lower bound of production cost indicated for current supply mix from Scottish & Southern- upper bound approx 2.5p/kWh
12. Comparison are made only to gas and electricity because these are the energies that would be substituted by renewable technologies
13. Gas and electricity prices based on rates for domestic and industrial supply weighted for IoW sector distribution

Table 13: Summary of Cost Benefit Analysis for Upper bounds for Renewable Targets for IoW

Upper Bound							Environmental & social cost		Total cost (average)			
Use / technology	Energy (heat) used / practicable output (GWh/annum)	Energy (electricity) used / practicable output (GWh/annum)	Capital cost (£ '000,000)	Direct economic cost (p/kWh) (6,7,8,9,10,11)	Price to consumer (p/kWh) (12, 13)	Simple ROR (rate of return)	Lower band (p/kWh)	Upper band (p/kWh)	Production cost (p/kWh)	Price to consumer (p/kWh)	Indicative ROR (simple)	ROR increase
Gas			n/a	0.7	1.1		0.4	0.8	1.3	1.7		
Electricity			n/a	2.0	5.0		0.8	1.5	3.2	6.1		
Wind - on-shore (1)		45.0	12.0	2.9		18.6%	0.1	0.1	3.0		23.1%	24%
Wind - off-shore (2)		160.0	49.7	3.6		16.0%	0.1	0.1	3.7		19.8%	24%
Biomass - AD (3, 4)	1.3	4.3	1.5	4.7		14.2%	0.6	0.6	5.3		17.6%	24%
				3.6		15.2%			3.6		19.1%	26%
Biomass - Cent. CHP (5)	59.2	39.5	9.3	2.6		28.2%	0.6	0.6	3.2		39.2%	39%
Tidal currents		9.4	3.0	7.0		15.5%	0.6	0.6	7.6		19.3%	24%
Solar water heating	0.5		0.65	13.9		0.8%					1.3%	54%
PV		0.08	0.65	78.5		0.6%	0.2	0.6	78.9		0.8%	24%

Table 14: Summary of Economic, Social and Environmental Costs for each specific technology to be considered in a Renewable Energy Strategy on the Isle of Wight

Renewable Technology	Specific Environmental Impact Indicators	Specific Social Impact Indicators
Wind- on shore	• Noise • Visual • Impact on landscape • Effect on birds • Planning process • Use of land	• Community cohesion • Tourism • Political • Employment • Education • Self reliance
Wind off shore	• Noise • Visual • Impact on landscape • Effect on birds • Planning process • Recreational	• Tourism • Political • Employment
Biomass- anaerobic digestion	• Noise • Visual • Use of land • Transport of fuel	• Community cohesion • Tourism • Political • Employment • Education • Self reliance
Biomass-centralised CHP	• Noise • Visual • Use of land • Transport of fuel • Planning process	• Employment • Education • Tourism
Biomass- de-centralised heat	As above	• Community cohesion

only		• Tourism • Political • Employment • Education • Self reliance
Tidal Currents	• Visual • Impact on landscape • Effect on marine life • Planning process • Recreational	• Tourism • Political • Employment • Education
Solar water heating	• Visual	• Employment • Education • Self reliance
Solar PV	• Visual	• Employment • Education • Self reliance
Biodiesel	• Use of land • Transport of fuel	• Employment

[i] European Commission, *Energy for the future: Renewable Sources of Energy; Green Paper for a Community Strategy*. COM (96) 576, 1996.
[ii] CBA on wind energy from the Web
[iii] Patterson et al, 1994