Technical Report

For

The Pembrokeshire Coast National Park Authority

Housing Site Assessment – Options for low and zero carbon technologies at:

Glasfryn Road – St Davids
Brynhir – Tenby
Butts Field – Tenby

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THE NATIONAL ENERGY FOUNDATION

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Glossary of Terms & Abbreviations

AD	Anaerobic Digestion to produce energy (usually via a biogas)
CfSH	Code for Sustainable Homes
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DER	Dwelling Emission Rate (as defined in the SAP)
DH	District Heating, generally without simultaneous electricity generation
ESCo	Energy Services Company
FIT	Feed In Tariff (for renewable energy into UK National Grid)
GIS	Geographical Information System
kWp	Kilowatt peak (maximum power output under specific test conditions)
LUC	Land Use Consultants (co-authors of the November 2008 report)
LZC	Low or Zero carbon
MWh/year	Megawatt hours per year
NEF	National Energy Foundation
PCNPA	Pembrokeshire Coast National Park Authority
PPS	Planning Policy Statement
SAP	The Government's Standard Assessment Procedure
TER	Target Emission Rate (as defined in the SAP)
WAG	Welsh Assembly Government

1. EXECUTIVE SUMMARY

This report outlines the outcome of an assessment undertaken by the National Energy Foundation in August 2009 into options for low and zero carbon technologies at three strategic housing sites identified in the Pembrokeshire Coast National Park Authority's Local Development Plan.

NEF's approach to the assessment has been based on the latest technical guidance provided by the Planning Advisory Service for PPS1 Planning & Climate Change for assessing low carbon and renewable technology potential for local development plans. We have also used the GIS Published Map data that accompanies the Renewable Energy Assessment for the Pembrokeshire Coast National Park[1] as a means of identifying constraints and opportunities for each site.

The sites assessed in this study are:

- HA737 (Glasfryn Road, St Davids)
- HA377 (Brynhir, Tenby)
- HA752 (Butts Field Car Park, Tenby)

The Local Development Plan is required to take account of the recent Ministerial Interim Planning Policy Statement (MIPPS) from the Welsh Assembly Government "Planning for Sustainable Buildings 01/2009" which outlines minimum standards for new development in Wales over the next two years. These standards have therefore been used in our assessment of the sites as they now supersede the standards of the Local Development Plan (Policy 17).

Our assessment concludes that for stand-alone on site LZC technologies on all of the sites, the most sustainable and cost-effective way to achieve the Welsh Sustainable Building Standards is for developers to specify the highest levels of building fabric performance as possible (energy efficiency) followed by inclusion of Biomass Boilers/stoves or Solar Thermal technologies (renewables). Solar Thermal provides the only stand-alone technology that could be deployed widely across all of the three sites. Other technologies such as heat pumps and photovoltaics are technically feasible carry the highest cost implications for a developer.

The provision of near-site/community LZC technologies is limited in potential. None of the sites are judged to be suitable for wind energy generation or large scale CHP and District Heating (DH). However, block heating would be suitable for the higher density site (Butts Field). Furthermore, the viability and suitability of small scale CHP or DH schemes including ESCos should be re-examined in the next review of the Local Development Plan to ensure that the forthcoming policy and funding mechanisms from the Welsh Assembly Government which seek to encourage CHP and District Heating in Wales are reflected in the Local Development Plan's future policy requirements.

[1] Development of a Renewable Energy Assessment and Target Information for the Pembrokeshire Coast National Park – Nov 2008 LUC/NEF

2. BACKGROUND

The Pembrokeshire Coast National Park Authority is in the process of undertaking an assessment of the potential for renewable energy and low carbon technologies for three strategic sites identified for housing development within the Local Development Plan. The sites are located in Tenby and St Davids. The details of each site are shown in Table 1 below, with maps showing the extent and location of the sites outlined in Appendix 1.

Table 2.1 Housing Site Details

Location	Proposals Map ID	Site Name	Area (ha)	Residential Units	Affordable Housing Provision expected (%)
St Davids	HA737	Glasfryn Road ,St Davids	3.80	90	45 (50%)
Tenby	HA377	Brynhir, Tenby	6.35	168	101 (60%)
Tenby	HA752	Butts Field Car Park, Tenby	0.94	80	48 (60%)

CO_2 Emission Reduction

The strategy of the Local Development Plan is to seek to minimise the contribution that certain developments will make to greenhouse gas emissions by promoting the use of renewable energy and by encouraging sustainable design in development.

To this end, the Deposit Local Development Plan contains a Policy (Policy 17 - Sustainable Design). This specifies a CO_2 emission reduction requirement for two of the sites (namely HA377 and HA737), and is to be achieved by incorporating the use of renewable or low carbon energy technologies in the development. The relevant section of Policy 17 is reproduced below:

Within the Brynhir, Tenby, and Glasfryn, St. Davids development sites new development should incorporate on-site and/or near-site and renewable or low-carbon energy technologies contributing at least an additional 20% in regulated CO_2 emissions (20% reduction of the Target Emission Rate). Developers will be expected to demonstrate that they have explored all energy options, and designed their schemes to incorporate these requirements.

Having set the CO_2 reduction target, the PCNPA have requested the specialist technical services of the NEF to assess all three sites in terms of the following issues:

- The potential for existing or proposed local and low and zero carbon energy supply systems (including district heating systems);
- The scope for new opportunities to supply proposed and existing development; and
- The scope for maximising opportunities to co-locate potential heat customers and suppliers.

This is to ensure that the Local Development Plan has taken account of the recent Ministerial Interim Planning Policy Statement (MIPPS) from the Welsh Assembly Government "Planning for Sustainable Buildings – 01/2009"[2] , which requires local planning authorities to ensure that in requiring higher sustainable building standards than the national minimum, what is proposed is evidence-based and viable.

It also outlines minimum sustainable building standards for Wales which are reproduced from the MIPPS in the box below:

2.12.4 To move towards more sustainable and zero carbon buildings in Wales, the Assembly Government expects that the following standards will be met:-

- Applications for 5 or more dwellings received on or after **1 September 2009** to meet Code for Sustainable Homes Level 3 and obtain 6 credits under *Ene1 - Dwelling Emission Rate**.
- Applications for 1 or more dwellings received on or after **1 September 2010** to meet Code for Sustainable Homes Level 3 and obtain 6 credits under *Ene1 - Dwelling Emission Rate**.

* Code for Sustainable Homes - Technical Guidance, Communities and Local Government,

The standards used are based on the Code for Sustainable Homes (CfSH)[3]. It covers nine sustainable design principles:

- Energy and CO_2 Emissions;
- Water;
- Materials;
- Surface water run-off;
- Waste;
- Pollution;
- Health and well-being;
- Management; and
- Ecology.

A home can achieve a rating from one to six stars, depending on how well it has achieved CfSH standards. One star is the entry level and six stars is the highest level: a zero carbon home. A zero carbon home is a home that achieves zero net emissions of carbon dioxide (CO_2) from **all** energy use in the home over the course of a year.

There are mandatory standards contained within the CfSH (for energy, surface water run-off and water) and credits for each of the categories are weighted to give an overall score.

In terms of Energy and CO_2 Emissions, each successive Level of the CfSH represents a further step in energy performance in excess of the current minimum standards as set by the current relevant building regulations[4] for lighting, space-heating and water-heating ('regulated energy').

The following table presents the minimum reduction in CO_2 emissions attributable to regulated energy that must be achieved by a new home to achieve each of the Levels for Energy and CO_2 emissions.

[2] Ministerial Interim PPS 01/2009 "Planning for Sustainable Buildings" – May 2009 – Welsh Assembly Government
[3] See www.communities.gov.uk/thecode
[4] Approved Document L1A: Conservation of fuel and power (New dwellings) (2006 edition)

Table 2.2 Energy Performance requirements for each of the Levels of the Code

Code Level	Minimum percentage reduction in CO_2 emissions versus current minimum permissible standard (%)
Level 1 (*)	10%
Level 2 (**)	18%
Level 3 (***)	25% (minimum – gives 5 Ene1 credits)
Level 4 (****)	44%
Level 5 (*****)	100%
Level 6 (******)	'Zero Carbon Home'

Level 3 **and** 6 credits under issue Ene1 require at least a 31% reduction in CO_2 emissions versus current minimum permissible standards (which are calculated by comparing the Dwelling Emission Rate (DER) to the base case Target Emission Rate (TER)) and can be achieved by:

- Improving the thermal efficiency of the walls, windows, and roof as far as is practically possible;
- Reducing air permeability to the minimum consistent with health requirements;
- Designing the fabric of the home to reduce thermal bridging;
- Installing high efficiency condensing boilers; and perhaps
- Employing Low- and Zero-Carbon (LZC) Energy Generation[5].

Both CfSH Level 3 and 6 credits under issue Ene1 can be achieved without the use of LZC energy generation but require a very high performance building fabric. Alternatively, adding LZC energy generation to a dwelling permits less stringent levels for insulation, glazing and air-tightness (and will typically reduce the capital cost).

Differences between Policy 17 requirements and new Welsh standards

The Local Development Plan Policy was developed and placed formally on deposit in March 2009 prior to the emergence of the new minimum standards outlined above which were published in May 2009. Policy 17 requires a 20% reduction in the Target Emission Rate (TER) of the dwellings to be developed on the two sites. The TER is the maximum CO_2 emission rate permitted by the prevailing Building Regulations. The Policy requires this reduction in CO_2 emissions to be achieved through on-site and/or near-site and renewable or low-carbon energy technologies as a means of encouraging greater use of these technologies in new development.

The new minimum standards are based on the Code for Sustainable Homes (CfSH) and specify that new homes must meet Code Level 3 and an additional 6 credits under issue *Ene1 – Dwelling Emission Rate*. The key difference between the Policy 17 requirement and the new standards is in relation to the level of flexibility as to how the CO_2 emission reductions are achieved. The CfSH seeks CO_2 emission reductions which can in the main be achieved through a variety of means including passive solar design, better building fabric and higher insulation standards etc, rather than on the use of renewable/local carbon technologies alone. The minimum standard of Code Level 3 plus 6 additional credits from Ene1 requires a greater

[5] Communities and Local Government (Dec 2006) " Code for Sustainable Homes – A Step Change in sustainable home building Practice"

percentage reduction in CO_2 over the Target Emission Rate that the 20% specified in Policy 17, so is therefore a higher reduction target.

The policy is to ensure that there is a level playing field across Wales avoiding the unnecessary burden for each local planning authority to devise, justify and propose similar policies to improve the sustainability of new buildings in their Local Development Plan (LDP).

As the WAG standards now effectively supersede the requirements of Policy 17, we have used these in our assessment of the sites.

The implications of meeting these standards on each of the sites taking account of the opportunities and constraints to LZC energy generation is discussed in Section 5 of the report.

Decentralised Energy: Heating, Cooling and Power

The MIPPS guidance also states in Paragraph 2.12.7 that “Particular attention should be given to opportunities for minimising carbon emissions associated with the heating, cooling and power systems for new developments. This can include utilising existing or proposed local and low and zero carbon energy supply systems (including district heating systems) encouraging the development of new opportunities to supply proposed and existing development, and maximising opportunities to co-locate potential heat customers and suppliers”.

Our assessment of the three sites has included looking at the scope for such schemes in accordance with this guidance.

3. OPPORTUNITIES AND CONSTRAINTS

The assessment has drawn upon the latest technical guidance provided by the Planning Advisory Service for PPS1 Planning & Climate Change for assessing low carbon and renewable technology potential. We have also used the GIS Published Map data that accompanies the Renewable Energy Assessment for the Pembrokeshire Coast National Park[6] as a means of identifying constraints and opportunities for each site.

A summary of the suitability for renewable energy technologies for each site is provided below. The background information from which this is drawn is outlined in the Constraints and Opportunities Matrix for each site in Appendix 2.

(HA737) Glasfryn – St Davids

Good potential – solar PV & thermal, ground source heat pumps

Limited potential – biomass

No potential – wind, small/micro hydro

(HA377) Brynhir – Tenby

Good potential – solar PV & thermal, ground source heat pumps

Limited potential – biomass

No potential – wind, small/micro hydro

(HA752) Butts Field Car Park – Tenby

Good potential – solar thermal

Limited potential – biomass, solar PV, ground source heat pumps

No potential – wind, small/micro hydro

[6] Development of a Renewable Energy Assessment and Target Information for the Pembrokeshire Coast National Park – Nov 2008 LUC/NEF

4. SITE ASSESSMENTS

This section presents an overview of the three sites and developments being assessed in this report:

- 4.1 - HA 737 (Glasfryn Road, St Davids);
- 4.2 - HA 377 (Brynhir, Tenby);
- 4.3 - HA 752 (Butts Field Car Park, Tenby).

4.1. HA737: Glasfryn Road, St Davids

St Davids is one of the main settlements within the Pembrokeshire National Park, located 15 miles to the North-west of Haverfordwest on the A487. It has an approximate resident population of 1,800[7].

HA737 is a 3.8 hectare green-field site currently used for grazing purposes. It is allocated for a residential development of 90 units (50% affordable).

Figure 4.1 HA737 as viewed from Glasfryn Road

Figure 4.2 Glasfryn Road

Table 4.1 Key Statistics for HA737 St Davids

Reference	Name	Residential Units	Area (hectare)	Density (units per hectare)	Affordable Units (%)
HA737	St Davids	90	3.8	24	50

[7] Office for National Statistics - Census 2001

Units are likely to be 1-, 2- and 3-bed semi-detached and terraced houses of no more than two storeys with floor areas between 75 and 90 m^2. Given the distinctive character of the architecture of St David's, the style of the houses will be sympathetic in character and detail.

The Local Development Plan Proposals Map (Appendix 1) displays HA737 as a housing allocation located on the North East periphery of St Davids. It is bordered to the North by Fishguard Road (A487), to the east by Glasfryn Road and to the West by residential areas (including Heol Dewi, Maes Dewi, Noddfa Dewi and Mount Gardens). The majority of these residential areas are in private ownership, however a small number of council-owned properties are scattered throughout.

The South of the site is earmarked for possible future residential development to the current existing boundary of Glasfryn Lane. At present however, the proposed development will extend to approximately 100m short of this boundary.

The site is slightly elevated to the south allowing for views from the north (B4583).

There is a recently-built industrial unit (St Davids Assemblies) and a workshop allocation (EA748) located to the north east of the site on Glasfryn Road as well as a live/work development allocation of 5 hectares (MA746) 100m to the south east.

Other businesses and services located near to the site are the Grove Hotel (400m to the south west), St Davids Rugby Football Club (40m to north west), Oriel y Parc (gallery, visitor and education centre 300m to south) and St David's County Secondary School (200m to south east). The school had a swimming pool until recently but this facility has since been closed.

There will be road improvements to Glasfryn Road associated with HA737. The preliminary designs are presented on the Deposit Plan Proposal Map for the town produced by the National Park Authority.

The site can be serviced by all utilities.

4.2. HA377: Brynhir, Tenby

HA377 is the first of the two housing allocation sites located in Tenby under assessment in this report.

Tenby is a walled seaside town in Pembrokeshire, south-west Wales, lying on Carmarthen Bay that has a population of approximately 5,000[8]. As with St Davids the number of households is currently rising steadily to meet the demand for housing.

HA377 lies to the north east of Tenby (east of the A478 Narbeth to Tenby road, and to the immediate north and east of the Lady Park/Upper Hill area of Tenby).

The site is amongst the most elevated land in the vicinity. Mature trees do however obscure the view of the site from most angles. (Site is visible from long range from the South and West). Extensive structural planting will be undertaken to create a more visually pleasing development and to allow the development to integrate better with its natural surroundings.

Figure 4.3 View to Tenby Harbour from HA377

Figure 4.4 View of northern part of HA377

Table 4.2 Key Statistics for HA377 Brynhir, Tenby

Reference	Name	Residential Units	Area (hectare)	Density (units per hectare)	Affordable Units (%)
HA377	Brynhir, Tenby	168	6.4	26	60

There is much housing running the length of the west of the site and a small number of newer homes to the north east of the site.

8 Office for National Statistics - Census 2001

The site as a whole is within a sensitive landscape due to its position, topography and agricultural character all of which contribute to the character of the National Park. The Landscape Character Area is defined as 1: Saundersfoot Settled Coast. There are many existing landscape features on-site worthy for retention, improvement or enhancement as not only do they make a contribution in terms of visual amenity and screening of development etc, but are also important habitats and feeding grounds for various species. There are also some archaeological sites nearby that need to be protected from any development (e.g. number 3673 on the regional sites and monuments record which has been adopted by the National Park lies immediately north of the site).

A new access road will be developed in conjunction with the residential development as existing access is not sufficient.

To minimise the impact of the development in close and distance the dwellings shall not exceed two storeys in height. Above the northern part of the site contains the highest ground and therefore the development of houses above one and a half storeys will not be permitted in this location. Larger two storey houses can be accommodated on the lower, less prominent parts of the site.

The site can be serviced by all utilities.

4.3. HA752: Butts Field Car Park, Tenby

HA752 is located less than 250m to the south east of HA377. It is currently in use as the park and ride facility for Tenby and is situated to the north of Tenby harbour. The site lies on a north west to south east axis and is approximately rectangular (200m x 40 m).

The site has mature trees around its periphery for which there will most probably be a requirement for them to be retained. This will lead to the site being very sheltered but may also possibly limit levels of daylight on-site.

There is some housing to the north east of the site and Tenby Cottage Hospital to the south west. There is also the "Silent World" Aquarium and Reptile Centre, but this is not of a sufficient scale to create a significant year round demand for heat.

Figure 4.5 Butts Field Car Park

Table 4.3 Key Statistics for HA752 Butts Field Car Park

Reference	Name	Residential Units	Area (hectare)	Density (units per hectare)	Affordable Units (%)
HA752	Butts Field Car Park, Tenby	80	0.9	85	60

The site can be serviced by all utilities.

5. Achieving the Energy Performance Standards

As the precise nature and form of the dwellings to be built in each development has not yet been finalised, all figures have been calculated on them comprising:

- 80 m^2 2–bed semi-detached units (HA377 and HA737); and
- 75 m^2 units in 2-storey apartment blocks of 10 units (HA752).

In each case it has been assumed that each site will need to achieve Code Level 3 (including 6 credits for issue Ene1). Solutions for reaching the targets will differ to a degree with smaller and larger dwellings (of varying forms) than those chosen for the assessment in this report. For the purpose of this study however, this size and type of property serves as a good representative sample of the likely building stock and results will not be significantly impacted by these assumptions.

The regulated energy demand per residential unit (for lighting, space heating and water heating) of each of the sample dwelling types are as presented in the following table (assuming use of grid electricity and natural gas-fired condensing boiler[9]):

Table 5.1 Energy Demands and Resultant CO_2 Emissions from Development

Dwelling Type	Standard	Lighting (kWh/year)	Space Heating (kWh/year)	Water Heating (kWh/year)	Total Energy Consumption (kWh/year)	CO_2 (Tonnes/year)
80 m^2 2–bed semi-detached	Code Level 3 plus ≥ 31% improvement of DER over TER	360	4,590	2,900	7,860	1.94
75 m^2 apartment	Code Level 3 plus ≥ 31% improvement of DER over TER	320	4,130	2,610	7,070	1.74

As previously stated, this standard of dwelling could be achieved without generation from LZC technologies by specifying a high performance building fabric. The specification of the building fabric could be relaxed if LZC energy generating technologies were integrated into the properties.

In many cases, Code Level 3 could be achieved with less expense to the developer if LZC energy generation technologies are employed (e.g. for dwellings a Solar Thermal Hot Water system is likely to achieve Code Level 3 with less expense than building fabric improvements alone. This is largely due to the expense of high-performance windows).

It is however important that the LZC technology solutions (stand-alone and community-scale) are not selected on the basis of achieving the minimum standards permissible with the lowest cost possible, but on the basis of achieving the lowest CO_2 abatement costs while

[9] CO_2 conversion factors used in these analyses were 0.194 kg per kWh of Natural Gas and 0.537 kg per kWh of grid electricity. These figures were updated by Defra in Summer 2009 but the difference will not materially alter the suggested outcomes.

serving their purpose for the occupants in a low-cost and convenient manner. (A CO_2 abatement cost relates to the financial investment in a technology per tonne of CO_2 it reduces over its lifetime (lifetime costs /lifetime CO_2 reduced i.e. £ per tonne). CO_2 abatement costs allow for comparison between technologies with different fuels, costs and lifetimes).

The following graph presents typical CO_2 abatement costs for stand-alone and community-scale LZC technologies in new developments (in blue and orange respectively).

Figure 5.1 Typical CO_2 Abatement Costs (£/tonne CO_2)[10]

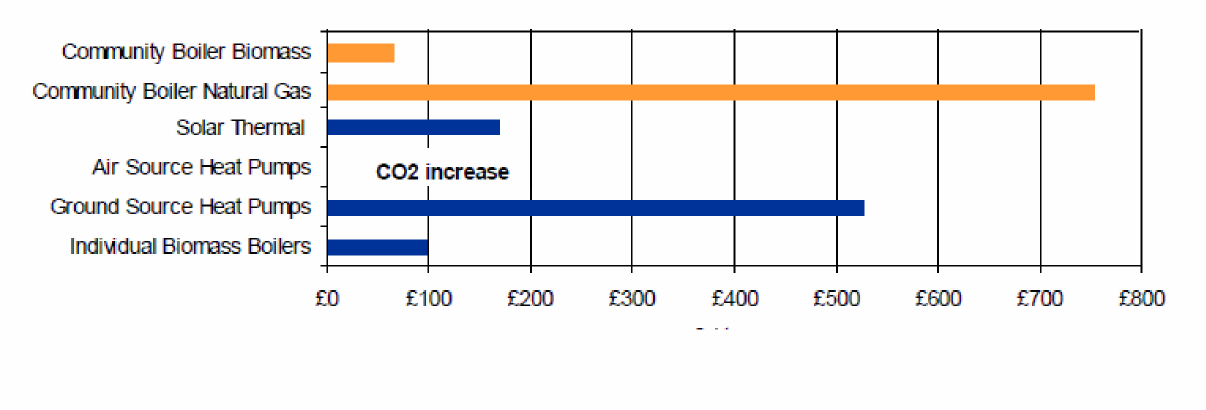


Figure 5.1 shows that, where appropriate, community biomass boilers typically provide the greatest environmental benefits per unit of cost (lowest CO_2 abatement costs) followed by individual Biomass Boilers, Solar Thermal Hot Water and Ground Source Heat Pumps[11].

Site-specific constraints and the exact nature of the development will however always affect these costs.

The remainder of this report provides an assessment of each of the LZC technologies' under the following criteria:

- lifetime, capital and running costs;
- contribution toward CO_2 emission reduction;
- site specifics and suitability, and
- suitability for the end-user

The outcomes and conclusions are presented in terms the suitability of standalone LZC technologies (Section 5.1) and suitability/opportunities for community scale LZC energy generation (Section 5.2) with reference to each of the sites. The conclusions represent what NEF consider would best achieve the Welsh Assembly Sustainable Building Standards in the most cost-effective and practical way.

[10] DECC (2009) 'The potential and costs of district heating networks - a report to DECC by Pöyry Energy Consulting and Faber Maunsell'

[11] The above analysis does not include CO_2 abatement costs from electricity generation from Solar Photovoltaics, Biomass- or natural gas-fired CHP or Wind turbines. Where appropriate, their CO_2 abatement costs will be discussed later in this report.

5.1. On-site standalone LZC Energy Generation

The following table presents an overview of the suitability of each of the stand-alone LZC technologies to contribute to the energy performance standards on the sites in question on a dwelling-by-dwelling basis (community-scale generation will be considered in the following section).

Table 5.1.1 Suitability of stand-alone LZC technologies to deliver cost-effective CO_2 emission reductions

LZC Technology	Potentially Suitable for houses	Potentially Suitable for apartments	Comments
Biomass (wood chip and pellet boilers and stoves)	Yes	No	High CO_2 emission reductions at relatively low capital cost for houses. Operation and procurement of fuel could however be burden to occupants in some instances. Storage space required for fuel. Not practical for apartments.
Heat Pumps (air source)	No	No	Running costs are not currently competitive with natural gas-fired condensing boilers, although CO2 emissions are less[12]. Density of developments may lead to possible problems with noise and vibration. Limit to number of units installed on-site dictated by District Network Operator. Possible corrosive effect of salinity of air on evaporator/compressor heat exchangers on Tenby sites.
Heat Pumps (ground source)	Yes	Sometimes	No constraints present on sites but high capital costs relative to other central-heating systems. CO_2 emission reductions achieved in reality less than calculated by SAP[13]. Not practical for larger blocks of flats. Limit to number installed on-site dictated by District Network Operator.
Micro Combined Heat and Power (micro-CHP)	No	No	Technology not suitable for small dwellings with low energy demands at present.
Solar Photovoltaics	Yes	Yes	Suitable. Capital costs can be offset through Feed in Tariffs (FITs) as of April 2010 but the income stream will be to occupant (not developer) and therefore house prices will have to increase to reflect this. Possible issue of over-shading from retained mature trees. Limits to implementation in apartment blocks due to roof-space.
Solar Thermal Hot Water	Yes	Yes	Very suitable. Low capital costs if integrated into roof and installed at time of construction.
Micro Wind Turbines (roof and pole mounted)	No	No	Not suitable due to density of development and obstructions to wind flows.

The technologies considered to be potentially suitable will now be examined in further detail:

- Biomass (wood chip and pellet boilers and stoves) (not for individual apartments);

[12] The annual CO_2 emissions of an ASHP are estimated to be approximately 30% less than a natural gas fired boiler but cost more (20%) to run – Source NEF.

[13] Standard Assessment Procedure – see www.bre.co.uk/sap2005

- Ground Source Heat Pumps (not for individual apartments);
- Solar Photovoltaics (PV); and
- Solar Thermal Hot Water.

5.1.1. Biomass (wood chip and pellet boilers and stoves)

A biomass boiler system that provides all of a dwellings heat demand could reduce the CO_2 emissions by up to 70% per year. A wood pellet stove used as a secondary (room) heater could reduce the CO_2 emissions by up to 8% per year.

In practice, there are a number of issues that might not lead to these reductions being realised for a significant period of time:

- Frequency of use of electric immersion heater for supplementary water-heating;
- Frequency of use of electric resistance heaters, such as fan heaters or flame effect electric fires, for supplementary space-heating; and
- Several aspects of poor operation can significantly reduce system lifetime and increase requirement for maintenance.

Typical additional capital costs associated with wood pellet boilers and stove systems are in the region of:

- Up to £2,500 for an 8 kW wood pellet boiler system; and
- Up to £1,750 for a 6 kW wood pellet stove for secondary heating.

Wood chips and wood pellets have running costs similar to, or slightly higher than, natural gas at present[14]. However there are additional operational issues that may limit suitability as a technology for all dwellings within a development scheme. These primarily centred around fuel supply and stoking. Pellets seem to offer few problems; there is a local bulk supplier with spare capacity, and pellet systems can usually be set up as an auto-feed system requiring little if any more intervention than would be commonly found in an oil heating system. Wood chip systems are less commonly available at a single dwelling basis, although could prove effective for the apartments, especially if combined with block heating. More traditional solid fuel systems, based on logs, require manual stoking and would be unlikely to meet with approval for speculative or social housing developments, due to uncertainty about the ability of the new occupants' ability to load them.

Conclusion

There are no site-specific constraints to the use of biomass boilers and stoves in the dwellings at the sites (although not practical for individual apartments). The operation of biomass boilers may however not be suitable for some occupants (the elderly, infirm or those without access to transport for instance) due to the cleaning, fuel-procurement and loading associated with their operation.

In comparison with the CO_2 abatement costs of the other LZC technologies, biomass boilers have the potential to offer significantly less costly CO_2 savings.

[14] Sutherland Table – Comparative Domestic Heating Costs – May 2009

5.1.2. Ground Source Heat Pumps

The only site-specific constraint for the employment of GSHP in the houses is the limitation on the number of GSHP installed in an area set by the District Network Operator, Western Power. A number of units in one area may present capacity issues for the grid so early consultation with the DNO will be required to assess feasibility.

The relatively high density of the properties on all three sites suggests that if GSHPs were to be widely deployed, they would require boreholes, and the scale of the development should permit this to be done at an acceptable cost. Although GSHPs are not generally very suitable for larger blocks of flats, the low-rise apartments considered here would have a building envelope similar to that of terraced homes, and so would be able to utilise the technology.

GSHP do not experience the same level of operational issues as biomass plant as no fuel is required (except grid electricity) and as there is no combustion involved (so no cleaning). The control systems are relatively easy to use (no different to a conventional boiler for example) but timer programming can be complex for the average occupant if the system is set up to use off-peak electricity to heat the buffer tank.

A suitably designed and installed GSHP heating system could reduce the regulated CO_2 emissions of the dwellings by up to 0.2 tonnes per year (10% of regulated CO_2 emissions)[15].

GSHP are known to be very reliable and these savings would be expected to be gained for up to 25 years (with maintenance). The ground collectors could also be expected to last 50 years in total and could therefore be used with a second GSHP once the first has been de-commissioned.

There is however a significant cost associated with GSHP. This can be in the region of £5,000 to £6,000 more than for a natural gas-fired condensing boiler central heating system (including additional under floor heating system instead of radiators). As was seen in Figure 5.1, GSHP have higher CO_2 abatement costs than the other stand-alone technologies.

Conclusion

It is considered that the capital required for the installation of GSHP would bring greater CO_2 emission savings if spent on building fabric improvements.

5.1.3. Solar Photovoltaics (PV)

Solar Photovoltaics (PV) represent an excellent route to achieving reductions in CO_2 emissions for both the houses and the apartments as the displacement of grid-electricity reduces CO_2 emissions far more per kWh than for natural gas. However, the degree to which Solar PV can be implemented on development on the Butts Field site will depend on the design and orientation of the development and how this supports the use of solar

[15] This figure is less than what is predicted by the method for demonstrating compliance due to the use of a CO2 conversion factor of 0.537 kg CO2 per kWh (rather than the SAP figure of 0.422). The higher figure is used in the analysis in this report as it relates to the actual average carbon intensity of grid-electricity (10 year rolling average) and therefore pertains to the likely reductions experienced in reality.

technologies on south facing roofs. The retention of mature trees on both the sites in Tenby may cause over-shading for some of the site; this can easily reduce the viability of this technology.

Capital costs for Solar PV arrays are high (in the region of £4,000 per kWp integrated in new-build). The introduction of Feed-in-Tariffs (FITs) in April 2010 will greatly improve the life-cycle economics of Solar PV bringing financial benefits to the home owners with Solar PV arrays, but it is unlikely to provide an incentive to developers wishing to reduce the CO_2 emissions of their developments to comply with regulations. For this reason, unless creative funding mechanisms are developed, Solar PV could not be integrated in the houses without increasing their purchase price significantly.

In each of the homes, the installation of a 2 kWp Solar PV array could reduce CO_2 emissions by 0.86 tonnes per year (just under half the dwelling's emissions attributable to its regulated energy use). In the absence of the FIT this would not lead to a CO_2 abatement cost that is competitive with the best of the other stand-alone technologies. However, taking into account the income stream from the FIT, the CO_2 abatement cost could be competitive with Biomass and Solar Thermal.

Without details of the built forms for the Butts Field site accurate calculations cannot be made. It can be assumed that the CO_2 reduction per unit in an apartment block would be significantly lower than that of a dwelling per unit capital cost. Section 5.3 details the potential for community 'block heating' which would allow for the utilisation of many of the aforementioned technologies in serving the apartments).

Conclusion

Although solar photovoltaics (PV) represent an excellent route to achieving reductions in CO_2 emissions, capital costs are high and consequently, may be uneconomical for developers to use unless financial incentives such as government funding/grants are provided in the future.

5.1.4. Solar Thermal Hot Water

Solar Thermal Hot Water systems provide the most cost-effective solution for achieving the CO_2 emission reductions required for achieving Code Level 3[16] and as was shown in Figure 5.1 have a comparatively low CO_2 abatement cost. This is especially the case when integrated into the building fabric of a number of dwellings in a development, the additional cost can be as little as £1,250 per house.

The technology can also reduce the CO_2 emissions by up to 0.3 tonnes per year (16% of regulated CO_2 emissions). The combination of an elevated building fabric standard and Solar Thermal Hot Water would therefore be the most cost-effective manner to reach Code Level 3 (if using only micro-generation technologies on a dwelling-by-dwelling basis).

As already outlined for Solar PV, the degree to which Solar thermal can be implemented on development on the Butts Field site will depend on the design and orientation of the development and how this supports the use of solar technologies on south facing roofs. The retention of mature trees in the sites in Tenby may cause over-shading for some of the site

[16] Communities and Local Government (2008) 'Cost Analysis of the Code for Sustainable Homes – Final Report'

and would need to be investigated prior to solar units being installed. However, a limited degree of over-shading is less critical for solar thermal than solar electric applications providing that there is enough direct solar energy to replenish the hot water supply tank on a daily basis.

Conclusion

Solar Thermal Hot Water systems, if used in conjunction with elevated building fabric standards, can provide the most cost-effective solution for achieving the CO_2 emission reductions required for achieving the Welsh Sustainable Building Standards.

Summary and Conclusions for on-site standalone LZC energy generation

The key statistics for the employment of the suitable technologies in the dwellings are as presented in the following table[17].

Table 5.1.2 Additional Costs associated with LZC Technologies and resultant CO_2 emission reductions

Technology	Description of Installation	Additional Capital Cost (£ per dwelling)	CO_2 Reduction (tonnes per year)	CO_2 Abatement Costs (£ per tonne)
Biomass boiler	8 kW Wood Pellet boiler	2,500	1.40 (house)	100
Biomass stove	6 kW Wood Pellet stove (secondary heating)	1,750	0.14 (house)	>600
GSHP	8 kW GSHP (horizontal trenches)	5,500	0.20 (house)	>500
Solar PV	2 kWp polycrystalline array	8,500	0.86 (house)	>500[18]
Solar Thermal	Flat Plate Collectors with surface area of 4 m^2	1,250	0.33 (house)	170

Conclusion

As can be seen from the preceding analysis, if the dwellings were considered independently of each other, the most sustainable and cost-effective manner to achieve the Welsh Sustainable Building Standards would be to primarily specify as high a performance building fabric as possible and include Biomass Boilers/stoves or Solar Thermal where necessary to make up any remaining deficit in the overall level of CO_2 emission reduction required. PV would also be technically suitable, but is likely to be financially prohibitive.

As the operation of Biomass Boilers may present difficulties for some occupants, Solar Thermal provides the only stand-alone technology that could be deployed wide-spread across all of the three sites.

This approach is considered to be the most energy efficient and cost-effective method to accord with the new Welsh Assembly Government requirements, and might possibly result in the solar technologies not being required at all if regulated CO_2 emissions can be achieved by the use of high performance building fabric and passive design alone.

[17] The technologies are not considered in terms of capital expenditure versus regulated CO_2 emissions achieved as to form judgements on the suitability of the LZC technologies on this basis would only lead to a reduction in capital costs rather than a reduction in CO_2 emissions as is the goal.

[18] This does not take into account any incentives for the generation of LZC energy. The introduction of Feed-in-Tariffs (FITs) in April 2010 will improve the lifetime economics of Solar PV systems (eg. a 2 kWp array installed in April 2010 will receive around £12,000 over a 25 year lifetime at 31p/kWh assuming a reduced rate for new build installations).

5.2. Near-Site/Community LZC Energy Generation

Opportunities for near-site/community LZC energy generation can include:

- Community-scale wind energy generation;
- Combined heat and power (CHP) and DH (biomass- and/or natural gas-fired), and
- Central boiler and district/block heating (DH) (biomass-fired, GSHP).

The Welsh Assembly Government intends to support community-sized wind, biomass and hydroelectric schemes through the provision of grants through the Climate Change Framework of the European Structural Funds programme. Entitled The Community Scale Renewable Energy Generation scheme, WAG propose to enable the establishment or further development of 22 sustainable social enterprises based on new community scale renewable energy installations, expected to result in £14 million investment[19].

Community-scale wind energy generation

None of the sites are judged to be suitable for wind energy generation on this scale due to urban proximity, obstacles affecting wind speed and flow (such as buildings and trees) and sensitivity of the landscape.[20]

Combined heat & power (CHP) and District Heating (DH) - biomass and/or natural gas

Current and short-term applications of biomass CHP in the UK are at the moment only linked to developments of at least 1,000 homes. As the largest of the three housing sites identified in the PCNPA Development Plan is for 168 dwellings, it is clear that this scale of CHP is not appropriate for any of the three sites. This narrows the options for community-scale LZC energy to biomass-fired DH and/or natural gas fired CHP and DH.

A recent study has revealed that in certain circumstances district heating can provide lower CO_2 abatement costs than stand-alone LZC technologies[21]. The environmental benefit (CO_2 reduction) and capital cost to the developer to meet the energy performance standards of the development (ie the additional cost per dwelling) with centralised boilers and district heating (and/or CHP) is discussed below.

Successful implementation of these schemes relate primarily to a site's building density and more specifically, to its heat demand density. This is due to the high capital and installation costs of the heat distribution network. The greater the distance between dwellings, the longer the pipe run and the greater the costs (even though the heat sold remains fixed).

As a rule of thumb, for a development of semi-detached dwellings (as HA377 and HA737), a threshold of approximately 250 residences (at a density of 25 per hectare) and for higher density developments (such as HA752) a threshold of approximately 200 units (at a density

[19] WAG National Energy Efficiency and Savings Plan – Consultation version – March 2009

[20] 'Land Use Consultants and the National Energy Foundation (2008) 'Development of a Renewable Energy Assessment and Target Information for the Pembrokeshire Coast National Park'

[21] DECC (2009) 'The potential and costs of district heating networks - a report to DECC by Pöyry Energy Consulting and Faber Maunsell'

of 100 units per hectare) would be required to make a development viable for private-sector investment. Although it would be technologically possible to link the two Tenby developments, the additional costs associated with building a heat main across the fields between them, the legal implications of requiring a wayleave for this heat main, and the need to ensure that the two developments were built in phase would almost certainly prevent this being an economic proposition.

On this basis, neither HA377, HA737 nor HA752 would be suitable for DH schemes.

There are no readily identifiable facilities located nearby any of the sites to which heat could be exported to increase the heat demand density and therefore the viability of a DH scheme. Future developments may however alter this situation, in particular, the provision of community facilities e.g. swimming pools, gyms at St Davids School.

Furthermore, as the viability of CHP systems rely on the presence of a heat demand year-round[22] and as the only current summer heat load would be that of the domestic hot water for the residences, only a very small CHP unit could be employed from which the sale of electricity would not have a significant impact on the overall economics of the project. (The workshop allocation EA748 and St Davids Assemblies may cumulatively provide an increase in summer heat demand for HA737. Unless EA748 houses an industry with a significant summer heat demand, the potential for CHP would still be low).

These systems also require management by Energy Service Companies (ESCos). They can take a variety of forms including a company which guarantees energy savings by making energy efficiency improvements and taking part of the savings as payment; public/private partnerships set up to deliver cheaper/lower carbon energy or community owned companies set up to own and manage local energy generation facilities.

WAG's Community Scale Renewable Energy Generation project (outlined earlier) will enable the establishment of sustainable, energy-based social enterprises in Wales. The Assembly Government is also working with Blaenau Gwent County Borough Council to select a private Energy Service Company (ESCo) partner to provide a low carbon energy supply to The Works Ebbw Vale project. The ESCo at The Works will be one of the first of its type in Wales and will serve as a model for forthcoming low carbon developments across the country. WAG proposes to continue to explore whether ESCos (particularly community led ESCos) may provide an appropriate mechanism for encouraging a transformation to a low carbon economy and consider whether action by the Assembly Government to stimulate their development may be appropriate.

Conclusion
The viability and suitability of small scale CHP or DH schemes including ESCos should be re-examined in the forthcoming review of the Development Plan to ensure that the Assembly's forthcoming policy and funding mechanisms for these types of schemes are reflected in the Development Plan's future policy requirements.

[22] To achieve attractive economical returns, CHP plants need to run for at least 4,000-5,000 hours per annum, which is equivalent to running the plant about 13-14 hours every day of the year

Central boiler block heating (biomass-fired, GSHP)

'Block-heating' could be readily employed for each of the apartment blocks on HA752. This would involve a centralised boiler (biomass or GSHP) serving each group of apartments. Operating a number of biomass boilers for this purpose would be too-labour intensive to be viable. The CO_2 abatement cost for GSHP would be less of an issue due to economies of scale than in the aforementioned applications, and could potentially benefit from being incorporated in the building foundations in the form of energy piles.

Conclusion

The most viable options for high density development on site HA752 would include building fabric improvements, passive solar design, 'block heating' with biomass/GSHP and a small contribution from Solar Thermal Hot Water if required.

Summary and Conclusions for Near-Site/Community LZC Energy Generation

Community-scale wind energy generation

None of the sites are judged to be suitable for wind energy generation on this scale due to urban proximity, obstacles affecting wind speed and flow (such as buildings and trees) and sensitivity of the landscape.

Combined heat & power (CHP) and District Heating (DH) - biomass and/or natural gas

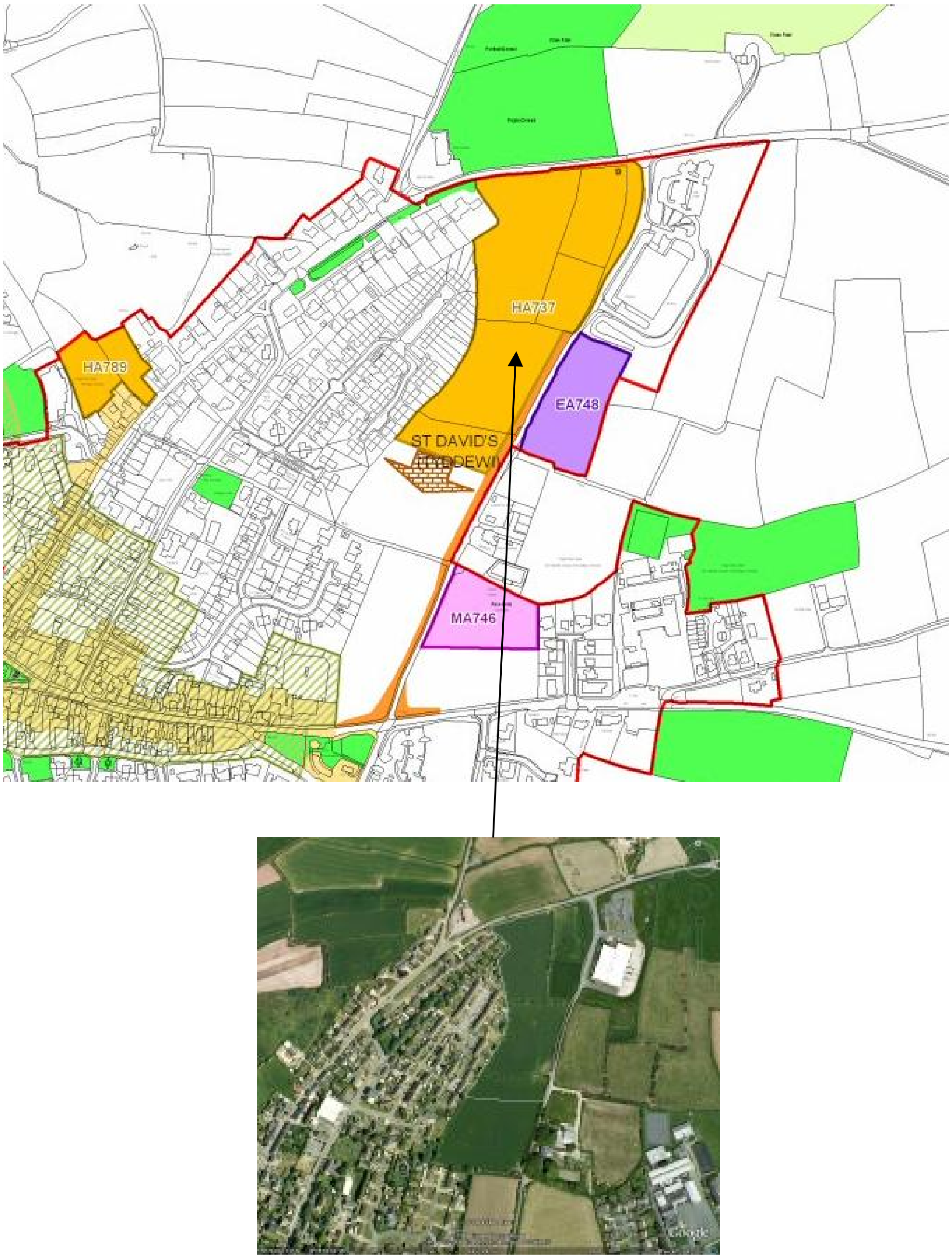
None of the sites are of a sufficient scale to make large scale biomass CHP a viable option; however they may be scope in future for smaller scale CHP/district heating supported by Energy Service Companies (ESCos) stimulated by forthcoming policy and funding mechanisms from the Welsh Assembly Government. The viability and suitability of small scale CHP or DH schemes including ESCos should therefore be re-examined in the next review of the Development Plan to ensure that the Assembly's forthcoming policy and funding mechanisms for these types of schemes are reflected in the Development Plan's future policy requirements.

Central boiler block heating (biomass-fired, GSHP)

The most viable options for high density development on site HA752 would include building fabric improvements, passive solar design, 'block heating' with biomass/GSHP and a small contribution from Solar Thermal Hot Water if required.

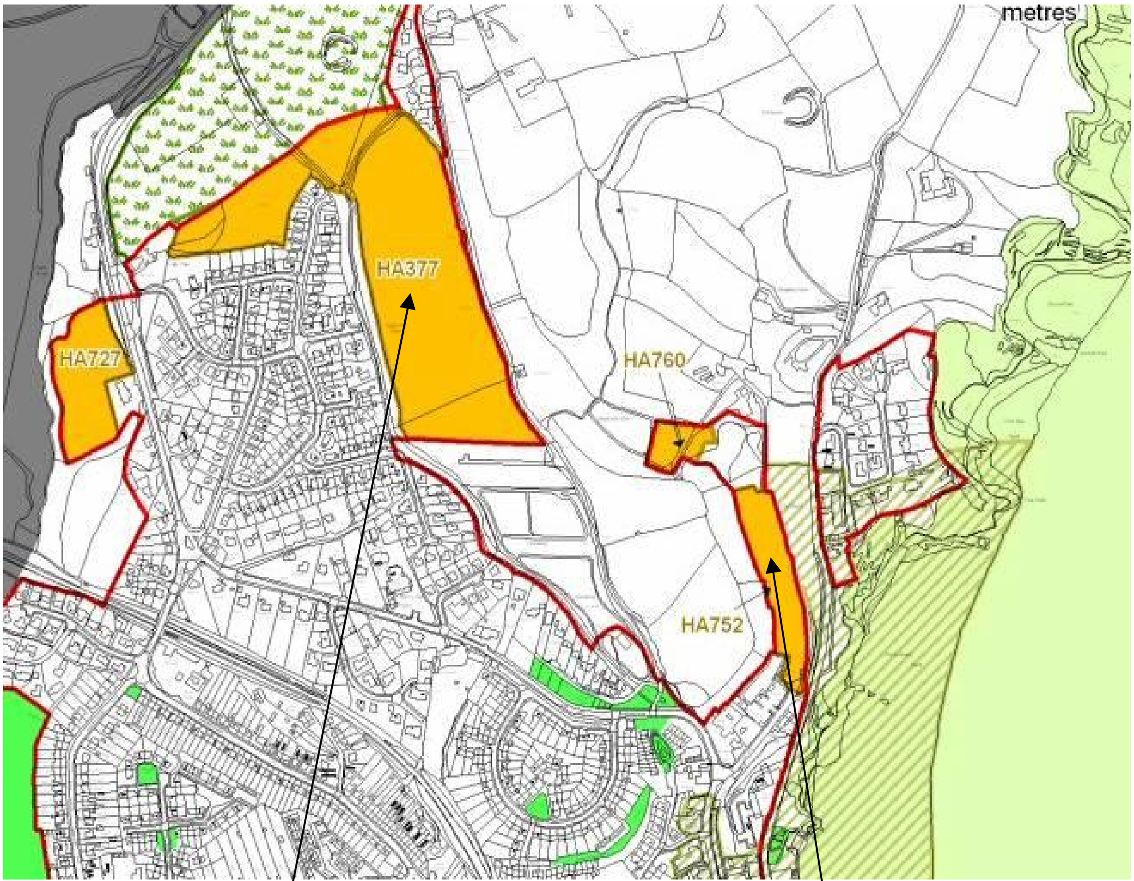
APPENDIX 1: Site Locations

St David's Site (HA737)



HA737 Glasfryn – St Davids

Tenby Sites (HA377 & HA752)



HA377 Brynhir

HA752 Butts Field Car Park

APPENDIX 2: Site Constraints and Opportunities Matrix

Brynhir - Tenby

Site Ref:	**HA377**	**Key**	**Potential**	
Location	**Brynhir, Tenby**	ü	Good	
		?	Limited	
Renewables - Constraints & Opportunities		û	None	
WIND				
a) Wind speeds	45m height - 7- 8m/s; 25m height - below 7m/s; 10m height - below 7m/s. Site is a quarry bounded by trees - potential for small scale/micro turbines will be limited unless roof mounted.		?	
b) Landscape	Landscape Character Area = No.2 -Tenby: The area is part of the urban landscape of Tenby which was not assessed in terms of its sensitivity to large, medium or small scale turbines. Town scale urban form/character is only likely to accommodate micro scale technology. [Potential = limited]		?	
c) MOD/NATS	No constraints in the area for any heights.	ü		
SOLAR	Good levels of solar radiation - within 1200 KWh/m2 banding in UK	ü		
BIOMASS/AD	Biomass - Local conifer plantations at Lodge Valley & New Hedges (NE of area); other areas of significant woodland include Rhode and Trevane Wood SE of Saundersfoot. . Pembrokeshire Bio Energy is a local supplier of pellets which provides biomass fuel for nearby Bluestone Holiday Village (2MW biomass CHP). Company looking for opportunites to expand. Study concluded that there is considerable scope to expand the use of medium-scale biomass heating systems across the National Park as long as the fcaility and storage can be intergated within the tradional settlement structure of the Park. AD - Only one dairy farm within Tenby area, no livestock farming in the near vicinity. Limited local resource.	ü	?	
HYDRO	No suitable water courses nearby.			û
GSHP	No underlying aquifer. Underlying geology is limestone & sandstone which provide good ground conditions for bore holes or horizontal trenches.	ü		
Grid availability	General: 33Kv line to Tenby - DNO is Western Power who do not see grid constraint issues precluding the development of small to medium-scale renewable energy generating developments within the area. However, detailed assessments will be needed to determine precise grid capacity.	ü	?	
Environmental Constraints	No key constraints	ü		

Butts Field Car Park – Tenby

Site Ref:	**HA752**	**Key**	**Potential**	
Location	**Butts Field Carpark, Tenby**	ü	Good	
		?	Limited	
Renewables - Constaints & Opportunities		û	None	
WIND				
a) Wind speeds	45m height - 7- 8m/s; 25m height - below 7m/s; 10m height - below 7m/s.The site is surrounded by tall trees which would shelter the site from the wind thereby adversely affecting wind speed and flow. As part of the urban area of Tenby, planned development on the site would also have a similarly adverse effect on wind speed and flow.		?	
b) Landscape	Landscape Character Area = No.2 - Tenby; The area is part of the urban landscape of Tenby which was not assessed in terms of its sensitivity to large, medium or small scale turbines. Town scale urban form/character is only likely to accommodate micro scale technology.		?	
c) MOD/NATS	No constraints in the area for any heights.	ü		
SOLAR	Good levels of solar radiation - within 1200 KWh/m2 banding in UK	ü		
BIOMASS/AD	**Biomass** - Local conifer plantations at Lodge Valley & New Hedges (NE of area); other areas of significant woodland include Rhode and Trevane Wood SE of Saundersfoot. Pembrokeshire Bio Energy is a local supplier of pellets which provides biomass fuel for nearby Bluestone Holiday Village (2MW biomass CHP). Company looking for opportunites to expand. Study concluded that there is considerable scope to expand the use of medium scale biomass heating systems across the National Park as long as the facility and storage can be intergated within the traditional settlement structure of the Park. **AD** - Only one dairy farm within Tenby area, no livestock farming in the near vicinity. Limited local resource.	ü	?	
HYDRO	No suitable water courses nearby.			û
GSHP	No underlying aquifer. Underlying geology is limestone & sandstone which provide good ground conditions for bore holes or horizontal trenches.	ü		
Grid availability	General: 33Kv line to Tenby - DNO is Western Power who do not see grid constraint issues precluding the development of small to medium-scale renewable energy generating developments within the area. However detailed assessments would be needed to determine precise grid	ü	?	
Environmental Constraints	No key constraints	ü		

Glasfryn Road, St David's

Site Ref:	HA737	Key	Potential	
Location	West of Glasfryn Road, St Davids	ü	Good	
		?	Limited	
Renewables - Constaints & Opportunities		û	None	
WIND				
a) Wind speeds	45m height - 7- 8m/s; 25m height - 7 - 8m/s; 10m height - below 7m/s	ü	?	
b) Landscape	Landscape Character Area = No.17 - St Davids. The site is considered to have high sensitivity to all scales of wind turbines.			û
c) MOD/NATS	No constraints in the area for any heights.	ü		
SOLAR	Good levels of solar radiation - within 1200 KWh/m2 banding in UK	ü		
BIOMASS/AD	Biomass - Limited areas of local woodland. Pembrokeshire Bio Energy is a local supplier of pellets which provides biomass fuel for the Bluestone Holiday Village (2MW biomass CHP). Company looking for opportunites to expand. Study concluded that there is considerable scope to expand the use of medium-scale biomass heating systems across the National Park as long as the facility and storage can be intergated within the tradional settlement structure of the Park. AD - 8 dairy farms and 3 livestock farms within 4 mile radius.	ü	?	
HYDRO	No water courses nearby.			û
GSHP	No underlying aquifer. Underlying geology is volcanic sedimentary and intrusive igneous which provide good ground conditions for bore holes or horizontal trenches.	ü		
Grid availability	General: 33Kv line to St Davids - DNO is Western Power who do not see grid constraint issues precluding the development of small to medium-scale renewable energy generating developments within the area. However, detailed assessment would be needed to determine precise grid capacity.	ü	?	
Environmental Constraints	No key constraints	ü		