Technical Annexes 16 – Energy

Contents

Technical Annexes 16A Energy

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Contents

16A – Calculation of Baseline Energy Consumption and Emissions

In order to determine the baseline consumption of the site, the following steps were taken.

16 A.1 Baseline building areas and uses

Surveys and photographs of the site were used to establish the areas, number of storeys and uses of the site as detailed in the following table:

Table 16A.1 Current building areas for Hayle harbour

Building Reference (see map)	Building Footprint (m^2)	Number of Storeys (No.)	Gross floor area (m^2)	As stated on Survey	Assumed Building Type
North Quay					
E-NQ 1	241	1	241	TW Harris	Chieftain's Aggregate Office
E-NQ 2	398	1	398	Garage & Workshop	Garage & Workshop
E-NQ 3	256	1	256	Store	Warehouse
E-NQ 4	75	1	75	Disused Building	Not applicable- no energy demand
E-NQ 5	338	1	338	Corrugated shed	Warehouse
E-NQ 6	147	1	147	Not stated on survey	Harbour master's office
Octel Building 1	633	2	1266	Thyatira print & design	Office
Octel Building 2	157	2	339	Café	Café
South Quay					
E-SQ 1	96	1	96	Disused Building	Not applicable- no energy demand
East Quay					
E-EQ 1	367	1	367	Not stated on survey	Small boat builders
E-EQ 2	791	1	791	Depot	Shellfish distributors
E-EQ 3	456	1	456	Not stated on survey	Shellfish distributors

16 A.2 Baseline energy benchmarks

Due to the age, condition and uses of the buildings, CIBSE Guide F ‘Typical Practice’ energy benchmarks were selected for calculating the baseline energy consumption.

Table 16A.2 Summary of baseline energy benchmarks

Summary of Baseline Energy Benchmarks						
Type	Description	Thermal (kWh/m^2)		Electricity (kWh/m^2)		Floor areas
North Quay						
Retail	Café	890	CIBSE Guide F, Table 20.1, Fast Food 'Typical Practice'	670	CIBSE Guide F, Table 20.1, Fast Food 'Typical Practice'	GFA
Office	Cheiftain's Aggregate Office, Harbour Master's Office & Thyatira print & design	151	CIBSE Guide F, Table 20.18, Type 2 Offices 'Typical Practice'	85	CIBSE Guide F, Table 20.18, Type 2 Offices 'Typical Practice'	GFA
Industrial Facilities	Warehouses/ workshops	67	CIBSE Guide F, Table 20.1, Distribution Warehouse 'Typical Practice'	169	CIBSE Guide F, Table 20.1, Distribution Warehouse 'Typical Practice'	GFA
East Quay						
Industrial Facilities	Small boat builders & shellfish distributors	132	CIBSE Guide F, Tables 20.18, Light manufacturing and Table 20.6, Refrigerated Warehouses	126	CIBSE Guide F, Tables 20.18, Light manufacturing and Table 20.6, Refrigerated Warehouses	GFA

16 A.3 Baseline energy consumption and CO_2 emissions

The CIBSE Guide F ‘Typical Practice’ energy benchmarks were used to calculate the annual energy consumption currently produced by the site as shown in the table below.

Table 16A.3 Baseline annual energy consumption estimates

	North Quay		South Quay		East Quay		Total	
	MWh	% of total	MWh	% of total	MWh	% of total	MWh	% of total
Heating & Hot Water	500	35%	0	0%	214	15%	749	53%
Electricity	449	32%	0	0%	203	14%	664	47%
Cooling	0	0%	0	0.0%	0	0%	0	0%
Total	949	67%	0	0%	416	29%	1,413	100%

In order to determine the associated CO_2 emissions, the following emissions factors as stated in CIBSE Guide F, Energy Efficiency in Buildings were used.

Table16A.4 CO2 conversion factors (CIBSE, 2004)

CO_2 Conversion Factors	
Fuel Source	Conversion Factor
Natural Gas	0.194
Electricity Consumed	0.43
Electricity Generated	0.568

The estimated current annual CO_2 emissions from the existing buildings are summarised in Table 16A.5 and 16A.6.

Table 16A.5 Estimated baseline CO_2 emissions by end use

	North Quay		South Quay		East Quay		Riviere Fields		Total	Total
	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total
Heating & Hot Water	97	23%	0	0%	41	10%	7	2%	145	32%
Electricity	193	45%	0	0%	87	20%	5	1%	286	65%
Cooling	0	0%	0	0.0%	0	0%	0	0%	0	0%
Total	290	67%	0	0%	129	30%	12	3%	431	100%

Table 16A.6 Baseline CO2 emissions by building type

The current annual energy related emissions for the site are estimated to be 431 tonnes of CO_2.

16B – Calculation of Unmitigated Scheme Energy Consumption & Emissions

This section details the process and calculations undertaken in order to establish the impact of the unmitigated scheme, summarised in Chapter 16, section 16.5.

16 B.1 Building areas and uses

The areas in Table 16B.1have been used as the basis for the energy demand calculations. These areas have been derived based on the information provided by LDA Design. The following assumptions have been made for the purposes of these calculations;

Car parking is assumed to be an average of 15m^2 per parking space.

Retail is assumed to be 60% shops and 40% food / drink.

Table 16B.1 Breakdown of areas for the proposed development

	North Quay		South Quay		East Quay		Riviere Fields		Total	Total
	Area (m^2)	% of total	Area (m^2)	% of total	Area (m^2)	% of total	Area (m^2)	% of total	Area (m^2)	% of total
Residential	37,164	29%	19,515	15%	0	0%	30,925	24%	87,604	68%
Retail	2,613	2%	10,585	8%	0	0%	0	0%	13,198	10%
Community	0	0%	2,000	2%	5,000	4%	0	0%	7,000	5%
Office	7,355	6%	5,150	4%	0	0%	0	0%	12,505	10%
Leisure	1,055	1%	0	0%	0	0%	0	0%	1,055	1%
Hotel	2,430	2%	0	0%	0	0%	0	0%	2,430	2%
Ind.Facility	5,575	4%	0	0%	0	0%	0	0%	5,575	4%
Total	56,192	43%	37,250	29%	5,000	4%	30,925	24%	129,367	100%

Figures are based on indicative floor areas. Clifftop areas (CT1, 2, 2a, 3) and Hilltop Western are included within North Quay; Hilltop Southern and Northern are included within Riviere Fields.

The sources and selection of the energy benchmarks used for the calculation of energy consumption of the unmitigated scheme are detailed in Tables 16B.2 and 16B.3.

16 B.2 Energy Benchmarks

Table 16B.2 Summary of benchmarks used to estimate the unmitigated scheme heating and cooling

Summary of Energy Benchmarks					
Type	**Description**	**Thermal (kWh/m^2)**		**Cooling (kWh/m^2)**	
For All Areas					
Residential	Houses and apartments	60	1. Space heating of 36kWh/m^2 & hot water of 24kWh/m2	0	No space cooling
Office		70	2. Type 3 Office gas use 87 kWh/m^2 minus 20% for Part L 2006, Based on TFA	35	4. Cooling elctrical usage of 14kWh/m^2
Retail	60% shops and 40% food & drink	229	3. Banks, clothes, department, high street and supermarket stores, restaurants and fast food, good practice, 289 kWh/m^2 minus 20% for Part L 2006	0	Load included within electrical demand for individual units
Car Parking	Open car parking	0	No space heating	0	No space cooling
North Quay					
Community	Creche	90	3. Primary school good practice 113 kWh/m^2 minus 20% for Part L 2006	0	Assume no space cooling required
Hotel		149	3. Business / holiday hotel good practice, 186 kWh/m^2 minus 20% for Part L 2006	43	5. cooling elctrical usage of 17kWh/m^2
Industrial	Industrial Units & Fisherman Support Building	64	3. Distribution facilities good practice, 80 kWh/m^2 for Part L 2006	0	No space cooling
Leisure	Sailing club, Gym, Harbour Office and Seafood Shop	95	3. Social club, fitness centre and frozen food shop, good practice and office based on ECG019, 119kWh/m^2 minus 20% for Part L 2006	0	Assume no space cooling required
South Quay					
Community	Health Centre & Tourist Information Centre	90	3. Day Centre & Museum, good practice, 113 kWh/m^2 minus 20% for Part L 2006	0	Assume no space cooling required
Leisure	Winter Gardens & Café	189	3. Social club and restaurant with bar good practice, 236 kWh/m2 minus 20% for Part L 2006	0	Assume no space cooling required
East Quay					
Community	Landmark Building	71	3. Museum, good practice, 96 kWh/m^2 minus 20% for Part L 2006	43	Assume no space cooling required

Figure 16B.3 Summary of benchmarks used to estimate the unmitigated scheme electricity use

Summary of Energy Benchmarks						
Type	**Description**	**Electricity (kWh/m^2)**				**Floor areas**
For All Areas		**All Usage**		**Part L**		
Residential	Houses and apartments	36	6. Electrical consumption of 3000kWh/year for a 84m2 property	10	Based on SAP calculations	GFA
Office		101	2. Gas use 115 kWh/m^2, Based on TFA	79	Reduction of 22% based on detailed breakdown in CIBSE Guide F	GFA convereted to TFA at rate of 95%
Retail	60% shops and 40% food & drink	295	3. Banks, clothes, department, high street and supermarket stores, restaurants and fast food good practice	221	Reduction of 25%	GFA convereted to TFA at rate of 65%
Car Parking	Open car parking	1	3. Car park, typical practice	1	No reduction	GFA
North Quay						
Community	Creche	22	3. Creche good practice	17	Reduction of 25%	GFA
Hotel		63	3. Business / holiday hotel good practice 90kWh/m^2	54	Reduction of 15%	GFA
Industrial	Industrial Units & Fisherman Support Building	20	3. Distribution facilities good practice	20	No reduction	GFA
Leisure	Sailing club, Gym, Harbour Office and Seafood Shop	229	3. Social club, fitness centre and frozen food shop, good practice and office based on ECG019	165	Reduction of 28%	GFA
South Quay						
Community	Health Centre & Tourist Information Centre	22	3. Day Centre & Museum, good practice	17	Reduction of 25%	GFA
Leisure	Winter Gardens & Café	119	3. Social club and restaurant with bar good practice	89	Reduction of 25%	GFA
East Quay						
Community	Landmark Building	57	3. Museum, good practice 57kWh/m2	43	Reduction of 25%	GFA

The references used for establishing the energy benchmarks are listed below:

Office of the Deputy Prime Minister (ODPM) (2006), *Approved Document L1A – Conservation of fuel and power in new dwellings*, Building Regulations 2000, 2006 edt. Crown Copyright, UK

Carbon Trust (2003), Energy Use in Offices ECG 019

CIBSE (2003) *Energy Efficiency in Buildings – CIBSE Guide F, Table 20.1*, Chartered Institute of Building Services Engineers, London, UK

CIBSE (2003) *Energy Efficiency in Buildings – CIBSE Guide F, Table 20.9*, Chartered Institute of Building Services Engineers, London, UK

CIBSE (2003) *Energy Efficiency in Buildings – CIBSE Guide F, Table 20.5*, Chartered Institute of Building Services Engineers, London, UK

University of Oxford (2005), *40% House*, The Environmental Change Institute

16 B.3 Unmitigated energy consumption and CO_2 emissions

The energy benchmarks were applied to the areas of the masterplan and yielded the following total energy consumption. An estimated 17,132 MWh is anticipated as the annual energy consumption for the proposed development.

Table 16B.4 – Total annual energy consumption for the proposed development by end use

	North Quay		South Quay		East Quay		Riviere Fields		Total	
	MWh	% of total	MWh	% of total	MWh	% of total	MWh	% of total	MWh	% of total
Heating & Hot Water	3,927	23%	3,269	19%	355	2%	1856	11%	9,406	55%
Electricity	3,110	18%	3,338	19%	285	2%	1113	6%	7,847	46%
Cooling	348	2%	171	1.0%	110	1%	0	0%	629	4%
Total	7,385	43%	6,779	40%	750	4%	2969	17%	17,132	100%

Figures are based on indicative floor areas. Hilltop areas are included within Riviere Fields and North Quay. The CO_2 emissions of the site were calculated using the CO_2 conversion factors shown in Table 16A. 4.

Energy consumption benchmarks are broken down between electricity use and fossil fuel use. All fossil fuels were assumed to be natural gas and the conversion factor was applied accordingly. Based on Building Regulations the factor used for electricity consumption is different to the factor used for on-site electricity generation.

The CO_2 emissions are broken down by end use and building type are detailed in Tables 16B.5 and 16B.6 below. The end use breakdown indicates the type of energy which will provide the most CO_2 savings. The building type breakdown clarifies which typologies require the most mitigation measures. Due to the high proportion of residential buildings they have the highest levels of emissions compared with the other building types. The majority of the residential emissions result from heating and hot water energy demands. This indicated a need for heat generation renewable technologies.

Table 16B.5 - Unmitigated scheme CO2 emissions by end use

	North Quay		South Quay		East Quay		Riviere Fields		Total	Total
	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total
Heating & Hot Water	762	14%	634	12%	69	1%	360	7%	1,825	34%
Electricity	1,337	25%	1,435	27%	123	2%	479	9%	3,374	64%
Cooling	60	1%	29	0.6%	19	0%	0	0%	108	2%
Total	2,159	41%	2,099	40%	210	4%	839	16%	5,307	100%

Table 16B.6 - Unmitigated scheme CO2 emissions by building type

	North Quay		South Quay		East Quay		Riviere Fields		Total	Total
	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total	tonnes CO_2	% of total
Residential	1,008	19%	529	10%	0	0%	839	16%	2,376	45%
Retail	291	5%	1,179	22%	0	0%	0	0%	1,470	28%
Community	0	0%	80	2%	210	4%	0	0%	290	5%
Office	440	8%	308	6%	0	0%	0	0%	749	14%
Leisure	123	2%	0	0%	0	0%	0	0%	123	2%
Hotel	172	3%	0	0%	0	0%	0	0%	172	3%
Ind.Facility	117	2%	0	0%	0	0%	0	0%	117	2%
Car Park	8	0%	3	0%	0	0%	0	0%	10	0%
Total	2,159	41%	2,099	40%	210	4%	839	16%	5,307	100%

The CO_2 emissions for the proposed development will require mitigation from the estimated sitewide total of 5,307 tonnes.

16 C – Calculation of mitigated scheme impacts

To achieve the planning requirement of 10% CO_2 reduction through onsite renewable energy technologies requires the mitigation of approximately 530 tonnes of CO_2 or greater through the use of renewable sources. A detailed description of the renewable energy technologies considered can be found in Annex 16 F.

A variety of different targets are reflected in the energy strategy for the proposed development. The overriding requirement is to achieve a 10% CO_2 reduction through the use of onsite renewables. Further client driven targets such as Code level 4 and BREEAM 'Very Good' provide an additional challenge.

16 C.1 Methodology for achieving BREEAM 'very good' rating for non-residential buildings:

The BREEAM process incorporates a system of points which combine to give a total score out of 100 available points. In order to achieve the 'very good' rating, the required points total is between 55 and 69. The midpoint is assumed to create an adequate safety margin in the event that points in other areas are not awarded, leading to a points target of 63. The points were applied on a pro-rata basis as all developments vary and it cannot be assured which categories will be most relevant. The 'energy related' items in the BREEAM assessment are as follows:

Table 16C.1 Summary of energy targets required to meet an equivalent BREEAM Very Good rating

BREEAM 'Very Good' Rating - Energy			
Item	Requirement	Points Available	Commentary
HW01	80% of net floor area to be daylit	1.2	Detailed Design Stage
EO1	CO2 emissions over & above Part L 2006 requirements: from 1% above requirements to 70% above requirements	0.8 11.4	Reduction of 27% would provide 8.1 points
EO2	Sub metering of light, power and major plant rooms	0.8	Expect to achieve
EO3	Sub metering of individual tenants/users	0.8	Expect to achieve
EO4	Energy efficient daylight controlled external lighting	0.8	Expect to achieve
PO6	NOx emissions =< 100mg/kwh =< 70mg/kwh =< 40mg/kwh	1.0 2.0 3.0	Not available if Biomass is part of proposed development
PO11	Application of renewable & low emission energy feasibility study carried out & implemented + 10% demand met from renewable/low emission energy + 15% demand met from renewable/low emission energy	1.0 2.0 3.0	Expect to achieve 2 points
Total points available for energy items EO1-4, PO6 & PO11		19.6	

The following calculations demonstrate the assumptions made in order to establish the required reduction of CO2 emissions for achieving a 'very good' rating:

Assuming the amount of points are attributed on a pro-rata basis, the points attributed are 19.6 x 63% = 12.4 points

Deduct the points from E02 – 4 and PO11 which are anticipated to be achieved (a total of 4.3 points) = 8.1 points required to be achieved through CO_2 emissions reductions.

Interpolating between the figures in the BREEAM Design & Procurement Pre-Assessment Estimator, the CO_2 saving required to achieve 8.1 points would be 27%.

This method of assessment has been agreed with the design team and BREEAM assessors as an acceptable method of determining requirements at a masterplanning stage. In summary it represents that to meet a 'Very Good' rating buildings will be designed to reduce CO_2 emissions by 27% lower than Building Regulations. This reduction has been used in assessing the impact of the mitigated scheme.

16 C.2 Achieving Code for Sustainable Homes- Level 4

The necessary 44% reduction in CO_2 emissions from Part L to achieve Level 4 Code for Sustainable Homes is shown below. The Standard Assessment Procedure (SAP) was used to establish the kg CO_2/m^2/year for a residential property. The SAP is the government's recommended system for energy rating of dwellings.

Table 16C.2 SAP assessment for a typical residential unit

Breakdown of Loads:		
	$kgCO_2 / m^2 /$ year	kWh/ m^2
Space heating	6.88	36.23
Water heating	4.64	24.44
Auxiliary energy	1.12	2.61
Lighting	3.36	7.82
Total	16.01	71.09

Riviere Fields and Hilltop:

The average area per residential unit on Riviere fields is 95 m^2 which, using the SAP figures above, gives average annual CO_2 emissions figure of 1,512 kg CO_2 per unit.

The SAP does not take into account energy consumption associated with cooking or appliances.

Table 16 C.3 shows the options available for the residential houses in Riviere Fields and Hilltop to achieve CfSH Level 4.

Table 16C.3 – Carbon emission savings beyond Part L to achieve Level 4 Code for Sustainable Homes for Riviere Fields

Area	Technology	Size		Carbon Savings with Option1 (kg CO2)	% Carbon Savings With Option 1	Carbon Savings with Option 2 (kg CO2)	% Carbon Savings With Option 2
	Biomass Boilers	25	kW	1104	73%		
OR	GSHP	4	kW			295	19%
	Solar thermal	4	m2			265	17%
	Solar PV	2	m2			105	7%
Total				1104	73%	665	44%

Option 1:

A biomass pellet boiler would provide a reduction of 1104 kg CO_2 per residential unit (73% improvement on Part L)

Option 2:

A 4 kW GSHP to provide space heating would provide a reduction of 295 kg CO_2 per residential unit (19% saving over emissions from a unit built to Part L)

4m^2 of Solar thermal to provide hot water would provide a further 17% CO_2 reduction

2m^2 of Solar PV to provide electricity would provide a further 7% CO_2 reduction

Residential areas in North and South Quays:

The average area per residential unit on North Quay is 97.5m2 and on South Quay it is 75m2. Using the SAP figures above, gives average annual CO_2 emissions figure of 1,560 kg CO_2 per unit on North quay and 1,200 kg CO2 per unit on South Quay.

The total unmitigated (Part L) CO_2 emissions for North Quay is calculated to be 1567 tonnes

The total residential (Part L) emissions = 592 tonnes, target 44% reduction = 261tonnes.

The total non-residential emissions = 975 tonnes,target 27% reduction = 263 tonnes.

The total reduction beyond Part L to meet targets on North Quay = 524 tonnes

The total unmitigated (Part L) CO_2 emissions for South Quay is calculated to be 1585 tonnes

The total residential (Part L) emissions = 311 tonnes, target 44% reduction = 137tonnes.

The total non-residential emissions = 1,274 tonnes,target 27% reduction = 344 tonnes.

The total reduction beyond Part L to meet targets on North Quay = 481 tonnes.

The areas of North and South Quay will be part of district heating schemes. Renewable energy options are discussed further in annex 16F. For providing the significant carbon savings required there are two main options available for fuelling the district heating schemes:

Table 16C.4 Carbon emission savings beyond Part L to achieve Level 4 code for sustainable homes for North Quay and South Quay

Area	Technology	Size	Target	Carbon Savings with Option1 (kg CO_2)	Carbon Savings with Option 2 (kg CO2)
North Quay			524		
Option 1	50% Biomass	750 kW		381	
Option 2	100% Biomass	2.8 MW			762
South Quay			481		
Option 1	50% Biomass	450 kW		317	
Option 2	100% Biomass	2.0 MW			634

50% of heat and hot water provided by biomass boilers:

50% heating requirement met by district heating scheme which would offset 50% of heat related CO_2 emissions. This equates to 381 tonnes for North Quay and 317 tonnes for South Quay. Other energy efficiency measures would need to be included to meet the BREEAM and CSH targets (524 and 481 tonnes respectively) would be achieved. This could take the form of higher insulation and glazing levels, efficient lighting or a variety of other measures as discussed in Annex 16E.

Option 2:

100% heating requirement met by district heating scheme would provide a reduction of 762 tonnes CO_2 on North Quay and 634 tonnes on South Quay, higher than the target levels required.

16 C.3 Renewable Energy Framework

The purpose of the energy strategy is to provide a framework with which the targets will be achieved. The framework sets out an achievable level to which additions and modifications can be made to further expand the CO_2 savings of the proposed development. In order to achieve the targets set forth, energy efficiency measures will be required to provide additional emissions savings to be inline with the Code Level 4 and BREEAM 'Very Good' standards.

Table 16 C.5 summarises the emission reductions to be achieved through the use of passive, energy efficient and renewable technology measures.

Table 16C.5 – Carbon emissions savings from meeting targets – by building type

	Building type	Reduction beyond Part L (tonnes CO2)	Carbon Savings	% Carbon Savings
North Quay				
BREEAM 'Very good'	Commercial	27%	263	5%
CfSH Level 4	Residential	44%	261	5%
South Quay				
BREEAM 'Very good'	Commercial	27%	344	6%
CfSH Level 4	Residential	44%	137	3%
East Quay				
BREEAM 'Very good'	Commercial	27%	49	1%
Riviere Fields				
CfSH Level 4	Residential	44%	217	4%
Total			1,270	24%

The mitigation of the proposed development would be a reduction of a minimum of 1,270 tonnes CO_2 (24%) for an overall residual impact of 4,037 tonnes of CO_2. This is 3,606 tonnes higher than the current estimated annual emissions.

Table 16C.6 summarises the emission reductions arising from the adoption of the renewable energy options that may be used to satisfy the needs of the renewable energy framework.

Table 16C.6 – Carbon emissions savings from alternative energy options

Area	Technology	Size	Carbon Savings with Option1 (tonnes)	% Carbon Savings With Option 1	Carbon Savings with Option 2 (tonnes)	% Carbon Savings With Option 2
North Quay						
Option 1	100% Biomass	2.8MW	762	14%		
Option 2	50% Biomass	1MW			381	7.2%
South Quay						
Option1	50% Biomass	0.6MW	317	6%		
Option2	CHP	160kWe			101	1.9%
East Quay						
Option1	100% GSHP	0.5 MW	33	0.6%	33	0.6%
Riviere Fields						
Option1	Biomass Boilers	25kW	360	7%		
Option2	GSHP	4kW			295	6%
	Solar HW	4m2			265	5%
	Solar PV	2m2			105	2%
Total			1472	28%	1180	22%

16 D – Passive energy consumption reduction measures

The following potential measures have been reviewed to determine suitability and potential impacts on carbon emissions:

- Improve building fabrics and glazing
- Improve air tightness
- Natural lighting
- Natural ventilation

Each of these issues is addressed in detail in the following pages and referenced sections of this report.

16 D.1 Improve Building Fabrics and Glazing

The proposed development would seek to minimise the carbon emissions by selecting building fabrics and overall building designs that exceed the requirements of Part L, whilst being economic in construction terms, delivering ongoing energy savings throughout the life of the building.

Improving the building fabric as well as reducing the emissivity of the glazing effectively diminishes heat loses / gains thus reducing the amount of energy required to maintain a comfort temperature in buildings. These reductions can also be achieved by using materials with less conductivity than the standard ones or purely by increasing the thickness of the materials used for insulation.

The proposed development will aim to reduce the U-values beyond Part L wherever possible. Further investigation will be carried out during detailed design.

16 D.2 Improve Air Tightness

Buildings with high air change rates (above the requirements for the occupants) have higher energy consumption because infiltrating air needs to be conditioned.

Building regulations 2006 Part L imposes a strict control on the air tightness of the buildings not allowing more than 10 $m^3/h.m^2$ at 50 Pa. and aiming at values around 7 $m^3/h.m^2$. Specific guidance is available from the ODPM and general measures that will help to improve air tightness are:

- Keep doors closed with automatic actuators in public buildings;
- Improving the building construction standards;
- Using high quality windows without leaks and
- Sealing joints along windows and doors.

- Building orientation is also important because leaky surfaces exposed to wind increase air infiltration thus extra attention has to be paid to surfaces exposed to prevailing winds. T

The proposed development will aim to increase the level of air tightness beyond Part L wherever possible. Further investigation will be carried out during detailed design.

16 D.3 Natural Lighting

A building designed to maximise the use of natural light allows for the reduction of energy consumption and related CO_2 emissions associated with lighting. This can be facilitated by maximising façade to floor plate ratios and minimising the depth of the floor plan. External circulation paths in the development needing artificial lighting should be minimised but without compromising safety. Natural lighting is of particular importance in public buildings such as schools, community centres, and etcetera.

Buildings and facilities can be specifically designed to make use of natural daylight, e.g. by the use of shallow depth spaces and maximising façade to floor plate ratios - this can result in significant energy savings by reducing the daily usage of the artificial lighting systems. In addition, occupants' sense of well being and productivity have been shown to increase when workplaces are wholly or predominantly naturally lit (CIIBSE,2003) .

- Natural lighting is one of the measures that cannot be used to further reduce CO_2 emissions beyond 2006 Part L regulations because, once implemented, no more savings could be accounted without changing the building.

- Natural lighting should be capable of reducing the electricity consumed by offices to levels around 8 W/m^2 according to internal research carried out and a case study presented in the Modern Building Services Journal (MBS, 2006). This is equivalent to a reduction of 40% in the energy consumption and carbon emission levels.. These can only be achieved if used together with some active mitigation measures like low energy lamps, high-frequency electronic ballasts, mirror luminaries and light sensors. Lamps may be smoothly dimmed down to 10% of their maximum light output and a suitable photocell responds to the combined daylight and artificial illumination level to provide a constant level of illumination. Where feasible, the use of light pipes and skylights should be encouraged.

- Although natural lighting is desirable, solar gains must be limited such that the average solar and internal gains during the occupancy in July are less than $35W/m^2$.

- The proposed development will aim to maximise the use of natural light wherever possible. Further investigation will be carried out during detailed design.

16 D.4 Natural Ventilation

Natural ventilation consists of providing fresh air to the building by natural means without using fans. By using natural ventilation strategies energy consumption in the building is reduced because there is no need to mechanically force air into spaces to condition them. Natural ventilation requires a careful design and centrally driven operation i.e. the BMS will actuate the windows, etcetera. when required.

Naturally ventilated buildings present some disadvantages. For example, some variation of the internal temperature with external climatic conditions must be expected and odours and noise can come through the openings. In addition to this, some buildings would have excessive internal gain or may not be suitable for a commercial letting market if not air conditioned or comfort cooled.

Statistics from major landlords show that for 2001 naturally ventilated offices' average energy charges based on net letable area were in the region of 10% of the total service charge compared with 15% of the total service charge for air-conditioned offices (CIBSE, 2003).

The use of air conditioning or comfort cooling may be reduced or avoided by adopting a night ventilation strategy to cool the building fabric overnight, thereby reducing peak indoor temperatures during occupied hours. Studies have shown that a night ventilation strategy can reduce peak daytime temperatures by around 2°C, effectively providing up to 20kWh/m^2/year of free cooling. (Connect, 2004)

For large buildings, the complete control of natural ventilation by manual window openings is not possible and some form of automatic control is essential normally via a BMS system. However, where natural ventilation is employed, some variation of internal temperature with external climatic conditions must be expected. Atria would be encouraged as would the use of high façade to floor plate ratios within buildings.

Commercial viability and acoustic concerns would influence the final solution for each building and whilst natural ventilation would be encouraged, selection will be driven by these factors. Generally residential developments would primarily utilize natural ventilation. Residential accommodation would be naturally ventilated for housing, in appropriate instances, although these may be impractical for other elements of the development due to:

Building Use – areas with high internal gains or restrictions to ventilation openings are unlikely to be viable for natural ventilation solutions.

Location – adjacency to roads may result in unacceptable air quality at low-level ventilation inlets and noise penetration through openings.

Commercial Concerns – to achieve the correct environment, e.g. hotels, some uses will show significant reduction in the value of the building area should competitive standards with similar building not be maintained.

The proposed development aims to utilise natural ventilation wherever possible. Further investigation will be carried out during detailed design.

16 E – Evaluation of energy efficiency measures

The following potential measures and technologies have been reviewed to determine suitability and potential impacts on carbon emissions:

- Intelligent control systems
- Low energy lighting
- Lighting control systems
- Demand driven ventilation
- Heat recovery systems
- High efficiency plant and small power equipment
- Energy monitoring
- District heating
- Combined heat and power (CHP)

Each of these issues is addressed in detail in the following pages and referenced sections of this report.

16 E.1 Intelligent Control Systems

A Building Management System (BMS) controls most energy consuming actions within a building hence it can limit energy wastage. BMS controls are composed of sensors, actuators and software that take decisions on which the BMS can control plant timing, shading, lighting and ventilation running on a suitable hardware.

Zones of the building with different solar exposure, occupancy or use should have separate time and temperature control. Central plant would only operate when the zone systems require it. Sensors can be situated in windows, doors, plant equipment (e.g. boilers), rooms, etcetera and should measure temperature, humidity, light levels, etcetera. They can also provide state info: open/close, empty/occupied, etcetera.

Actuators can be 100% adjustable to accommodate partial loads (e.g. pumps) or with intermediate positioning (e.g. window openings, lighting appliances).

The chosen BMS software has to be able to process multiple inputs from the sensors and produce the desired outputs for the actuators so that energy consumption is minimised and optimum conditions are achieved in the building.

Training for the operators and maintenance of the BMS software has to be provided and skill levels maintained over time. Building users have to be encouraged not to override controls and constant monitoring and adjustments to the systems can improve operational efficiency significantly.

Building envelopes, internal environments and the processes within buildings all contribute to the amount of energy consumed. Examination of existing buildings indicates avoidable energy wastage can range between 25 to 50%. In well-managed buildings energy wastage can be reduced to 15 % (CIBSE, 2000).

The use of building management systems and other intelligent controls will be investigated and incorporated as appropriate during detailed design of the proposed development.

16 E.2 Low Energy Lighting

Lighting is one of the largest consumers of electricity in buildings. It can account for up to 40% of the total electricity cost in a naturally ventilated building. New 2006 Part L Building Regulations expect that at least 30% of the appliances and sources of light should be low energy and high efficiency to minimise energy consumption hence associated CO_2 emissions. External lighting is also a point to focus when aiming at CO_2 emissions reduction.

High efficiency lamps offer a higher level of illumination per unit of energy. Installation within luminaries that properly reflect the light produced by the lamp, electricity is saved and CO_2 emissions are cut. The Commissioning Code L for lighting edited by CIBSE (CIBSE, 2003b) states that a value of 65 lumens per circuit-watt should be achieved well above the regulation. According to 2006 Part L Building Regulations, desired values of lighting efficacy in dwellings are 40 lumens per circuit-watt i.e. including lamps and their associated control gear and 45 lumens per circuit-watt in non-dwelling buildings. For display lighting, the values are not less than 15 lumens per circuit-watt

External lamps are usually lit for approximately 5,000 hours a year, so a small increase in effectiveness can yield a big decrease of the energy consumption (around 25%) per length of lit street. Streetlights should be controlled by light sensors and timing devices. 2006 Part L Building Regulations states that any fixed external lighting fitting should not exceed 150 W per fitting or it should have an efficacy above 40 lumens per circuit-watt.

The use of low energy lighting will be investigated and incorporated as appropriate during detailed design of the proposed development.

16 E.3 Lighting Control Systems

General lighting controls can be included in the form of manually operated switches no more than 6m (or twice the floor to ceiling height if greater) from the luminaries they control, and perimeter daylit space should be separately switched. Display lighting should be separately switched off at times when people will not be inspecting the display.

Lighting controls can be designed to take account of presence of people (e.g. pyroelectric infrared) in their area with photoelectric switching and dimming capacity. 2006 Part L Building Regulations assumes 10% reduction in carbon emissions in non-public buildings by implementing lighting controls that is assumed extendable to the rest of controls. However, not all buildings will be able to implement this measure on economical or technical grounds. Centralised lighting control systems also ensure that an overall control of the lighting is maintained and unoccupied areas are switched off providing the maximum benefit in energy terms. Case studies have shown that use of modern lighting controls, combined with natural lighting can result in a 30-40% reduction in the resultant lighting use (CIBSE, 1999)

The use of intelligent lighting controls will be investigated and incorporated as appropriate during detailed design of the proposed development. Given the south facing aspect of the majority of the development there is considerable potential for the use of natural lighting and the use high efficiency luminaires will be maximised subject to commercial considerations.

16 E.4 Demand Driven Ventilation

Demand driven ventilation employs CO_2 sensors in occupied areas to control the amount of fresh air supplied, via variable speed fans, in response to varying occupancy and the actual need for fresh air. These systems give scope for energy savings in areas of variable occupancy and where ventilation demand is driven by specific activities such as car parking.

Demand driven ventilation will be reviewed at detailed design stage for areas such as enclosed car parks where it has the greatest potential to deliver energy consumption reductions.

16 E.5 Heat Recovery Systems

Heat recovery systems recover heat from exhaust air streams that would otherwise be wastefully discharged to the outdoors and use it to raise the temperature of incoming fresh air. The use of a heat recovery system makes it possible to use fresh air in significant quantities with a reduced level of carbon emissions. However, climatic conditions may limit the days in the year when this technology is useful. Energy is saved and emissions reduced as the energy required to heat incoming air is reduced.

- According to 2006 Part L Building Regulations, expected efficiencies of heat exchangers would be above 66%. Fans supplying air in balanced systems should have a specific fan power of 2 W/l/s or less at 100% and 25% of the design flow rate. Fans for continuous supply (e.g. toilet rooms) should have specific fan power of 0.8 W/l/s.

When considering the application of heat recovery systems, the energy balance and running cost as well as capital cost must be considered. In addition to the operating cost of running wheels, pumps, fans, etc., consideration should be given to the flow resistance that heat recovery devices impose on systems thereby increasing their carbon emissions from the fan system. Where the application of a heat recovery device proves to be advantageous in cost/energy terms, then it shall be incorporated into the relevant system's design.

Similarly to CO_2 savings by natural ventilation, once a building in the development is designed as mechanically ventilated with heat recovery, its CO_2 emissions cannot be further reduced on these grounds. Hence, this measure cannot be used to cut CO_2 emissions beyond 2006 Part L.

The use of heat recovery systems will be investigated and incorporated as appropriate during detailed design of the proposed development There is potential to include heat recovery in the commercial elements of the development.

16 E.6 High efficiency plant and small power equipment

The following minimum standards for mechanical and electrical systems would generally be applied. It should be noted that Part L 2006 refers to another publication (Non-domestic Heating, Cooling and Ventilation Compliance Guide) for the minimum plant standards on this section, which is not yet published. Nevertheless, these requirements will be incorporated in all types of buildings in the proposed development.

If plant equipment (e.g. pumps, fans, motors, boilers, chillers, etc.) efficiency is high, less energy will be required to produce the same effect thus minimising energy wastage and CO_2 emissions. For example:

- Gas fired condensing boilers achieving a seasonal efficiency of at least 86%
- High efficiency chillers with a minimum seasonal coefficient of performance (COP) of 3
- Fans rated higher than 1,100 W should be equipped with variable speed drives.
- Small power equipment like IT equipment, washing machines and small appliances with "A" energy ratings
- The first two points are incompatible with a community/district heating/cooling scheme so both associated CO_2 emissions reductions cannot be accounted simultaneously.

- If this option is used to comply with 2006 Part L Building Regulations requirement there is small potential for further CO_2 reductions by improving plant efficiency or by using low energy consuming small power equipment.

The use of high efficiency plant and small power equipment will be investigated and incorporated as appropriate during detailed design of the proposed development

16 E.7 Energy Monitoring

This task will not reduce energy use or CO_2 emissions by itself other than enabling the elimination of operating systems wastefully, not as designed or identifying faults within the design, installation and operation of the systems. These faults, which are common in all buildings to a greater or lesser extent, could be identified and remedied if monitored.

Energy monitoring is needed to prevent energy wastage and have the possibility of knowing if other CO_2 saving measures are working properly. In the long term, it will provide energy trends and allow a better management of the energy. Consequently, 2006 Part L Building Regulations states that automatic monitoring and targeting of energy consumption with alarms for out of range values can achieve a reduction of up to 5% in carbon emissions according to table 3 in the approved document 2A of the 2006 Part L Building Regulations as it will enable the systems to be modified to operate at or near their optimum efficiency.

The use of energy monitoring will be investigated and incorporated as appropriate during detailed design of the proposed development

16 E.8 District Heating

A District Heating scheme is any scheme where there is centralised generation of heat which is then distributed to a number of buildings through a heating network (Rochas, 2004). This can vary in scale from links between two buildings, up to the provision of heat throughout a city.

The main benefits(Rochas, 2004) come from

Reducing the cost of fuel infrastructure and maintenance (e.g. only one location needs gas connection),

- Efficiencies in technology from larger plant,
- Reduced cost compared to distributed boilers,

The operator of the system may be able to secure a better tariff due to being a larger user of gas than each single residence.

The system does however bring disadvantages in that:

- A heat distribution system is needed,
- It reduces the financial viability of providing gas in flats for cooking,
- The operator of the system needs to organise billing for heat use.

It is interesting to note that Community Energy systems are very common in Northern European countries, where for example 98% of Greater Helsinki is supplied by community heating from a variety of sources (EST, 2002) and 60% of Danish space heating is from such systems (DBDH, 2004), but less common in the UK, providing heat to 1.8% of the building stock. However with the increasing tendency to building flats in the UK Community Energy it is becoming more common.

The availability of a community heating network will improve the economic viability of alternative heating technologies as it reduces the impact of sudden falls in demand and the network effectively acts as a thermal store. During the life of the district heating network, which may be in excess of 50 years, different heat generators or additional thermal storage can be added into the scheme as economics change. For instance a CHP engine or biomass boiler could be added at any time, or the network could be linked to another neighbouring scheme. In the same way the network can be adapted to include new clients whenever they arrive.

District or community heating schemes can be used with existing and new buildings but would require careful planning regarding flexibility to meet changes in future energy demands. A district heating scheme would serve to 'future proof' the development as it allows for review and addition of other renewable technologies as they become available. In such a system, only the central technology would need to be replaced rather than individual technologies within each building.

Using a District Heating system brings flexibility benefits to the proposed development. It can reduce the capital cost of construction due to the cost savings from not providing gas, gas boilers and flues to each property. It could allow for development through phases and for variations in future building designs and technology trends. District Heating will also provide operational savings for occupants through the bulk purchase of fuel and improved operating efficiencies.

A district scheme would promote community ownership and save space and energy but does require high densities to be viable. It would be recommended that a district heating scheme be utilised for North Quay and either a district heating or district heat and power scheme for South Quay. A district scheme is not being considered for Riviere Fields due to the low density of that area of the proposed development.

16 E.9 Combined Heat and Power (CHP)

CHP is the simultaneous generation of useful heat and power, providing efficiency benefits over traditional forms of power generation (CIBSE, 1999 and Action Energy, 2004). For maximum efficiency CHP units generate to serve a steady load (Action Energy, 1996). Peaks and troughs in power demand are then met through imports or exports to the national grid; heat loads are matched through the use of additional boilers, and by using thermal storage or heat dumping.

When compared in simple payback terms CHP does not usually prove economic compared with traditional supplies unless there are at least 4500 hours of full load operation required over the course of a year (Action Energy, 2004). Typically CHP units are sized to meet base heating demands to ensure that running time is sufficiently high. It is traditionally only cost-effective to operate CHP units for 17 hours a day, avoiding the night-period when the price of electricity is very low.

A CHP scheme can be managed by an ESCO (energy services company), who provide the equipment and maintenance in return for an agreed price structure. This reduces the capital cost to the developer, but introduces different risks. The ESCO may provide power over 'private wires' as an exempt supplier, this would provide large cost savings and improve the economics for installing a CHP scheme (EST, 2003).

CHP is usually powered by gas, and therefore it is not considered a form of renewable energy, so does not contribute to meeting the 10% renewables target but is viewed as an energy reduction method. CHP offers carbon savings, less reliance on the grid electricity supply and long-term cost savings (CIBSE, 1999).

The integration of CHP in the proposed development would depend strongly on the implementation of a district heating scheme and is being considered for both North and South Quay for use in conjunction with renewable energy technologies.

CHP promotes local involvement and brings significant operational savings for mixed use developments such as the proposed development as they provide a more consistent energy load profile which in turn allows for a more efficient system. Using a model of energy consumption profiles for the building type breakdown we have estimated the most appropriate size of CHP system for North Quay and South Quay. A 250kWe Gas CHP system operating for around 4500 hours annually would be suitable for North Quay while a 160kWe Gas CHP system operating for around 4800 hours annually would be suitable for South Quay.

16 F – Evaluation of renewable technologies

Alternative energy technologies use local generation techniques to reduce the energy consumed via the national grid and gas supply network. There are continual developments in this market, in terms of technology, economy, public perception and government policy; and there may be many changes in the next ten years that could influence the viability of their use. This report considers the technologies that are available and feasible now; they are made based on present day prices and experience of their application within the UK.

Having considered methods for the reduction of energy consumption this section considers how the remaining carbon dioxide emissions can be reduced through the introduction of on-site renewable energy generation to provide both heat and power to the development. The alternative energy technologies considered include low and zero carbon options applicable to a scheme of this scale and location.

Several constraints have informed the renewable options for the development. The first constraint is the location and limitations of the site in conjunction with the planning and design requirements of the development and community. Secondly the market cost and availability of renewable energy technologies. The final consideration is the density and phasing of the development and the viability of a community heat and power scheme.

16 F.1 Wind

Wind Turbines are well known as a source of renewable energy. The best location for a wind turbine is in an exposed site with high average wind speeds, and with the potential for linking to the National Grid. Smaller turbines can be located in many areas, but need good exposure to the wind to be economically viable (Edwards, 1999). Recently, however, a range of very small turbines aimed at roof top use have come to be used in domestic applications and are seen as a viable way of providing a proportion of a households power needs (Taylor, 2001). At present large wind turbines are the most efficient and cost-effective method of generating renewable power within the UK.

The main benefits of local wind power are:

- Provide power all the year round, at varying levels;
- Attract a Renewable Obligation Certificate (ROC) for each unit of power generated
- Visibly show a commitment to environmental issues
- Generate a large amount of publicity.

The main concerns raised over wind turbines are that they (Boyle, 2004):

- Intrude on the visual landscape
- Can be noisy if not well designed
- Affect radar systems
- Injure birds

Proposed Development

The potential for using wind turbines is an issue of scale, and deciding what is appropriate and cost-effective. The two extremes of scale are the use of a large, circa 1MW, wind turbine, to a series of small, circa 1.5kW, turbines on the roof of high-rise properties.

Large scale wind energy has the potential for community ownership, high electrical yields and is commercially viable. However, any proposal for a wind turbine must consider the impact on the local landscape. The proximity of the RSPB Reserve at Carnnsew Pool to the development would negate the use of medium or large scale wind turbines for this development. The only location on the site which is a sufficient distance (400m+) from residential buildings to avoid noise nuisance is on the triangular spit, adjacent to the bird reserve.

Small scale wind turbines could be utilised for way-finding, public art or educational purposes while making a minor contribution to the reduction of carbon dioxide emissions but may still pose a threat to birds. Urban wind typically has high levels of turbulence and low wind speeds. Small-scale wind turbines are therefore considered an expensive and unproven means of reducing CO_2. Integration of wind turbines requires early commitment to enable the structural and architectural ramifications to be resolved. A significant amount of risk is involved when dealing with urban wind speeds and this option is not recommended as an efficient means of meeting the energy targets.

16 F.2 Solar Photovoltaics (PV)

Solar photovoltaic panels convert direct and diffuse energy from the sun into electrical energy (Boyle, 2004).The panels can be easily integrated into roof spaces and facades or can be free standing to provide a renewable source of power that can be used directly or exported to the grid. Optimum annual output is achieved through installation on south facing elevations but near south, vertical walls and flat roofs can be used. PV panels can also be designed to make an architectural statement. There is a variety of panels available; framed modules, roof slates or glazing materials which can be used as direct alternatives to conventional building materials.

Benefits

- Direct generation of high value electricity to be fed straight to the user

- Each kWh will attract a Renewable Obligation Certificate (ROC)
- Provide shading to building that can reduce over-heating
- Clear statement of environmental commitment

Disadvantages

- The cost of solar PV panels is very high,
- The power is generated at times of low load and any excess power will only receive a low purchase price from the national grid.

Although the cost is high, this can be reduced to some extent by integration into the building fabric and from obtaining funding from external sources. In general Solar PV panels do not provide a great amount of useful energy for the cost of provision, being around 8 times less cost-effective than a small wind turbine.

Proposed Development

Solar PV would make a visible statement but has high capital costs for a small carbon savings. At this stage in the development it is not possible to know the availability of south facing roof or façade areas. The orientation of buildings in North Quay would lend themselves to addition of solar PV. It could also be considered for individual homes in Riviere Fields. Typically an area of 14m2 would provide approximately half of annual domestic electrical demand with capital cost of about £8,400 per property. The affect of the orientation of individual houses on the output would require further investigation.

Solar PV can be economical for low demand remote applications, such as signage, bus shelter lighting and street lighting. Use of solar PV for these applications will be reviewed as the design develops.

If solar PV were to be installed, it would be recommended that it be as an addition to other renewable technologies to give the development a ‘green’ image and minor CO_2 savings.

16 F.3 Solar Hot Water Heating

Solar thermal collectors absorb direct solar radiation and transfer it to circulating water, which exchanges the heat obtained with a hot water store. These collectors operate most effectively during the summer when there is maximum sunshine, which conversely, is when heat demand is at a minimum. They are therefore commonly sized to meet summer hot water demands. If combined with thermal storage or heat pumps the performance of solar collectors can be improved, but these systems are more complex and expensive.

Benefits:

- ‘Free’ energy from the sun
- Visual sign of energy commitment

- Can provide useful shading
- Low technology

Disadvantages

- Require space at high level that could be used as e.g. roof garden
- Additional service connections to reach hot water system
- May not match the aesthetics of buildings
- Can make CHP system less effective by reducing base heat load

Solar water collectors have many of the same solar access constraints as Solar PV but are not as affected by shading. Optimum annual output is achieved on south facing elevations but near south, vertical walls and flat roofs can be used. Evacuated tube collectors can be optimised by adjusting the solar angle enabling them to be vertically mounted which creates opportunities for architectural integration. It is best suited to residential and commercial properties or district heating and needs to be building integrated. Like Solar PV, solar hot water makes a visible statement but does require increased maintenance and capital expenditure.

Proposed Development

There are several areas throughout the site where this technology could be considered. Integration into individual homes in Riviere Fields would be the easiest means of utilising solar hot water as shared systems can become overly complex. Typically an area of 5m2 is required per property to provide approximately 60% of hot water demand with an associated cost of about £5,000 per property. The affect of the orientation of individual houses on the output would require further investigation.

16 F.4 Biomass

Biomass is a generic term for both liquid biofuels, such as biodiesel or bioethanol, and solid biofuels, such as woodchips and pellets. In this strategy biomass will refer to woodchips and pellets.

Using biomass fuels in modern efficient heating systems is a well-established technique. The boilers used are computer controlled for optimum efficiency and are easy to maintain and operate. Woodchips or pellets are delivered on a regular basis into a fuel store and then automatically fed into the boiler when demanded.

Benefits:

- Carbon neutral
- Cost savings based on present day prices
- Sustainable management of local woodland

- Benefits to local economy
- Establishment of reliable supply chain

Disadvantages:

- Additional capital cost of the boiler
- Additional need for fuel store, fuel transfer machinery and regular fuel deliveries via lorry
- Additional space requirement for boiler and fuel store

Proposed Development

The selection of a biomass system would depend strongly on inclusion of a district heating scheme. A biomass district heating scheme could be used in both North and South Quay with individual boilers to be used in Riviere Fields and areas of Hilltop. Biomass may be less viable in South Quay due to the predominantly commercial areas where regular deliveries may be undesirable. A similar scheme in North Quay would be situated near to industrial areas where such a conflict would be minimised.

There are several options in system scope for North and South Quay depending on desired emissions reduction and budget. A 2.7MW biomass system would be required to supply 100% of the heat and hot water for North Quay, while a system of 750kW would be required to achieve 50%. Both options could be used for South Quay with either a 2MW or 450kW system.

The low density of Riviere Fields would require the use of decentralised systems. A 25kW boiler in each property would be able to provide 100% of the heat and hot water demand.

Fuel Supply Study

Sources of woodchip investigated included the following:

- Logpile website (National Energy Foundation)
- Coordinated Woodfuel Initiative – South West Woodland Renaissance & Forestry Commission England
- Renewable Energy Association
- Local industry contacts

Potential suppliers were telephoned to determine how many were currently available and how many were likely to be available in the future. The suppliers investigated had wood sources within a 30 mile radius of Hayle; woodchip transported by lorry from further distances increases the carbon footprint.

From the Database Coordinated Woodfuel Initiative – South West Woodland Renaissance & Forestry Commission England – the following results were obtained:

Ref	Contact details	Comment
1	EnerTree Services See below Tel: 01453 543 387	No response (no website, personal answerphone)
2	Econergy Ltd Tel: 01767 652 800	Does not cover Cornwall
3	Forest Fuels Ltd Tel: 01409 281 977	Contact Sam Whatmore; covers Cornwall, can provide to any specification required by the boiler
4	Wood Energy Ltd Tel: 01398 351 349	Referred to Brookridge Timber
5	Scott Brown Tree Services Tel: 01209 210 154	No response
6	Tregothnan Estate Woodlands Tel: 01872 520 525	Contact Jonathan; currently supply a hotel within 20miles of Hayle, cover all of Cornwall with their own estates
7	Mount Pleasant Garden Services Tel: 01726 843 918	Does not supply
8	Cornish Garden Nurseries Tel: 01872 864 380	Does not supply
9	Cornovia Tree Services Tel: 01209 715 010	No response

Other Contacts

Ref	Contact details	Comment
1	Southwest Woodfuels Tel: 01398 324 558	Website and email information
2	Cornish Woodmeet Tel: 01579 351316	Referred to Truro Sawmills
3	Cornwall Sustainable Energy Partnership Tel: 01209 614974	Website
4	Regen SW Tel: 01392 494399	Website: no companies listed as woodchip suppliers
5	Renewable Energy Association (REA) Tel: 020 7747 1830	Website
6	Centre for Sustainable Energy Tel 0117 929 9550	Also Woodfuel South West Advice Service Website
7	Cornish Energy Efficiency Advice Centre Tel: 01209 614 975	Website
8	Brookridge Timber Tel:01823 680 546	Contact Kevin; company is associated with EcoWood Fuels; covers all of SW (Glos, Som, Wilt, Devon, Cornwall). Suppliers of pellet, just entering woodchip supply
9	Truro Sawmills Tel: 01872 561 070	Do not supply woodchip at the moment; are building a new sawmill and are planning to install chipper on it (approximately 2008)
10	Biomass Industrial Crops Ltd (Bical) Tel: 01984 656 606	No response
11	A1 Tree Surgery & Landscaping Tel: 01726 810 844	No response
12	Duchy of Cornwall Gloucestershire, Herefordshire	Manage local Duchy of Cornwall Woodland and other Estates. Produce a reliable supply of woodchip, some of which is used in local biomass boilers. Could form part of a local supply network.

13	National Industrial Symbiosis Programme 44 Imperial Court Kings Norton Business Centre Pershore Road South Birmingham B30 3ES Tel: 0121 433 2650	Can provide details of potential suppliers

Land Use Assessment

The table below gives an indication of the current land use throughout Cornwall, compiled by Atlantic Energy consultants for the CSEP. From this it can be seen that present land use in Cornwall is predominately agricultural (76%) with most of this being grassland over five years maturity.

The data in the table below was compiled in 2003. The current land use situation in Cornwall may be obtained from the analysis of a Geographical Information System. This may also be used to assess the suitability of crops to their sites. The Forestry Commission has information on woodland inventories and aerial photos which would supply a more complete picture of the current situation regarding the availability of land for fuel sources.

The options for growing the crops are either on agricultural land or on the mining ground. The agricultural landowners in the area are mostly small farmers, which may cause issues with regards to sharing machinery. Experience from the ARBRE Project shows that plots smaller than 10 ha are not usually cost-effective.

Type of Land use	Area (ha)	%
Agricultural uses	268,866	76%
grassland >5yrs	138,693	
grassland <5yrs	40,348	
rough grazing	13,486	
crops and fallow	61,491	
farm woodland, other	12,081	
Set Aside	2,767	
Woodland	26,775	8%
coniferous	6,062	
sitka spruce and douglas fir	2,980	

Type of Land use	Area (ha)	%
other conifers	3,082	
broadleaf	20,713	
oak	2,386	
mixed	13,556	
other	4,209	
coppice	562	
Derelict land	12,471	4%
metalliferous spoil heaps	2,207	
excavations and pits	757	
derelict railway land	298	
other	409	
china clay area approx.*	8,800	
Margins (approximate figures)	2,540	1%
useable road margins	540	
hedgerows	2,000	
Urban and other land	44,268	12%
Total land area	354,920	100%

* includes areas with existing planning

Summary

The following are current woodchip suppliers in the local area:

- Forest Fuels Ltd
- Tregothnan Estate Woodlands

The following are looking to supply woodchip in the future:

- Truro Sawmills
- Brookridge Timber

16 F.5 Biomass CHP

Combined Heat and Power (CHP, also cogeneration) is the generation of useful heat and electricity where a turbine or engine is connected to a dynamo to produce electricity while the exhaust heat is used to produce steam and hot water. Capturing the resultant heat from the generation of electricity is a more efficient technology than using large-scale power stations and gas boilers for power and hot water, however CHP is not considered to be a renewable energy source unless fed with a renewable fuel.

Renewable fuels are:

Hydrogen produced through electrolysis of water via a renewable source of power (solar, wind, wave, etc.). Future hydrogen grids are being discussed but are yet to be applied and there is limited opportunity for renewable sources of power on the IPL site.

Bioethanol and biodiesel fuels which are being promoted as transport fuels in the UK. Due to the lack of availability in the UK, but high demand for transport fuels, these are being imported from areas such as Brazil, West Africa and Indonesia. We do not recommend these as a stationary fuel in the long term due to long-term price, availability and sustainability concerns.

Biogas from the anaerobic digestion of organic waste. This process involves the storage and digestion of materials such as organic municipal solid waste, food processing waste, agricultural silage and human effluent. This process is the ultimate approach to local waste treatment, turning waste products into useful energy and fertiliser resources. However, there are few examples of this in the UK and the scale of technology required to provide sufficient biogas would be more appropriate in a rural location than in central Birmingham.

Biomass in the form of woodchips as a result of sustainable forestry management and timber processing industries is readily available in the UK. These sources can be supplemented by locally growing Short Rotation Coppice (Energy Crops) such as Willow and Poplar. In countries such as Austria, Germany, Denmark and Sweden biomass woodchip provides a substantial amount of heating and power needs. Biomass can be used in small domestic boilers but is more commonly used in district heating schemes, sometimes using CHP technology. Biomass is considered as a viable renewable fuel for IPL.

Biomass boilers are a renewable energy source for heating and, using locally sourced biomass, can provide substantial carbon savings. Even greater carbon savings are possible if a biomass CHP system could be used, by providing renewable and efficient power and a source of hot water from the one system.

The technology options for biomass CHP are:

- Steam (Carnot cycle)
- Organic Rankine Cycle
- Gasification

The Carnot cycle is the most common approach to biomass CHP, relying on traditional technologies in the form of direct combustion heating water-tube steam boilers generating high-pressure steam that is passed through a steam turbine. The heat to power ratio of this system is approximately 5 to 1 and the scale of system is usually large. Traditional waste incineration and coal-fired combustion relies on this technology.

The Organic Rankine Cycle uses a heating fluid such as a thermal oil to transfer heat to a steam generator which feeds the steam into a turbine or engine or to a Stirling engine. An example of an ORC has been developed by Talbotts in the UK.

Biomass gasification relies on the thermal degradation of biomass woodchip into gas in the absence of air. The gasification process is a proven concept and is similar to the process of producing towns gas from coal, however past attempts to apply it for small-scale woodchip gas production have not been as successful as hoped.

There are biomass CHP systems in use in Europe but there is minimal operating data available and most of the schemes in operation are in the order of 500kWe and up. While CHP itself is well established, the use of biofuels in CHP schemes presents technical challenges which are being addressed. While there are other technologies under investigation, there are two systems which are currently viable, gasification and direct combustion. Gasification is the conversion of the combustible part in the biofuel into gases (hydrogen, CO, methane, CO_2 and nitrogen) and char by combusting the fuel via a restricted flow of oxygen. The majority of these systems use woodchips as their fuel supply.

Proposed Development

Biomass CHP is still viewed as an unproven technology in the UK, however, the planned installation of several Biomass CHP systems will encourage the reassessment of the viability of this technology in the near future. A district heating scheme would serve to ‘future proof’ the development for the provision of new renewable technologies such as this. This would indicate integration into the district heating schemes of North and South Quay.

16 F.6 Ground Source Heat Pumps

Ground Source Heat Pump is an established technology and can be installed in horizontal trenches or vertical boreholes. Heat pumps upgrade low value energy with the use of electrical power via the refrigeration cycle (Rawlings, R.H.D, 1999). In the case of a closed Ground Source Heat Pump (GSHP) system a water-based solution is pumped through pipes drilled 60 to 100 metres into the ground using the relative warm ground temperature in the winter to provide heating at 40°C to the property. To do this they will require sufficient free underground area. It is not advised to drill the ground loops underneath the building construction, and usually they are positioned within an adjacent car park.

A closed loop system typically provides 20kW of heating for every 100 metre borehole; with each borehole placed 2 metres apart, so to provide a large amount of heating a substantial free area would be required for the ground loops. GSHP systems operate with a performance efficiency of around 300% (ETSU, 2004), due to the use of free energy from the ground. Each property would require roughly one borehole to provide its heating needs.

Alternatively an open-loop system could be used, pending the availability of a large underground aquifer beneath the site. In this case the aquifer would be used as a huge thermal store, balancing the heating demands of the winter with cooling demands of the summer. For maximum efficiency the site annual cooling demand should be matched as near as possible to the annual heat demand.

A heat pump system would be able to supply cooling at temperatures as low as 6°C and heating at temperatures up to 45°C (Rawlings, 1999). This would require the use of low-temperature/high-volume heating systems throughout the development, typically in the form of underfloor circuits. This places a restriction on the future design of heating and cooling systems. Another barrier is the reliance on electrical power to provide heating; this may be an issue in the long-term if electricity prices are predicted to rise.

Proposed Development

GSHPs could be used to provide heat and hot water to houses in Riviere Fields. Heat pumps are best suited for use with low temperature heating systems such as underfloor heating. If radiators were to be used, they would need to be oversized to achieve the required output. An estimated area of 66m^2 per property would be required for installation of a horizontal GSHP system. A ground survey would be required to assess the feasibility of using Ground Source Heat Pumps for the site.

16 F.7 Ground Water and Harbour Cooling

Harbour cooling operates in a similar way to the ground water heat pumps. Heat is extracted from a building by way of a heat pump and rejected into the harbour which acts as the heat sink. This raises the efficiency of the cooling system and requires less energy than conventional cooling systems. Where the water table is high, and a convenient borehole can be drilled, groundwater can be extracted from below the site and used for cooling. The water can then be used to pre-cool ventilation air by passing it through a heat exchanger. The ground water can be recycled as ‘grey-water’ for the building. In a similar way, harbour water could be extracted, filtered and used directly for cooling and grey-water use.

Benefits:

- Ventilation air cooled with no refrigeration system
- Can help to lower local water table
- Provides low energy cooling

Disadvantages

- Requires electrical energy to pump water
- Permission needed to extract water
- Extra mechanical systems to maintain.
- Salt water from the harbour may effect the efficiency and require higher maintenance

Proposed Development

A system that used the ground or harbour water as a natural cooling resource would be very similar in design to a ground source heat pump system. For harbour water cooling the difference would be that a licence would be required from the Environment Agency for extraction and insertion of water from and to the harbour, taking into account potential effects on marine life. In terms of infrastructure the costs may be much lower than for installing a number of boreholes in the ground. There is also no need for in-depth testing for a potentially available resource in the form of an aquifer. If the required licences can be obtained then the capital costs of this alternative cooling method can be much reduced.

Cooling demands should be reduced where possible but ground water cooling could be used in North Quay to meet the cooling demands of the office and hotel areas. A 1MW ground water cooling system would be required to meet the cooling demand.

There will be a need for filtration of the water from the harbour, due to the high levels of salt and silt, before it can be used in a heat exchanger or direct system. The building cooling systems should also be designed as high-volume systems to reduce the need for additional artificial cooling. The harbour water option must also be easy to maintain and resilient to possible water pollution, in the form of oil, waste or chemical spillage.

The harbour water will not provide the operating efficiency benefits of a ground water cooling system. The ground temperature below 10 metres is very stable all year around, generally from 10 to 12°C, whereas the harbour water temperature will vary much more, possibly from 0 to 10°C (EA, 2004).

The availability of permits for harbour water use needs to be investigated further. A more detailed study of potential cooling loads and a cost-benefit analysis of the various cooling technology options will need to be undertaken as the design develops.

The harbour will be refreshed every 6 hours which would allow for continually high efficiencies. A 500kW harbour cooling system could be used in South Quay to meet the demands from the office areas. Harbour cooling could also be considered for areas of North Quay and the landmark building situated on East Quay. Further investigation would be required as to the affect the rise in temperature would have on the ecology of the harbour and possible temperature gradients. Harbour cooling would result in a maximum CO_2 saving of the order of 1-2% of total sitewide emissions.

16 F.8 Energy from Waste

Waste management strategies for buildings should be tailored to the amount and composition of waste that will be generated. If energy from waste is to be incorporated to a building project, the amount and composition of residual waste, i.e. after recycling or composting, needs to be estimated.

The following is a list of potential energy from waste technologies, with a brief description of each that could treat waste generated at the proposed development:

Anaerobic digestion (AD) - Bacterial digestion of wet waste, typically food, green or human wastes, in absence of oxygen. Under such conditions, the organic waste fraction is transformed into biogas composed by 60% methane and 40% carbon dioxide and minor parts of sulphur and other compounds. The bio-gas can be used to fuel gas engine generators or CHP units and the solid and liquid by-products can be used as fertilisers. This process is commonly used as part of sewage treatment process.

Mass burn incineration - Direct combustion of waste to raise steam for electricity generation and reduce volume of waste to landfill. It is widely used and there are many plants in operation all around the world. Highly contentious in terms of opposition from environmental campaigners and local residents Needs extensive air pollution prevention equipment. Capable of handling most feedstocks.

Gasification/pyrolysis - Also known as ‘advanced thermal treatment’. Based on heating of separated non-recyclable waste in partial or total absence of oxygen (gasification and pyrolysis respectively). Gives off a ‘syngas’ which can be cleaned and used to fuel gas engine CHP units. Leaves a residue which can be landfilled or can be hazardous waste depending on specific process. There are many variants of this technology which is relatively common in Germany and Japan. Suited to dry feedstock with high calorific value.

Plasma arc gasification - Other innovative energy from waste technology that lags behind the previous is plasma arc gasification. However, it is commercially unproven. There is some experience though in using it aboard cruises and military ships and there are a few pilot commercial plants operating on municipal solid waste. Because of this, plasma arc technology is not considered any further.

A review of existing reports on the various forms of energy from waste showed that each technology is better suited to a type of waste and that it appears to be a lower limit in the quantities of waste that they require to operate economically as summarised in the next table:

Technology	Minimum throughput (tonnes per annum)	Suitable fuel
Anaerobic digestion	5,000	Organic waste
Gasification/Pyrolysis	30,000	Homogeneous pre-processed waste, e.g. refuse derived fuel
Incineration	60,000	Almost every type of fuel is suitable

According to section 9.5.3 of this report, there will be around 1,800 tonnes per annum of waste generated with around 40% of it being paper and cardboard with the second larger stream being organic and putrescible waste. Nonetheless, the quantities expected of any of the waste streams or their combinations are very low for any commercial energy from waste facility.

Proposed Development:

Consequently, energy from waste should not be considered further for the proposed development alone. Nonetheless, as part of a sustainable waste management strategy, reducing the amount of waste produced and enabling recycling and/or composting should be encouraged. Recycling could be done involving the community with campaigns and providing them with the necessary equipment, e.g. separated bins, appropriate collection services, etc. Home composting systems, or a communal in-vessel system if there is space in the development, could also be proposed.

Despite not being appropriate for the proposed development on its own, energy from waste should be considered, although at larger scales, as reflected in the local and regional strategies.

16 F.19 Geothermal – Hot Dry Rock (HDR)

The concept of Hot Dry Rock was first introduced during the first oil crisis in the early 1970s and still remains an experimental, unproven and expensive means of generating energy. There are few examples of HDR worldwide and no successful schemes within the UK.

The initial assumption on which the concept of HDR is based it that the deep hot crystalline basement rock formations are nearly dry and impermeable to fluids. Water is injected through a borehole into the hot permeable rocks, known as ‘thermal reservoir’ where it circulates absorbing heat from the artificially enlarged fissures in the process. The water would then be brought back to the surface through a second borehole to run steam turbines to generate electrical energy. The steam is produced in a secondary loop at low pressure or by using secondary fluid with a low boiling temperature.

The International Geothermal Association (IGA) estimates that the worldwide electricity generating capacity from geothermal sources is over 8,000MWe producing 50TWh per year with the potential for high temperature geothermal electricity being in the region of 36,600TWh per year (Smith,2003). HDR systems are required to produce a thermal capacity of 10 to 100 MW over a period of 20 years in order to get into the range of economy (Tenzer) with an optimum borehole depth of between 5-10 km. (Smith, 2003) If 0.1% of the heat from the ground were utilised over a 30 year period, the heat power available would be 100MW/km2 (Twidell,1986).

The most obvious use of the energy would be to generate electricity due to its high value. This is attractive only if the temperature is greater than 300°C and is considered unattractive if the temperature of the rock is below 150°C (Twidell, 1986).

The only previous attempt to utilise hot dry rock was carried out by the Camborne School of Mines was a small scale field trial in Rosemanowes in Cornwall which began in 1977 and ran until 1991 with various experiments and phasing which came to a cumulative cost of approximately 38 million pounds. The trial aimed at linking four 300m deep boreholes over a horizontal distance of 40m. A series of explosions were carried out to attempt to improve the permeability of the rock adjacent to the well bore through the creation of new fractures. 2 further boreholes were drilled to a depth of 2km rather than the commercially acceptable 6km. The conditions at 2km depth had no relevance to the conditions at 6km, such as thermal drawdown. Several further boreholes were drilled again to a depth of 2km which created a short circuit in the system. The trial continued to be unsuccessful until it finished in 1991.

The conclusions reached through the trial were that even at this advanced stage in the UK's HDR investigations, the understanding of the underground stimulation and of the engineering techniques required to construct a working underground heat exchanger were inadequate (MacDonald, 1992). The geological environment at 6km depth, the commercially feasible depth, remained purely conjectural and even if a successful HDR system were to be installed in the UK, each subsequent project would carry the same risk of failure due to the large geological variations prevalent in the UK. The main conclusion of the reviewing consultants was that the generation of electrical power from HDR was unlikely to be commercially or technically viable in Cornwall in the short or medium term (MacDonald, 1992). Further review in 1990 concluded that no satisfactory method had been created for an HDR heat exchanger, sealing short circuits, finding reliable information about rock joint and stresses likely to be encountered at 6km depth or for designing HDR power stations which could compete with conventional means. HDR was said to still be at an early stage of development and would not be likely to be viable in the foreseeable future.

Proposed Development:

In order to assess the viability of a HDR system for the proposed development, a full geological study would need to be carried out. This would entail an initial desk study to determine whether the necessary geological conditions are believed to be present in the area of the site. If deemed an area of interest, several on site tests would need to be carried out to further investigate. As is shown through the discussion of the trial by CSM, this is no guarantee of even moderate success. The capital cost and risk of HDR is extremely high and is not viewed to be an option which should be considered any further.

16 F.10 Hydro Power

Tidal power is the capture of the kinetic or potential energy held within the twice-daily ebb and flow of the tides. The amount of energy available for capture depends on the tidal range and the volume of water that can be held at the peak tides. There are two fundamental systems that can be used, and these can vary considerably in scale (Boyle, 2004):

In stream tidal generation

These systems are essentially the same as under-water windmills, and generate power directly from the flow of water as the tide ebbs and flows. There is minimal impact on wildlife, but clearly shipping would need to avoid the structures. This system is being proposed for off-shore or wide estuary locations with large tidal currents

Water capture schemes with turbines

This option involves the capture of water behind a barrier or in an enclosure at high tide, with the use of turbines to generate power when the tide has fallen sufficiently and there is a head to generate from. The largest current schemes are of this form, and involve building a barrage across the whole river, with clear disruption for wildlife and shipping. On a much smaller scale water can be captured in a more modest enclosure, and held back for later use. This is the system used at traditional Tide Mills, as at Woodbridge for example.

Sites with the highest ranges, which is the difference between high and low tide levels, have the greatest potential as a source of tidal energy. Major drawbacks of tidal energy are (Twiddel & Weir, 1986):

The mismatch of the principal lunar driven periods of 12h 25min and 24h 50min with the human (solar) period of 24hrs. This leads to the optimum tidal power generation being out of phase with demand.

The changing tidal range and flow over a two-week period, producing changing power production.

The requirement for large water volume flow at low head, necessitating many specially constructed turbines set in parallel

Very high capital costs

Potential ecological harm and disruption to extensive estuaries or marine regions.

The theory of tidal power is similar to wind power, with the advantage of predictable velocities of a fluid with a density 1000 times greater than air along with the disadvantage of low fluid velocity and an aquatic environment. The total power produced may not be large but generation at competitive prices may be possible for local consumption.

Proposed Development

Due to the listed nature of various structures within the proposed development and the protected status of the many pools on site, one area lends itself to use in this manner, Penpol Creek.

Penpol Creek is anticipated to remain at half tide level which is a range of approximately 3m. The range varies throughout the month from a maximum R_s for spring tides and R_n for neap tides. The mean power produced over a month was calculated using the following equation (Twiddel & Weir, 1986):

$$P_{Month} = \frac{\rho A g}{2\tau} \frac{R_s^2}{8} (3 + 2\alpha + 3\alpha^2)$$

Accordingly, the estimated mean power produced per month by tidal power in Penpol Creek is 8.5 MW.

Another option is the reinstatement of the sluicing structures to Copperhouse Pool and Carnsew Pool which represents the renewal of a significant use of renewable energy on the proposed development site. The use of tidal energy to reduce the requirement for mechanical dredging of the harbour areas is a form of renewable energy not accounted for in CO_2 savings from the site.

There is also the potential to include tidal power generation within the reinstatement of the sluicing structures, this will need further careful investigation to ensure it is compatible with the need to maintain water flow rates and volumes sufficient for sluicing to achieve its primary aim of avoiding sediment build up in the harbour. Proposals for generating power from the pools has been proposed by members of Exeter University. These proposals are not included in the CO2 savings in this scheme due to fears of environmental impacts and uncertainty regarding cost and performance, but will be investigated further at the more detailed design stages.

Technology	Assumptions	Procedure	Reference
For All Areas			
Wind- Large Scale	N/A	N/A	N/A
Wind- Small Scale	To be investigated	To be investigated	N/A
Solar Photovoltaics	14m2 to provide half of annual domestic electrical demand per property	Calculate domestic electrical demand and determine the amount of panels required to meet desired load	The Complete Solar Roof,2006 Solarcentury

Technology	Assumptions	Procedure	Reference
Solar Hot Water	5m2 to provide 60% of domestic hot water per property	Calculate domestic hot water demand and determine the amount of panels required to meet desired load	The Complete Solar Roof,2006 Solarcentury
Biomass	Woodchip boilers as lead, installed as part of district heating scheme	Calculate peak heat load and size the biomass boiler to meet 50% of load	Econergy & Woodenergy
Biomass CHP	Anearobic Digestion. Installed as part of district heating and electricity scheme	Calculate base heat load and size biomass CHP to meet desired load.	CHPA
Ground Source Heat Pumps	COP of 4 for heating, efficiency of 0.9 for electric imersion heating, COP of 15 for free cooling. 180-360kW per abstractio/ discharge well	Calculate peak heat/ cooling load and size the GSHP to meet desired load	Buro Happold calculations
Ground Water & Harbour Cooling	COP of 20 for cooling	Calculate peak cooling load and size to meet desired load. Flow rates and heat gradients to be investigated.	Buro Happold calculations
Energy from Waste	Anearobic Digestion	Establish whether the waste streams for the development would be enough to generate energy efficiently	Buro Happold calculations
Hydro Power from Sluicing	To be investigated	To be investigated	Exeter University
Geothermal (Hot dry rock)	N/A	N/A	Macdonald, 1992

16 G – Energy Strategy Consultation

The following organisations entered into consultation:

- Government Office for the South West

  Date: 19th July 2007

  Contact: Richard Omerod

- Cornwall Sustainable Energy Partnership

  Date: 19th July 2007

  Contact: Will Wason

- South West Regional Development Agency

  Date: 24th July 2007

  Contact: Nick Harrington

  Correspondence: From Nick Harrington, received on the 31st July 2007

  Awaiting feedback from the flowing consultees:

- Hayle Area Plan Partnership

  Contact Date: 31st July 2007

  Contact: Contacted directly

- Cornwall Sustainable Building Trust

  Contact Date: 31st July 2007

  Contact: Contacted directly

- Penwith District Council

  Contact Date: 19th July 2007

References

Penwith DC (2004). *Penwith Local Plan 2004*; Penwith District Council; 2004

Action Energy (1996) *Small-scale Combined Heat and Power for Buildings*. Good Practice Guide 176, Action Energy for the Carbon Trust, London.

Action Energy (2004) *Combined Heat and Power for Buildings*, Good Practice Guide 388, Action Energy for the Carbon Trust, London.

Boyle, G., 2004. *Renewable Energy- Power for a Sustainable Future,* Second Edition, Oxford University Press, Oxford.

CIBSE (1999) *Small-scale Combined Heat and Power for Buildings*. GIBSE Guide AM12, Chartered Institute of Building Services Engineers, London.

CIBSE (2000).*CIBSE Guide H Building control systems*, Chartered Institution of Building Services Engineers

CIBSE (2003).*Down the Tube, Building Services Journal*, Chartered Institution of Building Services Engineers

1. CIBSE (2003b).*Commissioning Code L: Lighting*. Chartered Institution of Building Services Engineers CIBSE

CIBSE (2004).*Energy Efficiency in Buildings*, Chartered Institution of Building Services Engineers.2nd edition.

CIBSE (1999).*Lighting Guide 10 – Daylighting and Window Design*, Chartered Institution of Building Services Engineers

Connect, Greenpeace Spring 2004

EA (2004) *Heat Sources*, International Energy Agency Heat Pump Centre, http://www.heatpumpcentre.org/

Edwards, B. (1999) *Sustainable Architecture,* 2nd Edition. Butterworth-Heinemann Ltd, Oxford.

ETSU (2000) *Heat Pumps in the UK – a monitoring report*, General Information Report 72, ETSU, Harwell, Oxon.

Rawlings, R.H.D. (1999) *Ground Source Heat Pumps – A technology review,* Technical Note 18/99, BSRIA Library, BSRIA, Bracknell.

Scoones, A. (2001) *Renewable Energy in the Built Environment*, The Building Centre Trust, London.

Taylor, D. (2001) Wind Power, in Scoones, A. (2001) *Renewable energy in the built environment*, pp.26-29, The Building Centre Trust, London, UK.

White House Website, US State Department

2. MBS (2006), Lighting that meets the energy-efficiency challenge, Modern Building Services 2006. First Published July 2004. http://www.modbs.co.uk/news/fullstory.php/aid/171/Lighting_that_meets_the_energy-efficiency_challenge.html

Rochas, C. (2004) *The Case for District Heating: 1000 Cities cannot be wrong*, DHCAN, Euroheat, http://www.euroheat.org/workgroup4/KN1531%20DHCAN%20Policy%20Guide.pdf

EST (2002) *The Potential for Community Heating in the UK*, by PB Power for the Energy Saving Trust, London.

DBDH (2004) *News from DBDH*, Journal number 2/2004, Danish Board of District Heating, Taastrup, Denmark.

Edwards, B. (1999) *Sustainable Architecture*, 2nd Edition. Butterworth-Heinemann Ltd, Oxford.

Taylor, D. (2001) Wind Power, in Scoones, A. (2001) *Renewable energy in the built environment*, pp.26-29, The Building Centre Trust, London, UK.

Boyle,G., 2004. *Renewable Energy- Power for a Sustainable Future*, Second Edition, Oxford University Press, Oxford.

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