

elementenergy

**EAST OF EXETER NEW
GROWTH POINT**

Energy Strategy

Final Report

for

East of Exeter New Growth Point
Delivery Team

21st July 2008

Project No: 602

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Glossary

CHP	Combined Heat and Power
COP	Coefficient of Performance
CSH	Code for Sustainable Homes
DH	District Heating (network / system)
District energy systems	Energy infrastructures linking groups of buildings on a single site
DNO	Distribution Network Operator
EEDNGP	Exeter and East Devon New Growth Point
EEDNGPDP	Exeter and East Devon New Growth Point Development Plan
EFW	Energy From Waste
EOENGP	East of Exeter New Growth Point
GSHP	Ground Source Heat Pump
IDNO	Independent Distribution Network Operator
IMFF	Inter Modal Freight Facility
JAAP	Joint Area Action Plan
Microgeneration	Small distributed energy technologies, often residential scale
NPV	Net Present Value
ORC	Organic Rankine Cycle
PV	Photovoltaics
RE4D	Renewable Energy 4 Devon
RES	Renewable Energy Systems
RIF	Regional Infrastructure Fund
RNSD	Royal Naval Stores Depot
RO	Renewables Obligation
ROC	Renewable Obligation Certificate
RSS	Regional Spatial Strategy (for South West England)
SAP	Standard Assessment Procedure
Site wide energy systems	Energy infrastructures linking groups of buildings on a single site
SWH	Solar Water Heating

1 EXECUTIVE SUMMARY

In November 2007 the East of Exeter Projects Team commissioned Element Energy to undertake a strategic analysis of CO₂ emissions from the new developments in East of Exeter Growth Point over the period to 2020. Over the same period, new national policy (such as the Code for Sustainable Homes, CSH) requires a significant reduction in CO₂ emitted from new buildings. This will necessitate significant improvement in building design, combined with the use of microgeneration technologies (such as solar photovoltaics, heat pumps and micro wind) and distributed generation technologies (such as district heating and combined heat and power).

The analysis predicts that building fabric performance improvements will result from the application of tighter CO₂ targets. This is because a basic set of fabric performance improvement measures is a relatively cost effective way of reducing energy consumption and CO₂ emissions and would allow houses to get to CSH level 3 without requiring microgeneration. Improving building fabric performance measures now would “futureproof” building designs against all but the highest code level. Legislating for code 3 compliance mainly through fabric measures would pay dividends by putting in place a good construction standard that need not change for some time to come.

Two distinct approaches to reducing carbon are a) treating each building individually (building by building approach), and b) using “site wide” systems, where energy is generated at a central point on site and distributed to end users via a district energy (heating and/or electricity) system.

Large sites across the Growth Point requiring intermediate carbon reductions (level 4 and above) will be most cost effectively served by site wide district heating; at higher code levels, this would be augmented with biomass CHP.

In the city-centre, district heating systems are ill-suited to the (typically smaller scale) developments. Here, a building-by-building approach to CO₂ reduction represents an upper-bound on cost. The City Council will need to ensure that all options for reducing costs are explored, such as connection to shared heating systems.

For the great majority of dwellings, the highest code level (level 6 – carbon free homes) can only be achieved with site energy/heating systems.

The higher heat densities at commercial developments such as the Science Park and Skypark means that site energy systems are predicted to be much more cost effective than microgeneration or renewable technologies in achieving significant CO₂ emission reductions.

The analysis shows that district heating is a key strategic technology for large developments in the Growth Point, enabling significant CO₂ reductions at lowest cost. A district heating system is not currently planned for the first phase of development at Cranbrook. Early investment in a district heating network will benefit the economics of future phases of Cranbrook.

While district energy systems show improved economics (relative to other means of achieving carbon reductions such as microgeneration technologies) their implementation is still a challenge. Capital costs are high (particularly for heat distribution networks); there is a risk of stranded assets if development plans are delayed, coordination of multi-developer sites is complex and there is a requirement for ongoing maintenance and management of energy systems.

Energy from waste, using advanced technologies could be a strategically important renewable resource. Gate fees from inbound waste make EfW systems economical. Locating an EfW plant adjacent to a significant heat demand will improve plant environmental performance and

economics. A specific opportunity would include an EfW plant at the Intermodal Freight Facility serving the heat demands of adjacent commercial developments.

Initial screening suggests that there is little scope for large (multi MW) wind systems (which can be amongst the most cost effective CO₂ reduction technologies). More detailed analysis is needed to confirm this conclusion.

Private wire systems can help improve the economics of CHP/district energy systems and in some sites this enhancement can make an important difference. However, the improvement is not so significant that it should be viewed as an enabling technology, or one with the strategic importance of district heating systems.

In summary, the variety of sites and the dispersion across the Growth Point means that there is not a single low carbon energy solution. While adjacent sites can share solutions, overall the development areas are too separate to benefit from integrated heat distribution networks. Electricity distribution among non-adjacent sites is most cost effectively achieved through existing grid infrastructure.

The key recommendations identified are:

1) Early adoption of Code for Sustainable Homes

The analysis shows that a basic set of improvements to building fabric is a relatively cost effective means of carbon reduction. Furthermore, the same set of measures still form part of the solution for all carbon reduction targets through to zero carbon (Code for Sustainable Homes Level 6).

Improving building fabric performance measures now would “futureproof” building designs against all but the highest code level. Legislating for code 3 compliance mainly through fabric measures would pay dividends by putting in place a good construction standard that need not change for some time to come, despite changes in national legislation.

2) Site energy systems

The analysis shows that district heating systems are (by a large margin) the least costly means of achieving significant carbon reductions (i.e. above Code 4). With the exception of development within Exeter city centre, policies should be developed to require all developments in the Growth Point to develop district heating systems to supply low carbon energy to end users.

It is recommended that the Regional Infrastructure Fund is used to provide the required cash flow for the development of a district heating infrastructure for the higher heat density town centre area of Cranbrook. Also, the Growth Point / developers should open discussions with utilities / ESCo’s to understand how they may be able assist in the development and maintenance of site energy systems.

3) A dedicated low carbon strategy for Exeter “City Centre” and “Rest of City” developments

Parts of the Growth Point where smaller pockets of development will occur are not suited to dedicated site wide energy systems that are applicable at larger sites. The development of a Sustainable Planning Guide targeted at smaller city centre type developments is recommended covering building based technologies, the connecting to existing supply systems, or using a new development as a catalyst to bring together and supply a number of existing heat users.

4) District heating networks at commercial sites

The higher heat densities of the commercial sites in the Growth Point result in better economic viability for district energy systems. It is recommended that district heating should be made a requirement for large commercial developments such as the Science Park and Sky Park. Further CO₂ reductions could be achieved through use of biomass or waste streams and the feasibility of using these should be examined.

5) An electricity system (private wire) linking the Sky Park and IMFF

The analysis shows that private wire system linking site energy systems at the Skypark and IMFF could improve the economics of these site energy systems. Any study examining the feasibility of district energy systems at commercial developments should include the beneficial aspects of private wire.

6) Energy from waste

An energy from waste facility in the Growth Point is likely to be economically viable and an important source of low carbon energy. The amendment to the Renewables Obligation and the increasing cost of landfill (high gate fees) combine to make advanced energy from waste plants a commercial proposition. However, there is some uncertainty surrounding availability of waste resource in the area and also the commercial readiness of the advanced conversion technologies (pyrolysis/gasification).

Further investigation a small energy from waste plant in the Growth Point, linked to a community or site energy system is required. This would comprise a detailed study into waste resource availability (focussed on commercial and industrial arisings) and the commercial readiness (bankability) and economics of small advanced treatment technologies.

7) Further work on large wind in the Growth Point

Large wind (MW scale) energy systems are predicted to be amongst the most economic means of reducing carbon emissions. Therefore large wind is a strategically important low carbon technology. However initial screening suggests that there are few (if any) suitable sites in the Growth Point. A detailed study to assess the potential for the installation of large scale wind turbines proximal to Exeter Airport is needed to confirm this.

8) Biomass supply chains

The most cost-effective means of meeting high Code for Sustainable Homes levels and meeting regional policy for renewable contribution to commercial developments is site-wide, biomass fuelled CHP systems. This will require substantial biomass resource. The woodfuel resource in the South West is sufficient, but the amount of woodland within proximity to the Growth Point is quite limited. Mapping exercises performed by the Renewable Energy 4 Devon (RE4D) and as part of the REvision 2020 exercise has identified significant potential for energy crops (particularly miscanthus).

The Growth Point needs to encourage the growth of biomass supply chains in the surrounding area. Consultations should be initiated with the Regen SW Bioheat programme, RE4D, BiCAL, the Forestry Commission, South West Wood fuel and local farmers & landowners, to discuss ways to generate a sustainable biomass supply in the area.

2 INTRODUCTION

The Exeter and East Devon New Growth Point (EEDNGP) identifies a number of locations for new residential developments and business parks in order to satisfy ambitious regional targets for new homes and employment. The significant scale of these developments has prompted serious consideration of how to measure and moderate their energy demands and their emissions of greenhouse gases.

This document addresses these concerns by estimating the CO₂ emissions from buildings in a “business as usual” approach to development, and identifying the impact of policies and technologies which would reduce emissions. Using this evidence base, the report develops a coherent and costed strategy to limit the energy demand and mitigate the environmental impact of these developments.

A bottom-up approach is adopted, as this provides the strongest evidence base upon which to develop a strategy. The main stages in the analysis are summarised below:

Calculating the baseline emissions for each site:

- For each of the sites in the Growth Point, identify the likely mixture of flats, houses, commercial developments, offices etc. that will be built out to 2020.
- Identify the build rate over the programme for the developments (the period to 2020 is of particular interest as it is in this period that low carbon building regulation is expected to be implemented)
- Develop a standard energy model for each of these developments, and adjust as required to ensure compliance with relevant regional or national energy legislation (i.e. Code for Sustainable Homes)¹.

Identify technologies leading to lowest cost compliance for each building type

- From a range of energy efficiency measures (such as increased insulation); microgeneration technologies (such as photovoltaics or solar water heaters) and site energy technologies (Combined Heat and Power and District Heating); identify the lowest cost means of compliance with regulation².
- Develop a route map showing the lowest cost means of compliance with energy legislation to 2020.

Develop scenarios for CO₂ reduction and cost implications

- Define scenarios for more extensive CO₂ reductions.
- Define their performance in terms of predicted annual CO₂ savings.
- Estimate the cost of these relative to the regulatory baseline.

Examine the role of Growth Point energy systems

- The potential role of multi-site energy systems, such as private wire or extended district heating systems is examined.
- The potential role of a locally sourced waste to energy resource, is also investigated.

¹ On 1st May 2008 the government launched a mandatory rating standard for new homes, the Code for Sustainable Homes (CSH). The code measures the sustainability of new home designs and gives each a 1-6 star rating. The draft Regional Spatial Strategy for the Government Office of the South West considers an accelerated timetable for the introduction of the CSH

² The CSH addresses a range of issues related to sustainability, one of which is energy and CO₂ emissions from dwellings in use. This analysis reports on projected costs for meeting the CO₂ emissions target of the code, and not costs related to other aspects of the code such as water, emissions during construction, etc.

3 EAST OF EXETER DEVELOPMENT PLAN

Exeter is a Principal Urban Area designated for development in the Way Ahead document³, the Sustainable Communities Plan for the South West⁴ and in the draft Regional Spatial Strategy⁵. It is economically important in the South West as one of the fastest growing economic centres, a hub of the Exeter and Heart of Devon economic spatial strategy⁶ and pivotal in transport and economic connections in the South West. The development and growth of Exeter (and the surrounding areas) is central to the government's domestic and economic plans for the South West region and in ameliorating the need for affordable housing and jobs in a growing Exeter (affordability of housing in Exeter is the second worst in Britain behind London).

To keep pace with Exeter's growth, proposals have been tabled for an additional 18,500 homes in the sub-region by 2026. This domestic growth will be supported by accelerated take up of employment land (and associated job creation. Developments in improved transport infrastructure, public amenities and business office space will also be essential.

Although extensive domestic development is planned for Exeter City itself, the tight borders of the city dictate that much of the development proposed in the local Growth Point Delivery Plan (EEDNGPDP⁷) will occur to the east of the city. The proposed developments can be split into those situated to the east and those situated to the west of the M5 motorway. The planned developments and their spatial relationships are highlighted in the following aerial views.

³ The Way Ahead: Delivering Sustainable Communities in the South West: http://southwest-ra.gov.uk/media/SWRA/Housing/The_Way_Ahead_Delivering_Sustainable_Communities_in_the_SW.pdf

⁴ Sustainable Communities in the South West: <http://www.communities.gov.uk/documents/communities/pdf/144035>

⁵ The draft Regional Spatial Strategy envisages 6,500 dwellings (<http://www.southwest-ra.gov.uk/media/SWRA/RSS%20Documents/Final%20Draft/drafttrssfull.pdf>)

⁶ http://www.exeter.gov.uk/media/doc/c/2/Exec_Summary_EHODEP_EDS_April_2005_1.doc

⁷ Exeter and East Devon New Growth Point Delivery Plan

http://www.eastdevon.gov.uk/index/your_council/councillors_and_meetings/committee_minutes_and_agendas/eb_311007_item12app2.pdf

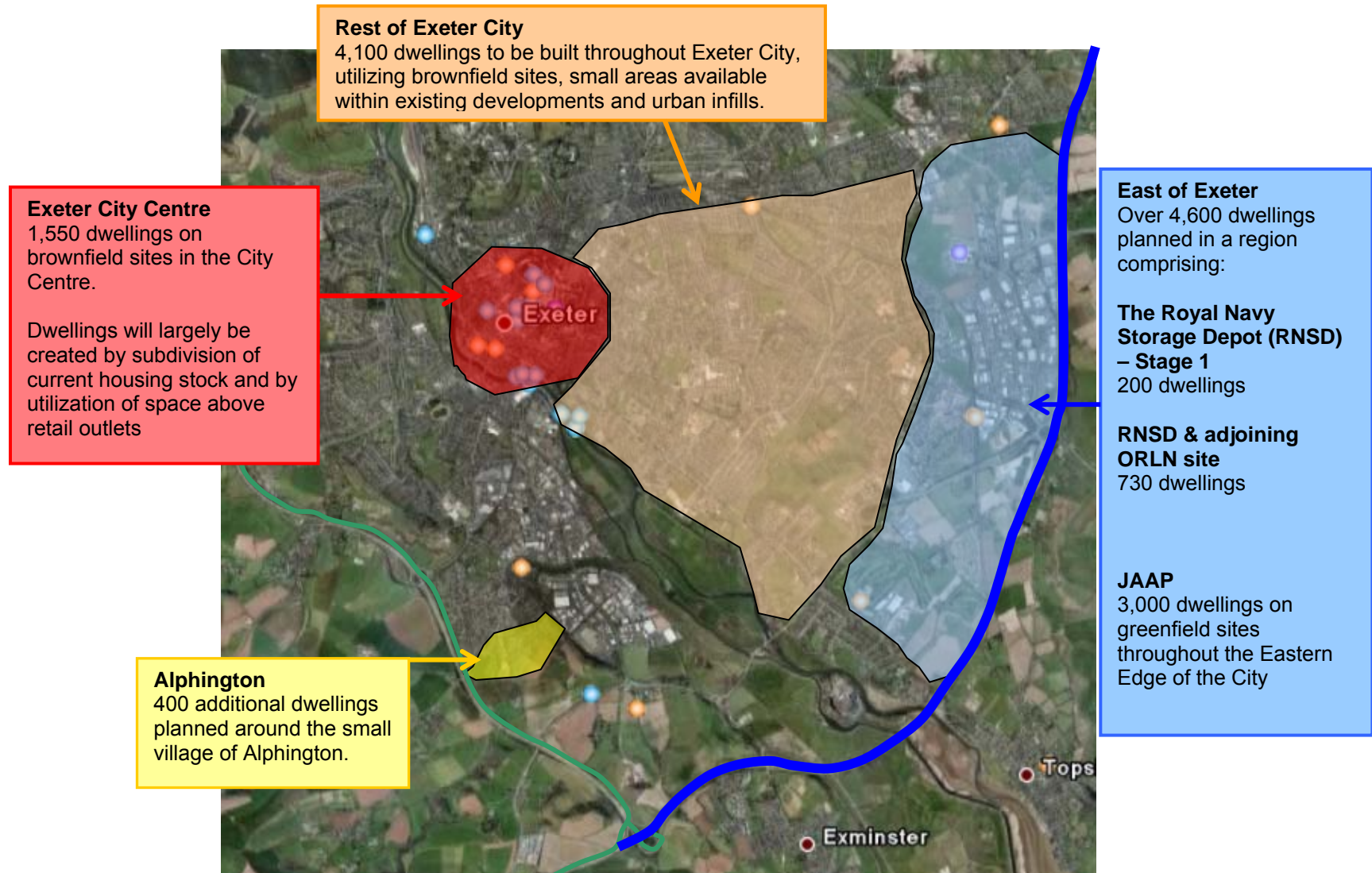


Figure 1, Major residential development areas to the West of the M5, in and around Exeter city centre.

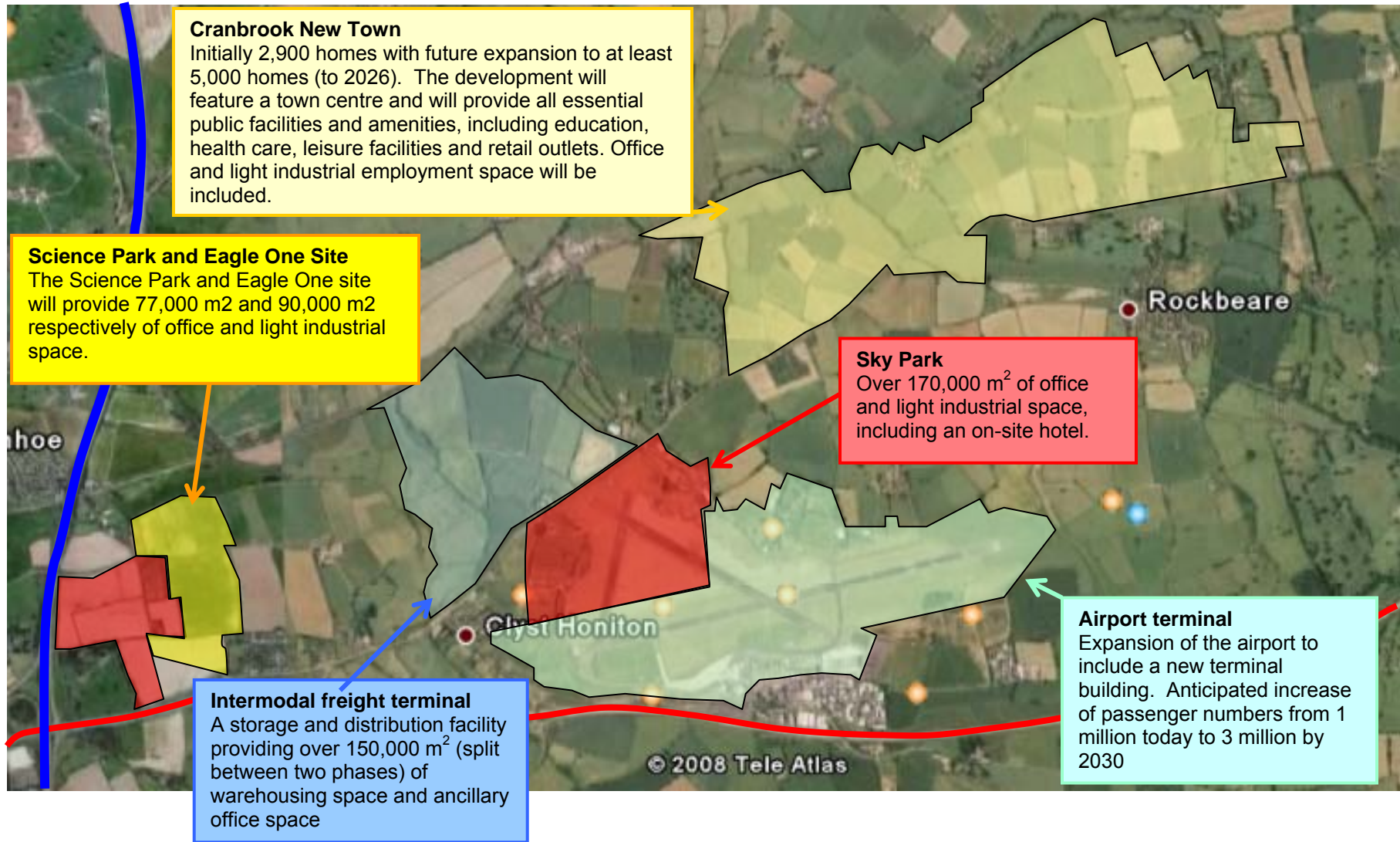


Figure 2, Major development areas to the East of the M5. The area includes large commercial developments and the Cranbrook New Community.

3.1 The nature of the Exeter and East Devon developments

When considering the potential and viability of low carbon strategies for a number of extended developments, it is essential to consider the siting, nature and build date of the sites. Comprehensive data on the following is required:

3.1.1 Geography

There are two important aspects to consider:

- The locations of the developments' footprints on the ground and their relative position with respect to each other.

This data is vital when considering the possibility of using a low carbon strategy linking development sites e.g. a CHP system with a district heating network.

- The master-plan of a development.

Master plans contain information on residential site dwelling density and data relating to the exact land use of any planned non-residential development. This data is essential when assessing the viability of district heating systems. For some sites, master-plan information is not yet available. However, where this data is available, it indicates that residential developments are likely to be built at a density of circa 40 dwellings per hectare.

3.1.2 Development nature

The East of Exeter New Growth Point is comprised of a number of largely residential developments, particularly to the West of the M5, and significant employment provision to the east and west of the motorway. The Cranbrook New Community stands apart as a development comprising a substantial mixed-use area.

Determining the land use for non-residential sites:

Different land uses can lead to entirely different energy demands and in turn widely varying levels of CO₂ emissions. As such, it is important to assign the land uses on a non-residential site as accurately as possible.

Data regarding non-residential land use was available from the EEDNGPDP for the non-residential developments planned. Projections of energy consumption and in turn CO₂ emissions for these sites can then be made using standard benchmark data.

Determining the housing breakdown for residential sites:

Different types and sizes of dwelling have different heating and electricity demands. As such, it is essential to determine the fractions of different dwelling types and sizes on a site as accurately as possible.

For certain developments master planning data detailing the housing mix was obtained⁸. In those cases where master-planning data was not available, projections of the housing mix have been

⁸ Private communication, Exeter City Council planning department

derived based on information supplied by Exeter City Council⁹ and using the aspirational targets for affordable and market price housing contained within the Exeter and Torbay Strategic Housing Market Assessment¹⁰.

The housing mix provided or estimated for each of the residential developments is summarized in Figure 3.

Development	Houses				Flats			
	2b	3b	4b	5b	1b	2b	3b	4b
Cranbrook	20%	8%	4%	4%	28%	26%	10%	0%
Alphington	34%	39%	10%	18%	0%	0%	0%	0%
Exeter city centre	0%	0%	0%	0%	34%	39%	10%	18%
RNSD	16%	22%	33%	0%	14%	15%	0%	0%
RNSD + ORLN	16%	22%	33%	0%	14%	15%	0%	0%
JAAP	16%	22%	33%	0%	14%	15%	0%	0%
Rest of Exeter City	0%	0%	0%	0%	34%	39%	10%	18%

Figure 3, Dwelling breakdown (by type and size) for the residential developments under the EEDNGPDP. For clarity, only the main house/flat types are shown.

3.1.3 Development phasing

Having accurate phasing data for the new build developments is essential, as heating and electricity loads increase as and when new properties are built and/or populated. The time at which a residential property is built also determines which CO₂ emissions benchmark the property must adhere to under the Code for Sustainable Homes. This in turn impacts on the cumulative baseline energy demands of a residential development with respect to time.

3.1.3.1 Residential phasing

The phasing for the residential sites in and around Exeter was reconstructed (where possible) from the EEDNGPDP. There was insufficient information to allow accurate reconstruction of the phasing of the planned Urban Capacity Study sites and the sites denoted as currently having planning permission. For these developments (west of the M5) the rate of development was assumed to be essentially linear to 2025.

The phasing of the residential developments is summarised below:

⁹ communication with Exeter City Council planning department.

¹⁰ Exeter and Torbay Strategic Housing Market Assessment 2007 - http://www.dshg.org.uk/2007_07_17_main_report_-_front_cover_and_index.pdf

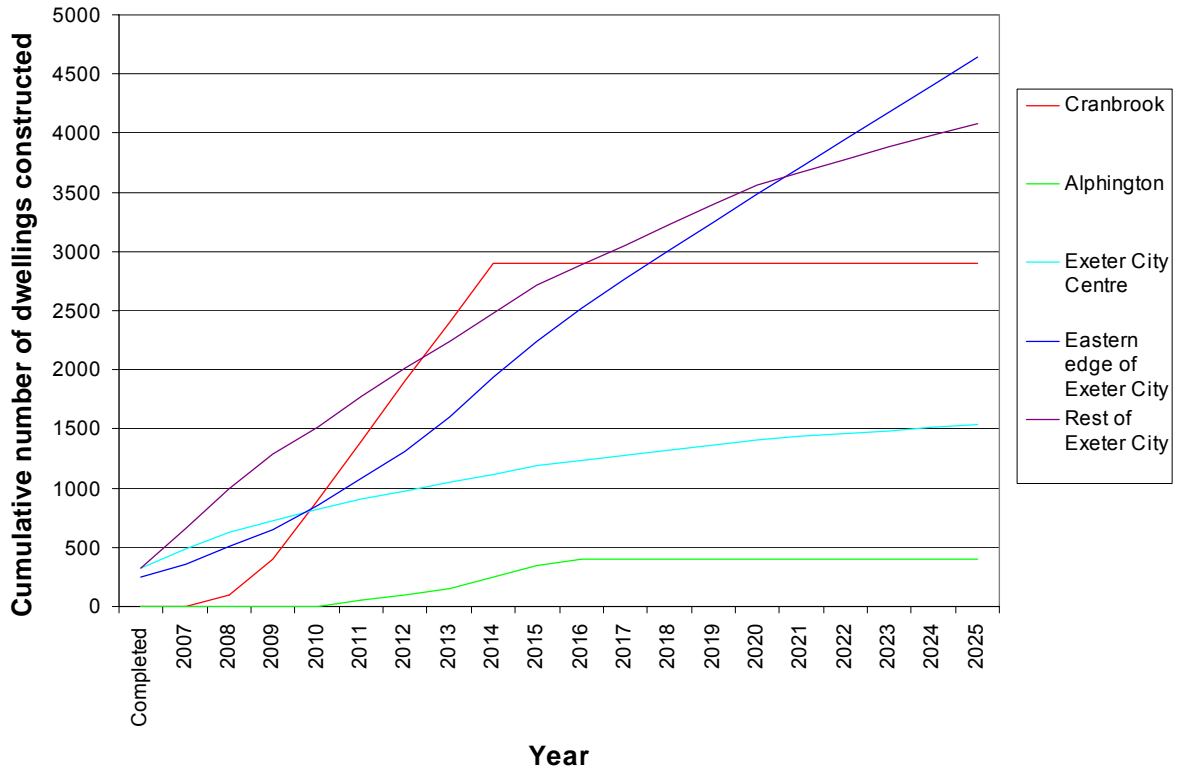


Figure 4, residential construction rates under the EEDNGPDP. N.B. The Cranbrook and Eastern edge of Exeter City developments can be split further into their sub-developments.

The overall residential build rate under the EEDNGPDP is as follows:

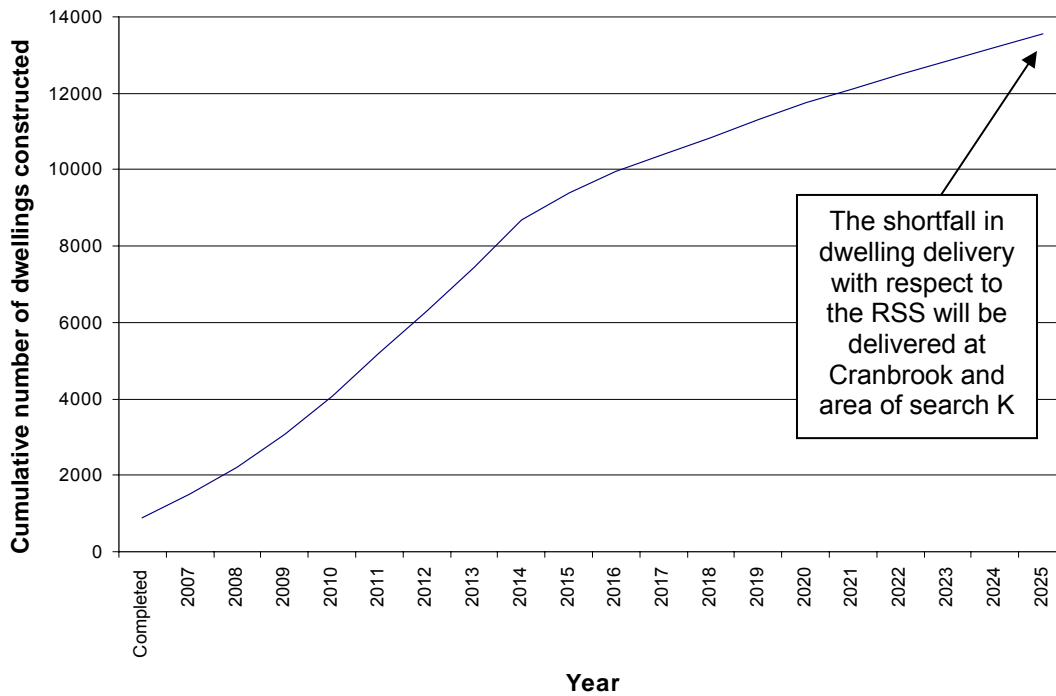


Figure 5, overall residential dwelling construction rate for the developments under the EEDNGPDP.

3.1.3.2 Non-residential phasing

Virtually all the non-residential development planned is located to the east of the M5 motorway e.g. non-residential developments at Cranbrook, the IMFF etc. The phasing and nature of these developments is discussed in their individual energy strategy analyses (see section 6).

3.2 Low carbon policy

The build rates presented above are an important component in setting the baseline energy demand and CO₂ emissions. Relevant national (and regional) legislation in place at the time of construction will form the energy / CO₂ baseline and these are discussed below.

3.2.1 National policy background

The government is currently structuring a policy framework that is intended to guide the construction industry towards the ultimate goal of zero carbon developments. In the case of residential developments, this has been formalized through the Code for Sustainable Homes¹¹. The Code sets out a system to rate the sustainability of dwellings against a range of metrics, of which energy use and CO₂ emissions is a key factor (see Figure 7). Increasing code levels will become mandatory standards through tightening of the building regulations on a timetable set out in the Department of Communities and Local Government policy document ‘Building a Greener Future – Towards Zero Carbon Developments’¹². The anticipated timescale for mandatory introduction of the Code levels is tabulated in Figure 6.

	2010	2013	2016
Minimum acceptable CO₂ reduction compared to Part L 2006 baseline	25% of regulated emissions	44% of regulated emissions	100% of total emissions*
Equivalent carbon standard in the Code	Level 3	Level 4	Level 6

* Level 6 corresponds to zero carbon in relation to all energy use within the home, i.e. both regulated emissions (heating, lighting ventilation) and emissions such as those related to cooking and appliances.

Figure 6, Anticipated timetable for introduction of Code for Sustainable Homes equivalent CO₂ reductions through tightening of the Building Regulations.

¹¹ ‘Code for Sustainable Homes – a step-change in sustainable home building practice’, December 2006, http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

¹² ‘Building a Greener Future: Towards zero carbon development’, 8 March 2007, www.communities.gov.uk/archived/publications/planningandbuilding/buildinggreener

Code for sustainable homes



The code for sustainable homes is a single national standard to guide industry in the design and construction of sustainable homes. The standards associated with the code are to be introduced incrementally over the next decade, culminating in the design of houses that are net zero carbon.

The code rates the sustainability of houses from 1 to 6 based on performance in a number of categories. Points are awarded for performance in each category and for each code level there is a minimum total points threshold that must be reached to achieve that code rating. In some categories there are minimum standards that must be met to achieve a certain code rating, whereas in other categories there are no minimum standards, leaving the developer greater flexibility on where to concentrate efforts to accumulate points. In all there are 9 different categories, as tabulated below:

Categories	Flexibility
<ul style="list-style-type: none"> • Energy • Water 	Minimum standards
<ul style="list-style-type: none"> • Materials • Surface water run-off • Waste 	Minimum standards at Code entry level
<ul style="list-style-type: none"> • Pollution • Health & well-being • Management • Ecology 	No minimum standards

Energy is one of the categories that has minimum standards that must be achieved for each code rating. These standards are expressed in terms of improvement of the dwellings CO₂ emissions compared to Part L (2006).

The percentage emissions improvements required to achieve the various code levels are tabulated below:

Code Level	Minimum Standard % Improvement on Part L (2006)	
1	10	 <p>% reduction of emissions relating to regulated emissions (i.e. heating, lighting and ventilation)</p>
2	18	
3	25	
4	44	
5	100	
6	A net zero carbon home	 <p>Net zero CO₂ with respect to all emissions relating to energy use in the home (i.e. including all appliances, cooking etc)</p>

Attainment of Code Level 5 requires the elimination of all emissions associated with the use of heating fuel and electrical use for lighting, heating and ventilation. However, CO₂ emissions relating to the electrical consumption of appliances are allowed.

Only for Code Level 6 must all CO₂ emissions from the home, including electrical appliances and cooking, be eliminated. Code level 6 also stipulates that the heat loss parameter of the building fabric itself should not exceed 0.8W/m²K.

Figure 7, Brief summary of the key requirements of the Code for Sustainable Homes with respect to energy and CO₂ reduction targets.

Prior to the 2010 amendment to the Building Regulations, it will be mandatory for all new dwellings to have a code rating, although it will not be mandatory to achieve any particular level. Still it is expected that this will incentivise developers to build to an increased standard of sustainability.

Policy on non-residential developments is less well developed, however in the 2008 budget the government announced an ambition to reach zero carbon standard in all new non-domestic buildings by 2019¹³. In the near-term the principle driver for low carbon non-residential development will be a revised version of BREEAM, planned to be introduced in 2008. BREEAM 2008 will include a new level of 'Outstanding' and will set mandatory standards for CO₂ reduction for higher ratings to be achieved. It is expected that the revised BREEAM will be a pre-cursor to a Code for Sustainable Non-domestic Buildings.

Planning Policy Statement 1 (PPS1: Delivering Sustainable Development) sets-out the government's overarching policies on delivering sustainability through the planning system. The recent 'Planning and Climate Change' supplement to PPS1 sets out the instrumental role that local authorities are to play in shaping energy supply and sustainable development in their area through their regional spatial strategies. The policy shifts the focus from purely on-site renewables (i.e. the previous 'Merton Rule' approach) to renewables and low carbon energy with emphasis on the potential role of energy networks and neighbourhood scale decentralized energy sources.

3.2.2 Regional low carbon policy

The draft Regional Spatial Strategy for the South West¹⁴ sets an accelerated timescale for reducing carbon emissions from new developments in the area compared to national policy. This more aggressive approach is implemented through two proposed policies – Policy G on zero carbon development and Policy RE5 on required reduction of carbon emission through renewable energy. The evidence base on which this accelerated approach is justified is a substantial report¹⁵ on the cost implications and technical feasibility of delivering low and zero carbon developments in the region.

The requirements for minimum CO₂ reduction and on-site renewable contribution stipulated by these two policies are tabulated in *Figure 8*. Achieving these CO₂ reduction policies sets the framework within which energy strategies for the EEDNGPDP must be developed.

3.2.3 Carbon saving

The impact of the CO₂ reduction policies defined within the Regional Spatial Strategy on the emissions from the new developments in the EEDNGPDP is shown in *Figure 9*. The figure compares the projected emissions in a Business as Usual case (building regulations standards), with emissions where the Regional Spatial Strategy policies are implemented.

The overall impact of the policies is approximately a one-third reduction in the CO₂ emissions attributable to the EEDNGPDP, compared to a business-as-usual scenario

¹³ 'Budget 2008', 12 March 2008, www.hm-treasury.gov.uk/media/4/7/bud08_chapter6.pdf

¹⁴ 'The Draft Regional Spatial Strategy for the South West', http://www.southwest-ra.gov.uk/nqcontent.cfm?a_id=836

¹⁵ 'Supporting and delivering zero carbon development on the South West', Faber Maunsell and Peter Capener, January 2007

Residential developments

Date	Scale of Development	Level of the Code for Sustainable Homes	Of Which, Minimum Requirements for On-Site CO2 Reduction Required Beyond Requirement of Part L BR 2006	Of Which, Minimum On- Site Renewables Required to Meet Policy RE5
		To meet requirements of Development Policy G		To meet requirement of Policy RE5
2008-2010	Residential, 10 or more dwellings	Level 4	44% regulated emissions (44% of 2006 TER)	20% regulated emissions (20% of 2006 TER)
2011-2015	Residential, 10 or more dwellings	Level 5	100% regulated emissions (100% of 2006 TER)	
2016 on	Residential: 10 to 50 dwellings	Level 5	100% regulated emissions (100% of 2006 TER)	
	Residential: > 50 dwellings	Level 6	100% total emissions	

Non residential developments

Date	Scale of Development	Minimum Requirements for On-Site CO2 Reduction Required Beyond Requirement of Part L BR 2006 to Meet Development Policy G	Of Which, Minimum Onsite Renewables Required to Meet Policy RE5
2008-2010	Non residential > 1000m ²	25% regulated emissions (25% of 2006 TER)	20% regulated emissions (20% of 2006 TER)
2011-2015	Non residential > 1000m ²	34% regulated emissions (34% of 2006 TER ¹)	
2016 on	Non residential > 1000m ²	44% regulated emissions (44% of 2006 TER)	

Figure 8, Summary of the Draft South West Regional Spatial Strategy policies on low carbon buildings and renewable energy contributions in residential and non-residential buildings.

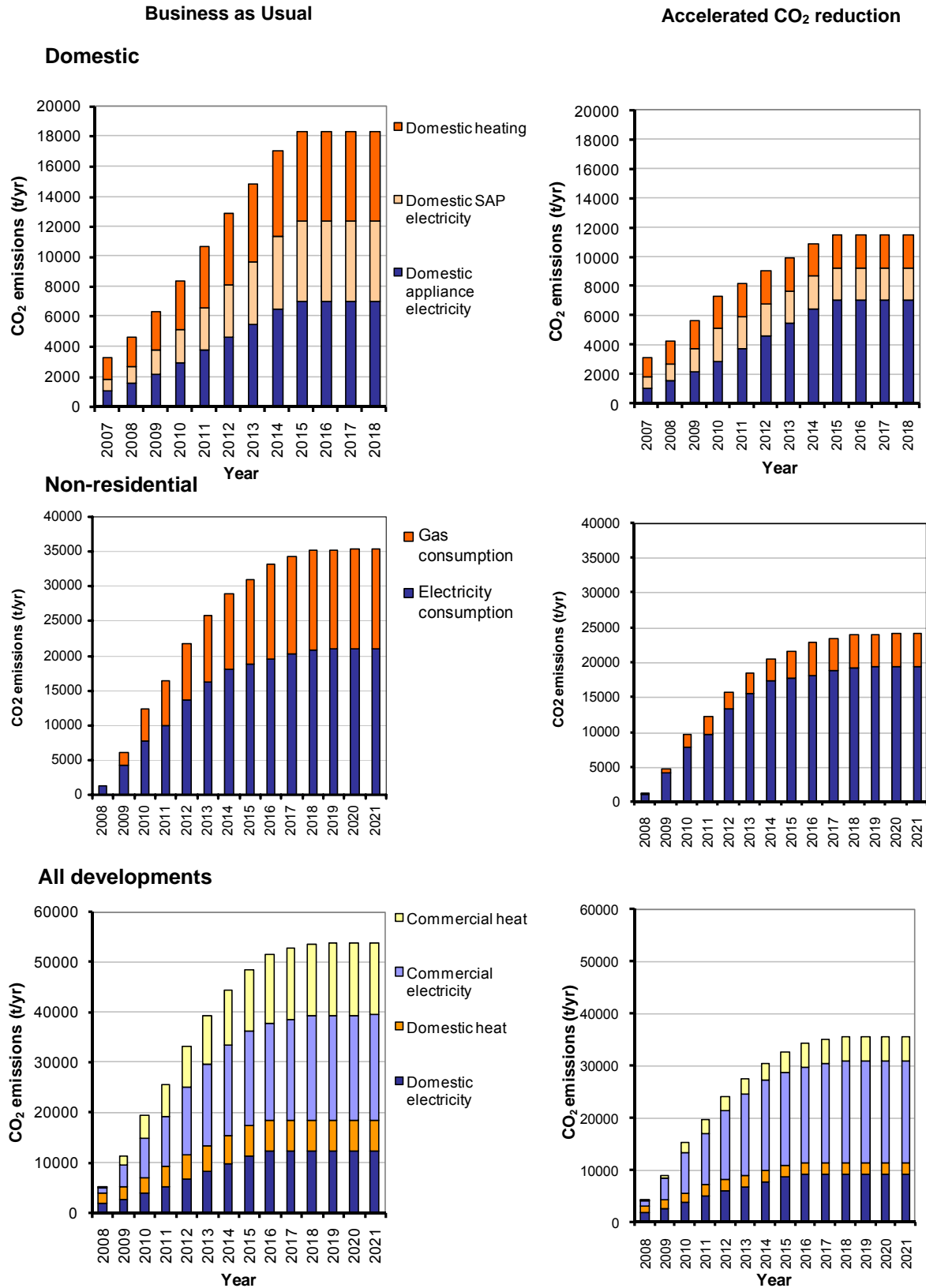


Figure 9, Impact of the Draft RSS policies on CO₂ reduction on the emissions from the EEDNGP developments compared to adherence to anticipated government policy.

Summary

- The Draft RSS has set aggressive targets for carbon reduction and renewable energy contribution from new developments in the region, which are in advance of anticipated government legislation.
- Under a business-as-usual scenario (all developments in line with government legislation) the annual emissions will be in excess of 50 ktpa, once fully occupied. Enforcement of Draft RSS policy will reduce the CO₂ impact by around one-third to c.35 ktpa.
- In this document, unless otherwise stated, the business-as-usual emissions (assuming CO₂ reductions in line with anticipated government legislation) is the baseline against which the efficacy of energy strategies are measured.

4 CRANBROOK ENERGY ASSESSMENT

4.1 Baseline energy consumption and emissions

In the first instance, the Cranbrook New Community has been considered as a settlement of 2,900 dwellings together with some employment and community space. The intention of the Regional Spatial Strategy for Cranbrook to be extended to provide 6,500 to 7,500 dwellings is recognised in this document and the implications of this for the energy strategy are discussed in Section 4.5.

A projection of the energy consumption of the Cranbrook development has been made, based on the assumption that the 2,900 dwellings are built to Code for Sustainable Homes Level 3 standards and that non-residential buildings are built to the best practice standards, as identified in the Richard Hodkinson Sustainability Strategy¹⁶. The heating fuel and electricity consumption for each building sector are tabulated below.

Sector	Net Area (m ²)	Heating & Hot Water (MWh/yr)	Electricity (MWh/yr)
Light industrial	5,500	825	396
Leisure (gym)	400	86	30
Schools	12,672	142.2	304
Hotel	2,000	480	160
Offices	12,000	1,200	1,440
Small retail	2,700	136.5	292.5
Supermarket	4,000	800	3,600
Community facility	3,230	494.4	301.6
Hospitality	650	715	422.5
Domestic	248,240	12,930	10,127
TOTAL		19,690	17,074

Figure 10, breakdown of development areas and associated projected energy consumption for the Cranbrook development. All dwellings are taken to be constructed to Code for Sustainable Homes Level 3 standard.

The associated CO₂ emissions are tabulated below, assuming that heating is provided by natural gas. The CO₂ intensity of natural gas is 0.19kg/kWh, that of grid electricity is 0.42kg/kWh.

Sector	Natural gas CO ₂ (tCO ₂ /yr)	Electricity CO ₂ (tCO ₂ /yr)	TOTAL (tCO ₂ /yr)
Non-domestic	1,284	2,932	4,216
Domestic	2,457	4,274	6,731
TOTAL (tCO₂/yr)	3,741	7,206	10,947

Figure 11, Estimation of CO₂ emissions from Cranbrook assuming conventional energy services (natural gas-fired condensing boilers and grid electricity).

¹⁶ Sustainability Strategy Rev 16, Richard Hodkinson, October 2007

The existing Sustainability Strategy for the site recommends that biomass is used to provide heat to the non-domestic buildings. Non-domestic heating accounts for approx 18% of the projected energy consumption of the site. Assuming that biomass meets 90% of this heating load (this is assumed by Richard Hodgkinson consulting), this corresponds to a 16.5% renewable contribution to the overall energy loads of the site and a 10.5% reduction in the site's CO₂ emissions.

The growth in the site's CO₂ emissions as the build of the development progresses and the impact of the strategy to supply the non-domestic heating requirement from biomass is shown in the charts below.

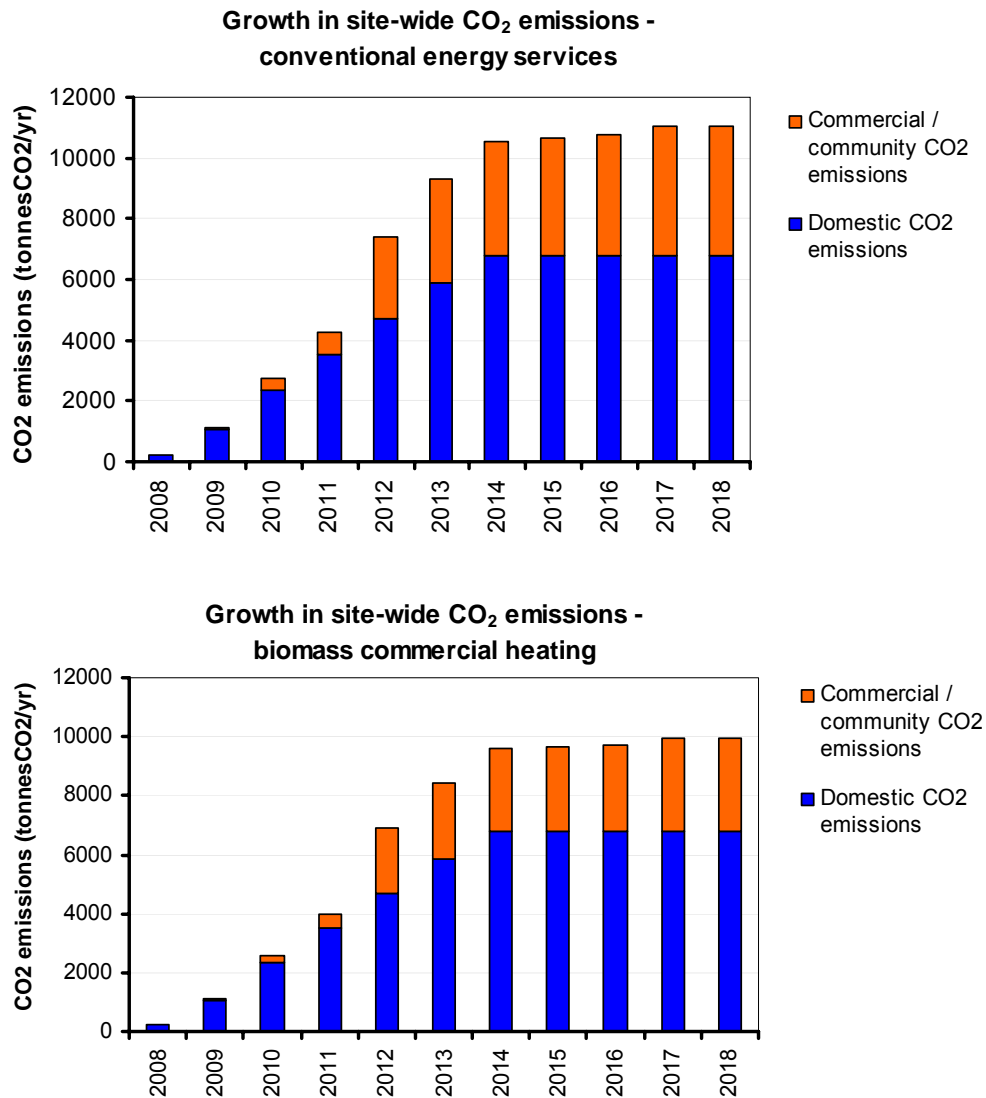


Figure 12, Growth in CO₂ emissions as Cranbrook site develops and becomes occupied. (TOP) Emissions assuming that all developments are heated with gas-fired plant. (BOTTOM) Emissions assuming that biomass boilers are installed in all commercial buildings.

The existing strategy is to achieve level 3 of the Code for Sustainable Homes through energy efficient construction and to provide a renewable energy contribution through biomass heating systems in each of the non-domestic buildings. This is taken as the base case in the following

analysis. The relative CO₂ benefit and costs of additional sustainability measures are in relation to this baseline.

4.2 Energy demand reduction in the residential sector

Improvements over the baseline standards may be achieved through adoption of higher building fabric efficiency measures, and/or the use of renewable and low carbon heat and electricity generation technologies. An extensive cost/benefit analysis is presented below.

4.2.1 Building fabric energy efficiency measures

Improvements in the efficiency of energy use, through improvements in the building's fabric, providing more efficient plant and better control over how energy is used, can reduce CO₂ emissions and cut fuel bills for the building's occupants throughout the whole life of the building.

The reductions in energy consumption and CO₂ emissions that can be provided by energy efficiency measures have been assessed with reference to the minimum standard required for Part L (2006) compliance.

The following assumptions are inherent in the calculation of Part L (2006) energy loads for domestic properties:

Heating plant	90% efficient condensing boiler
U-values	
Walls	0.3W/m ² K
Windows	2W/m ² K
Lighting/ventilation electricity demand	4kWh/m ² /yr

A wide range of energy efficiency measures have been analysed. The measures included in the assessment are as follows:

Energy efficiency measures included in assessment
Delayed start thermostat
Thermostatic control in hot water cylinder + separate hot water time control
Zone and time controlled heating
Air permeability of external walls reduced to 5m ³ /m ² /hr
Window U values reduced to 1.3 W/m ² K
External wall U values reduced to 0.21 W/m ² K
High efficiency boiler (93.5%)
Air permeability of external walls reduced to 3m ³ /m ² /hr + balanced whole house ventilation and heat recovery
4:1 ratio of S:N window glazing
(Aerated taps/water fittings)
(Use of energy efficient lighting only)

Figure 13, Energy efficiency measures considered in analysis of demand reduction from the residential sector

The measures in brackets generate significant CO₂ savings, however these CO₂ savings are not currently given credit under the Code for Sustainable Homes methodology (as currently drafted). They are included here as they are important and cost-effective CO₂ measures despite currently being excluded under the CSH.

For each measure, the CO₂ saving delivered and the whole life cost of implementation (over a 15 year period) were calculated¹⁷ with a 2/3 bedroom house used for illustration. The cost of carbon saved (whole-life cost over lifetime CO₂ saving) for each of the above fabric measures is shown in the chart in Figure 14 and is an important metric when assessing the relative benefits of options.

¹⁷ The CO₂ savings and capital costs associated with the measures were taken from the recent, extensive study on building fabric undertaken by Cyril Sweett consultants (A Cost Review of the Code for Sustainable Homes- Report for English Partnerships and the Housing Corporation:- Cyril Sweett (February 2007))

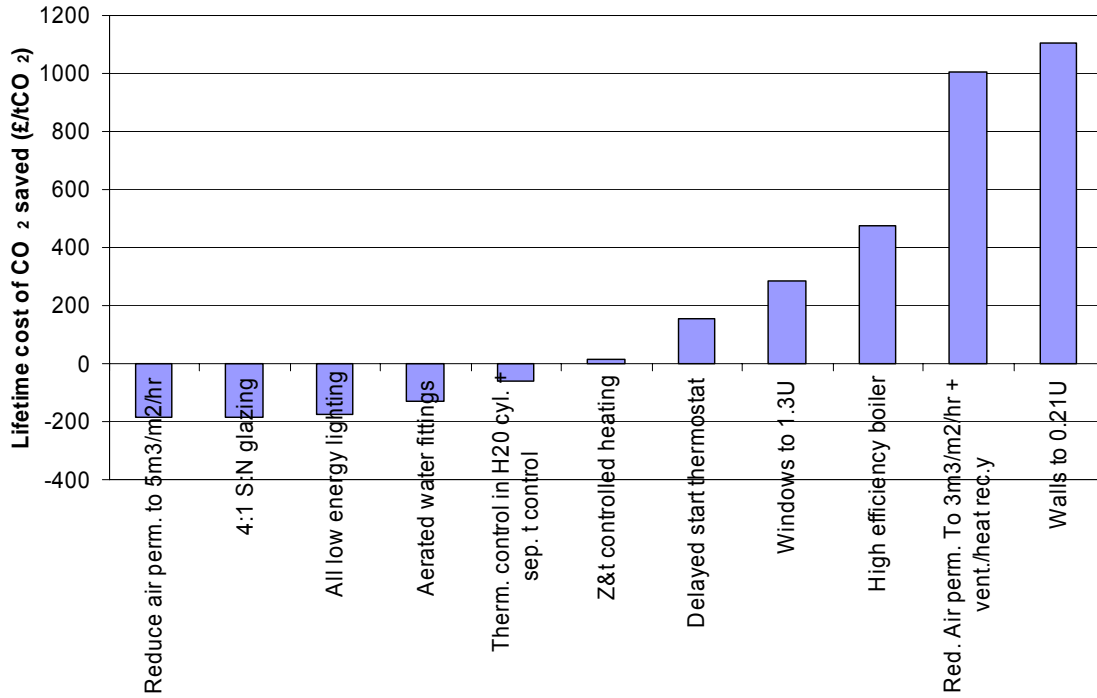


Figure 14, Comparison of the cost-effectiveness of a range of energy efficiency measures on a cost per tonne of carbon saved basis (considering whole-life costs and carbon saving over a 15 year life-time), based on a typical 2/3 bedroom house.

A negative cost of carbon means that the measure both saves CO₂ and money i.e. the initial capital outlay is paid off by the saving in energy costs over the life-time of operation. If the initial outlay is not recouped, a positive cost of carbon results. Measures with a negative carbon cost are strongly recommended (although they may not be cost neutral to the developer).

It is clear from Figure 14 that reducing the wall and window U-values of properties to the standards tabulated in Figure 13 is a relatively expensive route to achieving CO₂ emissions savings. However, it should be noted that the highest level of the Code for Sustainable Homes stipulates a maximum permissible heat loss parameter (0.8W/m²K), which will require these high standards of fabric efficiency to be met. In this analysis, high energy efficiency standards are demonstrated to be required for compliance with the highest code levels.

Often developers are more focussed on identifying the lowest cost CO₂ reduction strategy in capital terms, rather than valuing the whole-life benefits. The cost of carbon saved in capital terms (i.e. capital cost over life-time CO₂ saving) is presented in Figure 15.

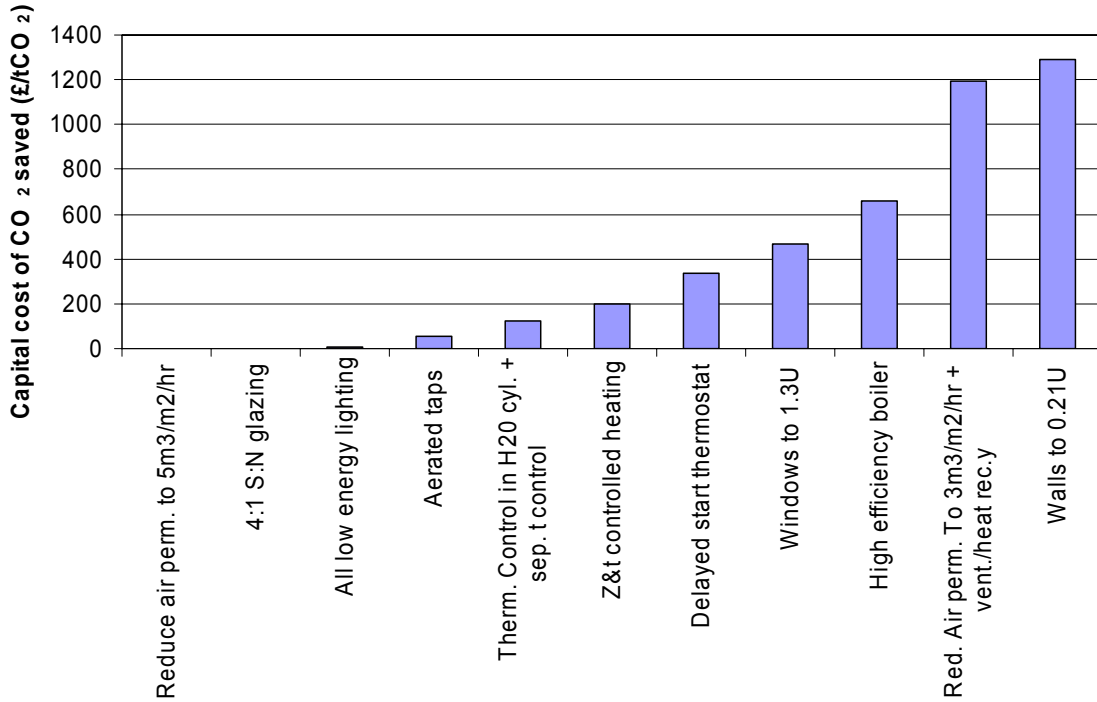


Figure 15, Comparison of the cost-effectiveness of a range of energy efficiency measures on a capital cost per tonne of carbon saved basis, based on modelling of a typical 2/3 bedroom house.

The relative cost-effectiveness of measures in capital terms mirrors that implied by the whole-life cost assessment.

The impact of incrementally improving the energy efficiency of a typical house on the CO₂ emissions that house is expected to create is explored in the chart in Figure 16. The CO₂ reduction shown is the cumulative effect of sequentially adding measures to a Part L (2006) compliant house (the Baseline – leftmost bar on the chart). It can be seen from the chart that the CO₂ savings delivered by low energy light-fittings and aerated taps are relatively large (far right of the chart), although they do not count towards compliance with Code for Sustainable Homes targets. The CO₂ reduction achieved by combination of all other measures is sufficient to achieve Level 3 of the Code for Sustainable Homes¹⁸.

¹⁸ The charts presented in Figure 14, Figure 15 and Figure 16 are specific to a typically modelled 2/3 bedroom house.

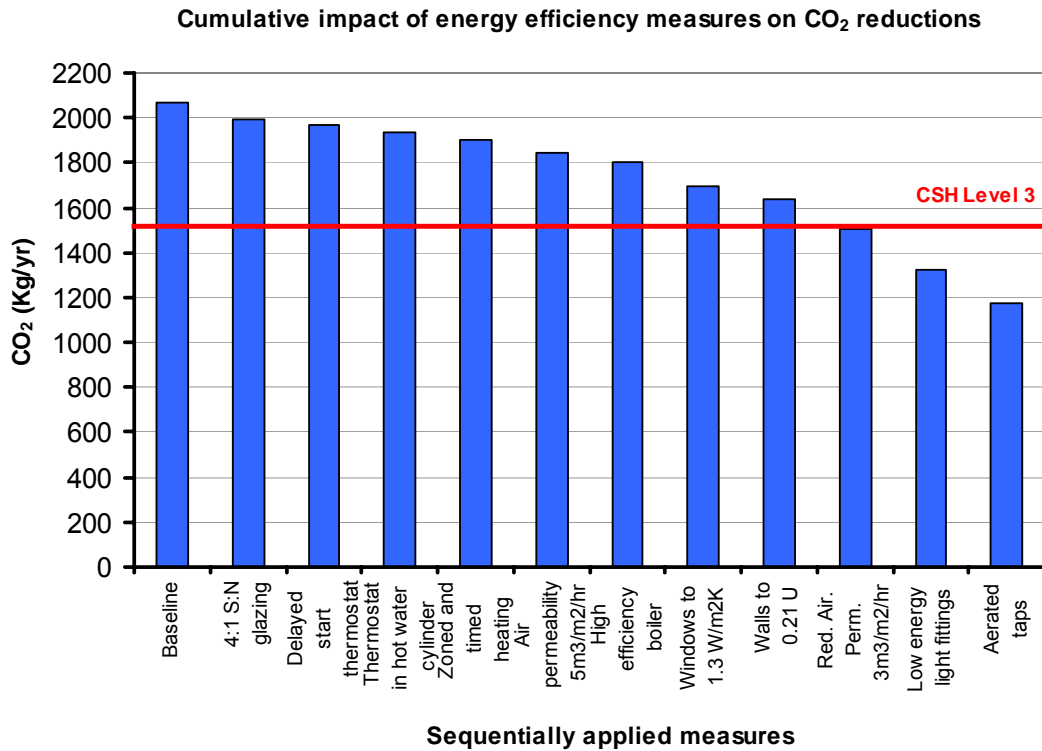


Figure 16, Cumulative impact of addition of energy efficiency measures to a typical 2/3 bed house. Note that low energy light-fittings and aerated taps (far right bars on the chart) are not credited under the Code for Sustainable Homes. However, Code Level 3 is reached by combination of the other measures.

It is shown in Figure 16 that significant CO₂ savings can be provided by energy efficiency improvements, however, in terms of the Code for Sustainable Homes it is not possible to go beyond Level 3 through energy efficiency alone (even achieving Level 3 will be out of reach in small flats). Low and zero carbon energy generation measures are required to achieve Code Level 4 and beyond. Active generation technologies that could be applied on an individual dwelling scale – microgeneration measures – are discussed in the following section.

4.2.2 Micro-generation measures

An assessment has been made of the potential to reduce the domestic CO₂ emissions in line with levels 5 and 6 of the Code for Sustainable Homes via implementation of micro-generation technologies. The technologies considered in this assessment are presented in Figure 17.

Micro-generation technology	Impact	Assumptions made
Solar water heating (SWH)	Reduction of gas consumption for domestic hot water provision	<ul style="list-style-type: none"> - Heater sized to provide 50% of the domestic hot water demand - Flat panel unit with a PV powered pump
Photovoltaics (PV)	Arrays generate electricity directly. This electricity is used in the home or exported to the grid to offset emissions associated with heating fuel and grid electricity use	<ul style="list-style-type: none"> - Monocrystalline PV utilized (most efficient) - Calculations of suitably inclined roof area assume pitched roofs for houses and flat roofs for flats - 75% of suitably oriented roof area appropriate for PV use - Flats are low rise ≤ 3 storeys
Micro-biomass boilers (~15kW)	Drastically reduces heating related emissions since biomass combustion replaces that of gas. Must be combined with an electricity generating technology (e.g. PV) to achieve CSH 5	<ul style="list-style-type: none"> - ~15kW system - Fuelled by wood pellets (storage available in homes) - Size and potential fire hazard may limit applicability in flats. - Requirement for a gas boiler is offset.
Micro-Wind	Electricity generated directly and used in the home to offset grid electricity use and associated emissions	<ul style="list-style-type: none"> - Generous load factor assigned (still performs poorly) - Generally applicable (may be less so in urban areas)
Ground source heat pumps	Reduction of CO ₂ emissions related to heating. Electrical consumption increases due to consumption of the heat pump. An electricity generating technology is also required to meet CL 5 or 6.	<ul style="list-style-type: none"> - Seasonal performance factor of 4 and 2.5 assumed for space heating and hot-water loads respectively. - Widespread uptake would require significant space for burying heat exchangers (slinkies) or drilling boreholes.

Figure 17, Micro-generation measures applicable to properties in Exeter and East Devon and a brief summary of their impacts. A brief description of any assumptions made with respect to their analysis is provided. Further information on the technology is given in section 6.1.2.

The cost of CO₂ saving metric was used (on a whole-life cost basis) to compare the cost effectiveness of these microgeneration technologies, as shown in Figure 18.

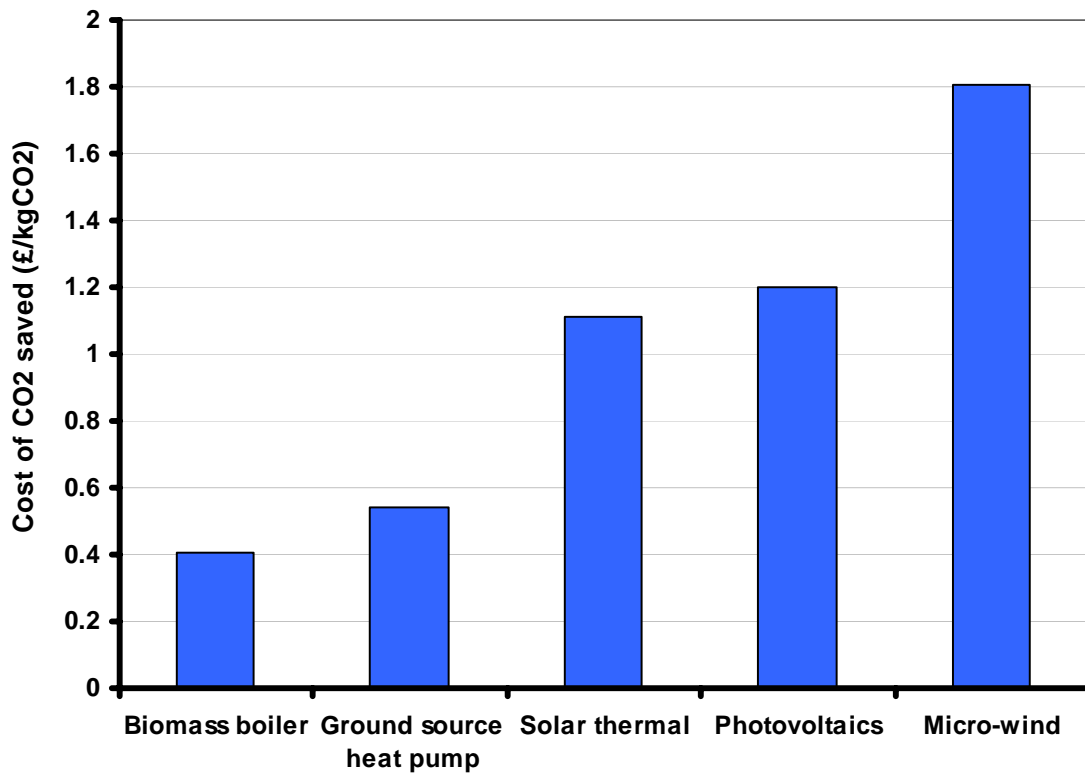


Figure 18, Comparison of the whole life cost of CO₂ saving delivered by micro-generation technologies (whole life cost over 20 year period).

CO₂ figures are calculated using a displaced electricity intensity of 0.57kg CO₂/kWh. This is higher than the average grid intensity of 0.43kg CO₂/kWh and follows the methodology set out in the standard assessment procedure (SAP). The most cost-effective CO₂ savings are delivered by the heating technologies, particularly biomass boilers and ground source heat pumps. Although substantially more expensive on a whole-life basis, solar thermal systems may be preferred by developers faced with reaching Code Level 3 of the Code for Sustainable Homes due to their lower capital costs.

In order to meet Code Level 5 or 6, a renewable electricity generating technology is required. Micro-wind technology is shown to be the most expensive means of saving carbon of the technologies assessed in Figure 18. This is because micro-wind, which is a relatively immature technology, has been shown to operate at disappointing load factors in early field trials¹⁹. Photovoltaics are therefore expected to be selected in carbon reduction strategies aimed at addressing electricity-derived emissions.

4.2.3 Methods of achieving Code for Sustainable Homes accreditation using energy efficiency and micro generation

Based on the analysis of carbon reduction impact and cost-effectiveness of energy efficiency and microgeneration measures discussed in the preceding sections, strategies to meet the CO₂ reduction targets of each of the Code for Sustainable Homes levels can be developed. For each Code Level, the lowest cost combination of energy efficiency and

¹⁹TPPT www.warwickwindtrials.org.uk

microgeneration measures, in terms of capital cost per dwelling, to provide the requisite CO₂ emission reduction has been identified.

In *Figure 15* it was shown that there is a large spread in the cost-effectiveness of energy efficiency measures. As a result, the most cost-effective means of achieving Code levels up to Level 5 involve combination of the most cost effective energy efficiency measures, supplemented with appropriate microgeneration technologies. In order to meet the requirements of Code Level 6, less cost-effective energy efficiency measures would also be required so as to meet the minimum fabric performance standard. For this reason, the energy efficiency measures considered in Section 4.2.1 have been sub-divided into Package A and B – more and less cost-effective measures respectively.

Fabric Package A- initial, highly cost effective fabric efficiency measures (typical house)	Fabric Package B- Less cost-effective fabric efficiency measures (typical house)
4:1 S:N glazing ratio	Walls to 0.21 W/m ² K
Delayed start thermostat	Reduce air permeability to 3m ³ /m ² /hr + add
Thermostat in hot water cylinder	balanced whole house ventilation and heat
Zone and time controlled heating	recovery
Air permeability to 5m ³ /m ² /hr	
High efficiency condensing boiler (omitted for micro-biomass and GSHP strategies)	
Windows to 1.3W/m ² K	

Figure 19, Classification of energy efficiency measures into Package A – highly cost-effective measures – and Package B – less cost-effective measures.

The lowest cost strategy for achieving each Code for Sustainable Homes level and the attendant capital costs per dwelling are shown in *Figure 20*. These costs are based on a typical 2/3 bedroom house. The lowest cost strategies for typical flats exhibit minor variations, as discussed in Appendix B.2²⁰.

²⁰TP²⁰PT A full treatment of the varying strategies for meeting each Code Level in typical houses and flats is given in Appendix B

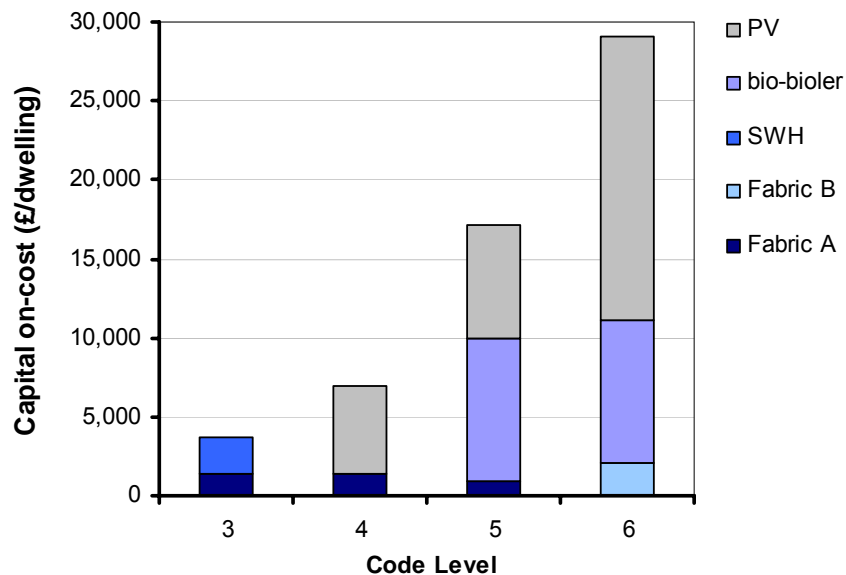


Figure 20, Chart of the on-cost per dwelling of achieving each Code Level for the lowest capital cost strategy.

As indicated in the *Figure 20*, the capital on-costs associated with achieving high Code levels are very high. At Code level 5 & 6, a renewable heating and electricity generating technology is required to provide the necessary CO₂ reductions and the cost of doing this becomes prohibitive. Although an on-cost is shown for achieving Code Level 6, which is dominated by the cost of the large PV array required to offset all electricity based CO₂ emissions, this solution is unlikely to be practicable due to constraints on roof space.

The analysis thus far has been focussed on the residential sector and on measures that are applied on an individual dwelling basis. A more cost-effective approach may be to consider site-wide energy systems, involving centralised plant and energy distribution across the site. These site-wide measures, which may address both the residential and non-residential developments, are discussed in detail in the following sections.

4.3 Site-wide energy options

A site-wide energy system consists of centralised energy plant, which can be thermal plant (e.g. boilers), electricity generating plant or a combined heat and power system, and a distribution system to convey either the heat and/or power across the site to the end-users.

Heat is distributed around the site via a district heating (DH) system, which is a network of pipes carrying hot-water to each building it serves. Electricity generating plant could be connected to the distribution network, i.e. export electricity to the grid, or a private wire electrical network could be implemented to directly supply electricity from the centralised plant (the private wire would still have a connection to the grid to allow export of excess and import of electricity to meet peaks).

The feasibility of heat networks and private wire systems is analysed below. However it is important to note that as currently drafted, the Code for Sustainable Homes stipulates that on-site renewable electricity generators should supply electricity directly to the dwellings via a private wire if that electricity is to be credited in the calculation of the emissions of the dwellings.

4.3.1 DH networks

Two scenarios have been considered for district heating networks in Cranbrook, as follows:

1. **Site-wide** – district heating system to connect the whole of the Cranbrook development – i.e. 2,900 dwellings and town centre commercial / community areas.
2. **Town Centre** – a system serving only the mixed use town centre (Parcel B). This area includes residential properties (built at a higher density than the site-wide average) and the bulk of the commercial and community buildings.

District heating networks can be split into two levels – the distribution network, which transports heat around the site, and the branches that connect the individual buildings to the distribution network. An outline design of the distribution network has been developed in order to assess the length of the network and pipe dimensions required to serve the developments heat loads. The indicative distribution system layout is shown in *Figure 21* for the Site-wide system. The Town centre system is the area within the blue outline and the buildings that this system is expected to serve are shown in the table inset. Danish district energy consulting engineers Ramboll were contracted to develop outline designs and costs for the district heating system.

Town centre scenario	
Domestic properties	
Total number of dwellings	450
Non-residential	
	Floor area (m²)
Supermarket	4,000
Small shops	200
Office space	9,000
Workshops	5,500
Schools	10,455
Hotel	2,000
Gym	400
Restaurant / pub	650
Children's centre / creche	450
Town hall	580
Doctor's surgery	400
Police station	350

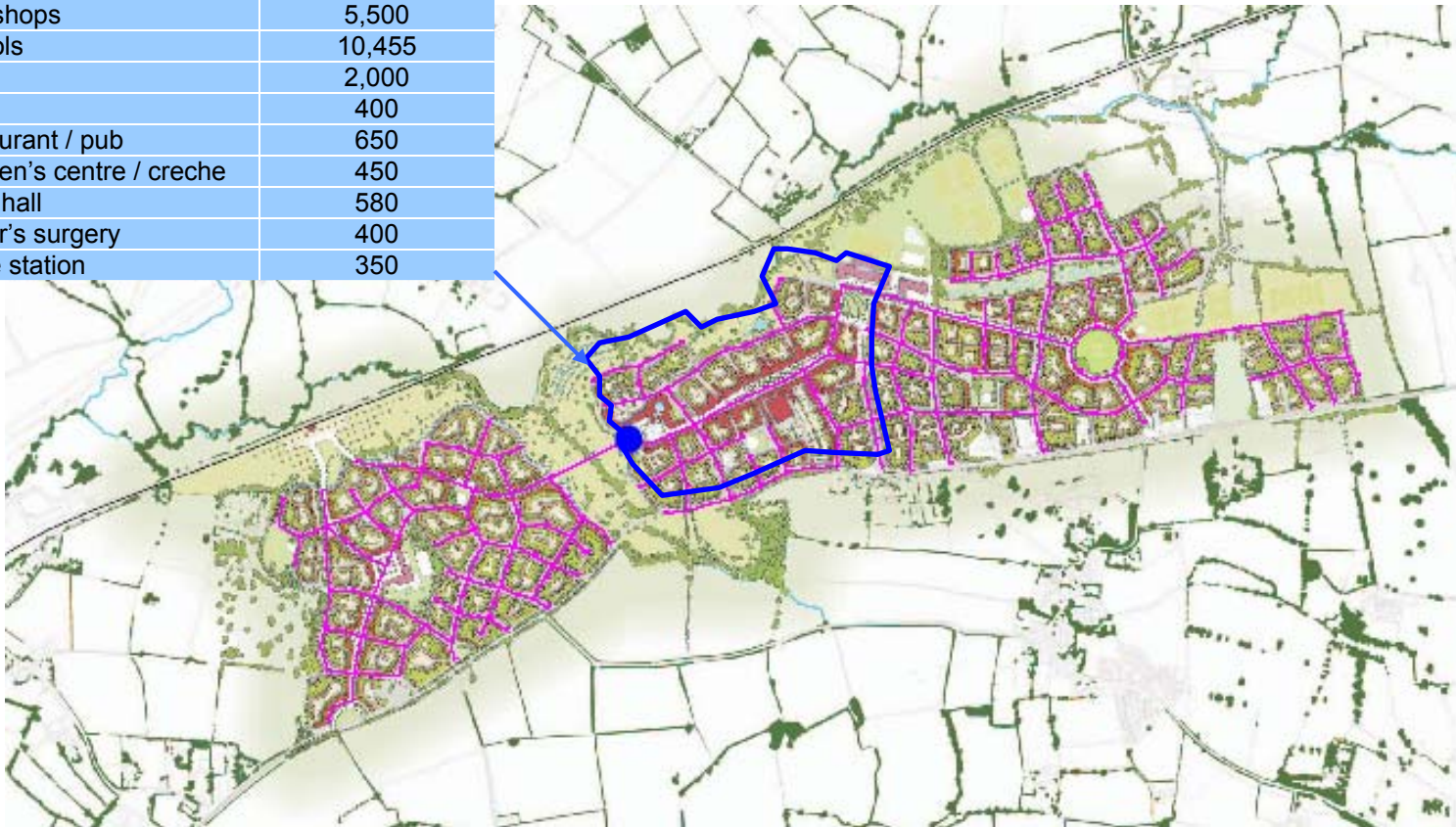


Figure 21, Layout of main heat distribution pipes in a site-wide district heating network for Cranbrook

4.3.1.1 DH capital costs

Each building on the network will have a connection to the flow and return pipes of the district heating system. Within the property there will be a heat exchanger, which provides the interface between the heat network and the property's internal heat system. The heat exchanger unit will also incorporate a heat meter to measure the amount of heat supplied to the property for billing purposes. From the perspective of the building occupant, the level of control over the heating within the building should be identical to that enjoyed in a building served by an individual boiler.

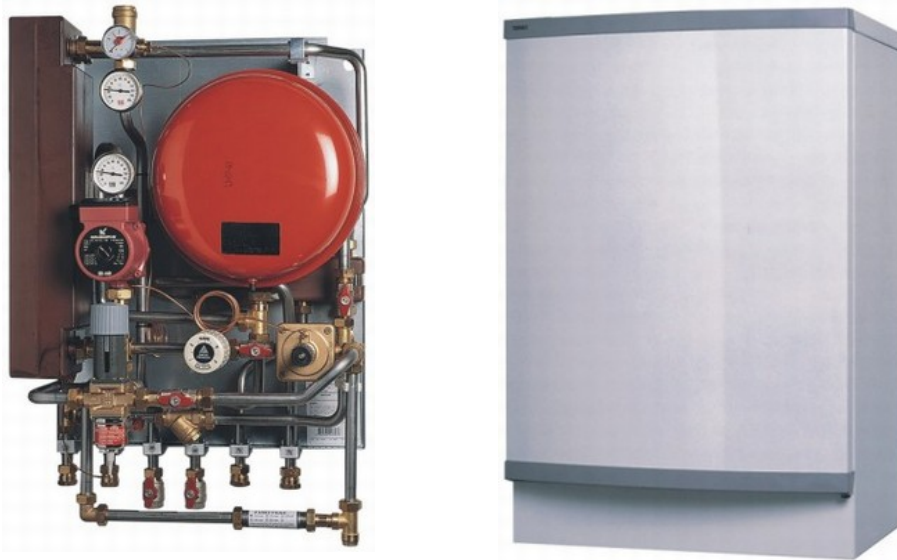


Figure 22, Image of domestic Heat Interface Unit (HIU), from Termix

Properties connected to the district heating network do not require a boiler or connection to the natural gas infrastructure. Depending on the design of the system, hot-water storage tanks may or may not be required in the buildings. Installation of hot-water storage in the buildings takes up space, but can reduce the peak heat loads that have to be met by the district heating system, which in turn can reduce the size of the pipes required in the network and overall network cost.

A district heating network requires a significant capital investment. The cost of the system is primarily dictated by the peak heat demand, the length of the network and the number of individual connections. The ground conditions will also heavily influence the installation costs, a large part of which is the cost of digging trenches. The Cranbrook site is attractive in the latter respect as it is a green field site and offers the opportunity for installation of the system simultaneously with installation of other services (potential cross-subsidy of installation costs).

District heating network cost estimates have been made for the Site-wide and Town centre systems, based on the distribution network layout shown in *Figure 21* (additional allowance have been made for the branch pipes). The cost is primarily made up of the following components:

- Distribution network
- Branch pipes
- Heat exchanger units

This is partially offset by the saving made on the cost of installation of condensing boilers and natural gas connections for each domestic property and the cost of biomass boiler systems for

each non-residential property, i.e. the base case. The capital on-costs of both site-wide and Town centre systems are shown in *Figure 23*.

	Site-wide network	Town Centre network	Note
Assumptions			
No of houses connected	2,320	230	
No of blocks of flats	58	18	
No of non-residential blocks connected	33	23	
Length of distribution mains	19,495	4,320	m
Length of small distribution pipe	14,500	1,750	m
District heating system costs			
Total network cost	£13,225,000	£2,564,815	
Heat exchanger cost	£2,505,000	£567,500	
Fees & contingency	£1,573,000	£313,231	
Total district heating system cost	£17,303,000	£3,445,546	
Avoided costs			
Boiler plant	£7,475,000	£1,625,000	
Natural gas connections	£1,342,000	£197,000	
Total avoided costs	£8,817,000	£1,822,000	
On-cost of district heating system	£8,486,000	£1,623,546	

Figure 23, Estimate of the capital costs and on-costs (i.e. including savings in avoided plant) for the Site-wide and Town centre district heating networks.

4.3.2 CHP system

The suitability and performance of a variety of types of CHP system for the Cranbrook energy system, both Site-wide and Town centre, has been assessed. The types of system included in the study are tabulated in *Figure 24*.

	Electrical efficiency	Heat to power ratio	Fuel	Description
Reciprocating engine	35 – 40%	1.2:1	Gas / diesel	An internal combustion engine.
Steam cycle	20-25%	3:1	Flexible	Consisting of a steam raising boiler and steam turbine. A variety of fuels, including biomass can be combusted to provide heat to the steam boiler.
Organic rankine cycle (ORC)	15%	4.3:1	Flexible	An external combustion process supplies heat to an organic working fluid, which evaporates and expands through a turbine. The organic fluid is then condensed and heat recovered. The external combustion process provides fuel flexibility.

Figure 24, Types of CHP engine considered in analysis of Cranbrook DH systems

CHP systems are normally operated to follow the heat load. This is the most efficient mode of operation as heat is only generated when there is an on-site demand (no heat is wasted) and the electricity generated simultaneously is either used on-site or is exported to the local grid. In some circumstances however, it can be more economic to operate a CHP system to follow the electricity load (or to maximise the revenue from sale of electricity by operating near continuously) and accept that some heat will be rejected.

Sizing of CHP systems for each of the Cranbrook DH scenarios has been performed based on simulation of the heat loads²¹. As a rule-of-thumb, a CHP system should operate for at least 5,000 (preferably 6,000) full load equivalent run hours per year, in order to be economically viable. The CHP system sizes selected for further economic analysis are tabulated below.

Technology	Fuel	Capacity MW _e /MW _{th}	Mode	Rationale
<i>Site-wide system</i>				
Recip engine	Natural gas	2 / 2.4	Heat-led	Achieves > 6,000 full load run hours in heat-matched mode.
ORC	Biomass	0.5 / 2.4	Heat-led	Achieves > 6,000 full load run hours in heat-matched mode.
Steam cycle	Biomass	2.5 / 7	Elec led	Lack of availability of technology of appropriate size for heat-matched operation. 2.5 MWe is lowest capacity of proven technology Electricity-led mode required to maximise revenues.

TP²¹PT The heat loads have been estimated based on the assumption that the energy performance of the dwellings is in line with Code Level 3 of the Code for Sustainable Homes (achieved through implementation of fabric efficiency measures) and the non-residential buildings are constructed to current best practice standards.

Town centre system				
ORC	Biomass	0.5 / 2.4	Heat-led	Only achieves 4,500 full load run hours per year, but is lowest capacity biomass system available
Biomass boilers	Biomass	5 MW thermal	Heat-led	Heat-only technology considered due to lack of availability of well-matched CHP technology. Centralised boiler plant may be more practical than multiple systems in individual buildings ²² .

Figure 25, Specific CHP engine options considered in Cranbrook Site-wide and Town centre district heating scenarios.

4.3.2.1 CHP capital costs

Capital costs for the energy centre – CHP system, back-up boilers, balance of plant etc. – have been estimated for each of the centralized plant options defined in Figure 25. These cost estimates are tabulated in Figure 26.

Cost component	Gas engine 2 MWe	Biomass ORC 500 kWe	Biomass steam 2.5 Mwe	Biomass boilers 5 MWth
CHP system	£1,000,000	£1,800,000	£4,999,500	zero
Boiler plant	£243,501	£243,501	£243,501	£650,100
CHP connections	£100,000	£100,000	£100,000	£50,000
Energy centre	£450,000	£700,000	£750,000	£400,000
Fees / contingency	£269,025	£426,525	£1,218,600	£165,571
Total	£2,062,526	£3,270,026	£7,311,601	£1,265,671

* Includes civils, thermal storage, balance of plant and, in biomass system, fuel storage and handling

** 15% of sub-total

Figure 26, Capital cost estimates for energy centre based on i) a gas-fired reciprocating engine CHP system, ii) a biomass-fuelled Organic Rankine Cycle based CHP system, iii) a biomass-fuelled steam cycle CHP system and iv) biomass boilers. In each case it is assumed that peak and back-up demand is met by gas-fired boiler plant.

The biomass systems are considerably higher specific capital cost (£/kWe) than the gas engine. The total district heating system cost is the combination of the heating pipe infrastructure cost (Figure 23) and the appropriate CHP engine cost. It is clear that, in all cases, a large fraction of the overall system cost is invested in the heat pipe network.

²² It can also be noted that centralising the biomass boiler plant would allow the use of more cost effective wood chip (instead of more costly wood pellets that would likely be required for smaller biomass boilers).

4.3.3 CHP / DH Economics

The capital investment in a district heating system and ongoing operating costs – fuel, maintenance and management overheads – are recouped through sale of heat and power. Heat is sold to tenants over the district heating system while the electricity can be exported to the grid and sold to a licensed electricity supply company or could be sold directly to tenants (there are a number of arrangements whereby electricity can be supplied to tenants, discussed in more detail in Section 7).

In the case of the biomass fuelled system, the trading of Renewables Obligation Certificates (ROCs) provides an additional revenue stream. However there is currently debate over the “double counting” of ROC’s – for example where new renewable energy capacity helps meet a CSH level, as well as the resulting ROC’s being sold. Taking ROC’s out of circulation (retiring them so that they cannot be sold) is one solution, although currently it is not believed that this is an efficient exercise. The outcome of this debate on ROC’s and additionality will have an impact on the economic viability of biomass CHP systems. For this investigation, it is assumed ROC’s may be sold at a market price.

The economics of the various system configurations – combination of DH scenario and centralized plant – have been assessed. The analysis has been performed over a 15 year period. The investment in the energy centre is made at the outset of the project, while it is assumed that the investment in heat distribution infrastructure can be spread over the early years of the development. The energy demands, and therefore revenues, grow over the period to 2017, linked to the rate of build of the development (see Section 4.1).

The other key assumptions made in the economic analysis of each system are tabulated below:

Parameter	Assumption
Fuel costs	
Natural gas	25 £/MWh
Wood chip	£ 35 /tonne (50% moisture content)
Revenue parameters	
Electricity sale tariff:	40 £/MWh
Base ROC price	45 £/MWh
ROC band (biomass CHP)	2 (for good quality biomass CHP)
CHP lifetime & maintenance	
Lifetime	15 years
O&M	
Gas engine	
Biomass ORC	13 £/MWh
Financial	
Project lifetime	15 years
Discount rate	10%

Figure 27, Major assumptions used in the economic analysis of site-wide CHP systems

Detailed cashflows for all scenarios are included in Appendix A. The economic analyses are summarized in the bar charts in *Figure 28* and *Figure 29*. The charts show the present value of the major cost and revenue components for each system over the 15 year analysis period. The final set of bars (on the right of the charts) shows the Net Present Value of investment in each system – the NPV is the summation at a discount rate of 10% of all other bars on the chart.

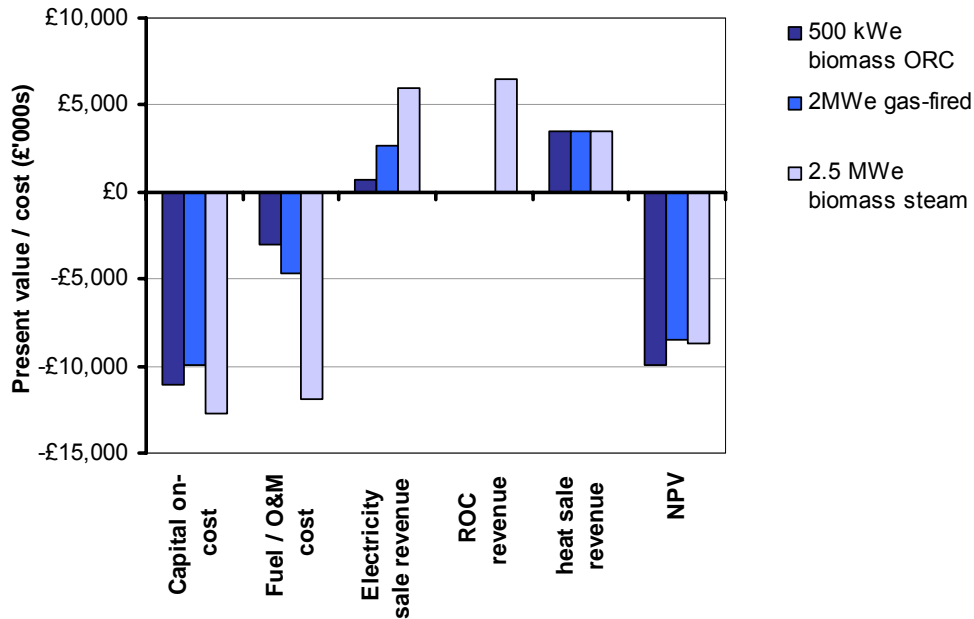


Figure 28, Summary of the economic analysis of the site-wide DH scenario with various CHP engine options. The rightmost bar is the net present value, i.e. summation of the present values of all other costs and revenues shown in the chart. The negative NPVs indicate that none of the systems are economically viable (at 10% discount rate over 15 years).

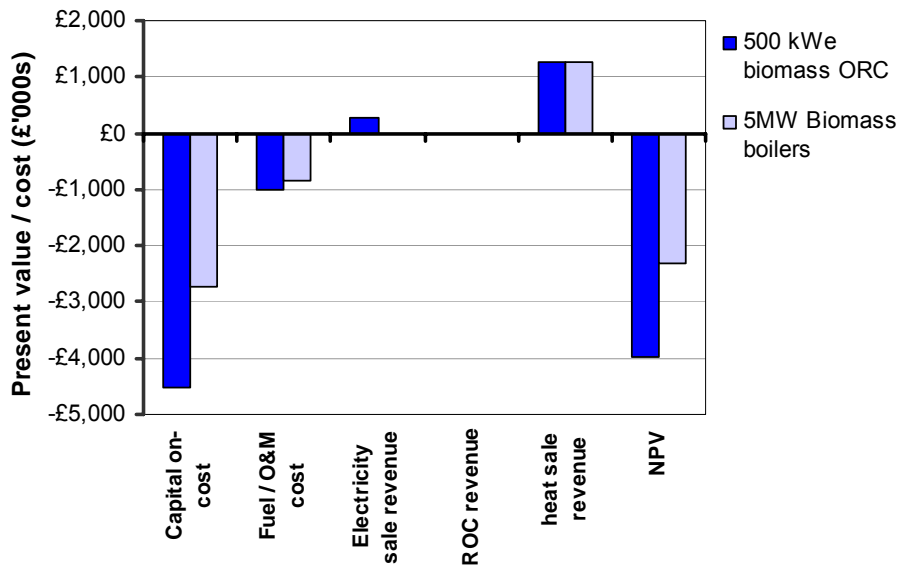


Figure 29, Summary of the economic analyses for the Town centre district heating scenario. Again, the NPVs are negative indicating that the systems are not economically attractive without subsidy.

4.3.4 Environmental impact of site-wide measures

The impact on the CO₂ emissions for each scenario has been assessed. In each case the district heating system serves both domestic and commercial loads, however, in order to assess the implications of the systems on Code for Sustainable Homes eligibility of the domestic properties, the emissions attributable to each sector have been separated. The CO₂ reductions compared to the base case are shown in

Figure 30 and *Figure 31* for Site-wide and Town centre systems respectively.

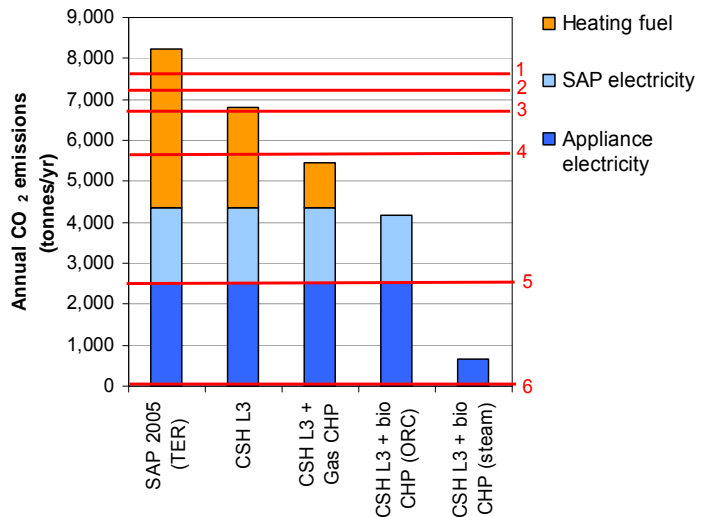
In the case of the biomass systems, the emissions relating to the generation of heat and power are very low (a minor CO₂ emissions impact is attributed to burning wood fuel, sufficient to account for the CO₂ impact of logging and transportation). In the analysis of CO₂ reductions of biomass CHP systems, the heating CO₂ emissions have been taken to be zero and those emissions that the biomass CHP system does emit are attributed to the electricity.

Domestic CO₂ emissions

Implementation of the gas engine system will achieve Code for Sustainable Homes level 4 across all dwellings.

The biomass-fired ORC system makes a larger CO₂ reduction, but does not achieve better than level 4 as the amount of renewable electricity generated is not that large (only 500 kWe capacity).

The steam-based system virtually achieves Level 6 – only 600 kg CO₂ attributable to the 2,900 dwellings per year. A slight modification to the operating assumptions would ensure Level 6 is achieved.

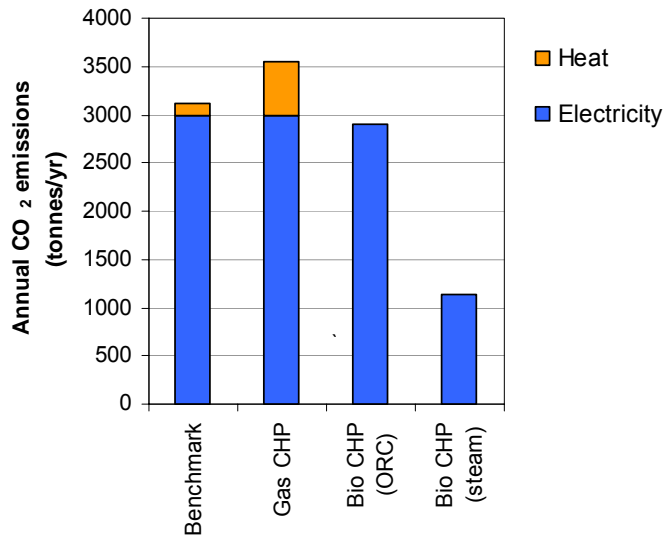


Commercial CO₂ emissions

The CO₂ emissions attributed to commercial heating is low in the Base Case due to the assumption of biomass boilers.

The gas CHP system actually leads to an increase in CO₂ emissions from the commercial sector, as the CHP heat is more CO₂ intense than renewable heat in the Base Case.

CO₂ reductions are delivered in the commercial sector by the biomass CHP systems, due to the renewable electricity generation. In the case of the steam based system, the CO₂ cuts are deep.



Total site-wide CO₂ emissions

Overall emissions savings compared to the Base case are delivered by all the CHP engine options.

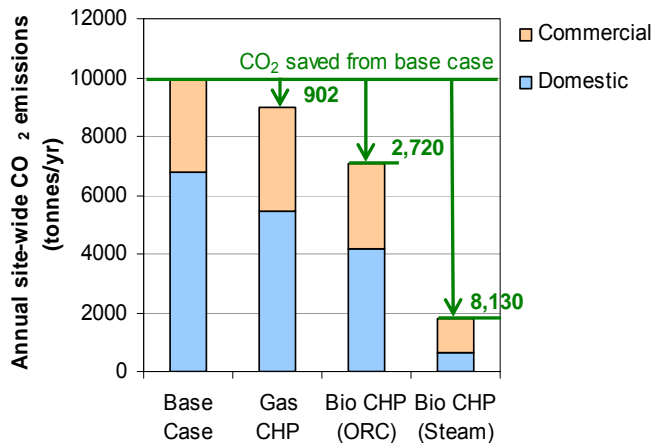
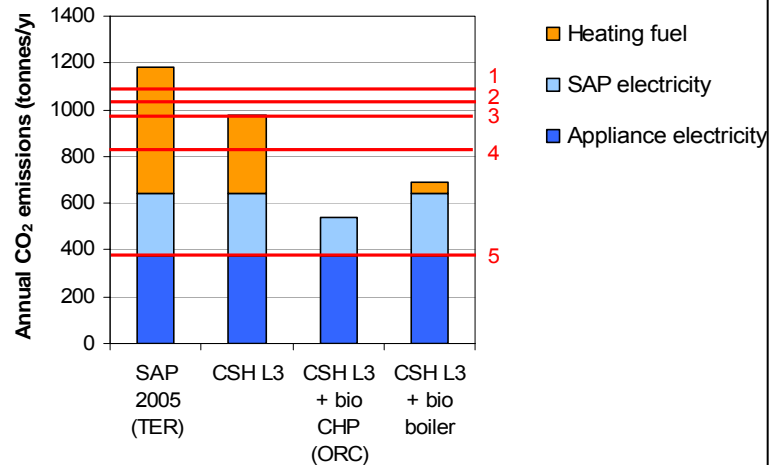


Figure 30, Assessment of CO₂ reductions delivered by the various Site-wide CHP / DH system options.

Domestic CO₂ emissions

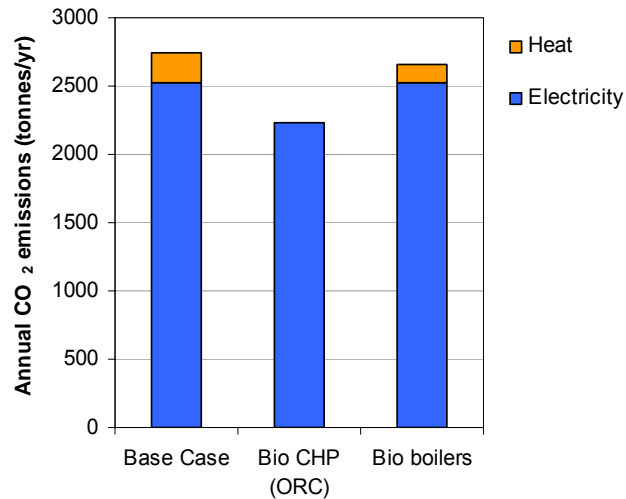
In the Town centre scenario, the implementation of centralized biomass heating reduces domestic CO₂ emissions in line with Code for Sustainable Homes Level 4.

Clearly in this case, Code for Sustainable Homes Level 4 is only achieved in a small part of the overall residential development.



Commercial CO₂ emissions

As the Base Case involves biomass boilers in all commercial properties (providing 90% of the heat load) the CO₂ reductions from the Base Case in the commercial sector are relatively small.



Total town centre emissions

Overall emissions savings compared to the Base case are delivered by all the CHP engine options.

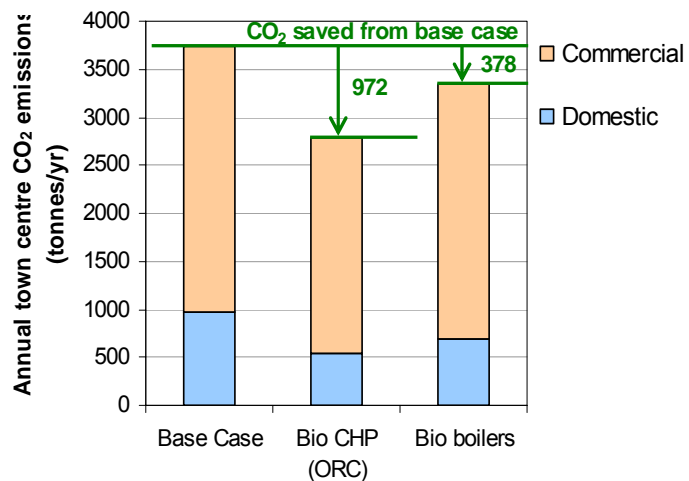


Figure 31, Assessment of CO₂ reductions delivered by the various Site-wide CHP / DH system options.

4.3.5 Biomass resource use

The preceding analysis has shown varying levels of CO₂ reduction for the varying plant options. Substantially the largest CO₂ saving is delivered by the steam cycle biomass system operating in an electrically-led mode. However, in this scenario a substantial fraction of the heat generated by the system must be rejected as it is excess to the site’s thermal loads. The implication of operation with heat rejection is that the efficiency of use of the biomass resource is reduced, compared to a system that is operated to follow the heat load. The biomass resource requirement and efficiency of resource usage are shown in the table below for the biomass systems considered.

	Resource requirement (based on 50% wet woodchip)	Efficiency of use of biomass resource
<i>Site-wide system</i>		
0.5 MWe biomass ORC (heat –led)	9,500 tonnes/yr	80%
2.5 MWe steam CHP (electrically-led)	37,600 tonnes/yr	40%
<i>Town centre system</i>		
0.5 MWe biomass ORC (heat –led)	4,239 tonnes/yr	80%
5 MWe biomass boilers	3,057	85 – 90%

Figure 32, Biomass resource consumption for each biomass CHP option, assuming woodchip systems. The efficiency of resource usage includes the efficiency of the CHP system and any heat rejection, but does not include distribution losses.

Clearly the electrically driven steam-based option requires a considerably larger biomass resource per year and uses that resource inefficiently compared to the other options. Careful consideration of the resource potential in close proximity to Cranbrook is required to explore whether such a demand can be met sustainably (see Appendix C).

4.4 Summary of CHP / DH options and comparison with individual building solutions

The key results of the assessment of site-wide energy system options for Cranbrook are tabulated below.

Option	Capital on-cost	NPV	CSH level achieved	CO ₂ saved (tonnes/yr)	Cost of CO ₂ saved (£/tonne)
<i>Site wide</i>					
2MWe gas engine	£ 10.85 M	- £ 8.2 M	4	902	£ 580
500 kWe biomass (heat-led)	£ 12.1 M	- £ 10 M	4	2,720	£ 280
2.5 MWe biomass (elec led)	£ 16.2 M	- £ 8.2 M	6	8,130	£ 58
<i>Town centre (Parcel B)</i>					
500 kWe biomass (heat-led)	£ 4.9 M	- £ 4 M	4	972	£ 372
Biomass boilers	£ 2.9 M	- £ 2.3 M	4	378	£ 552

Figure 33, Summary of the economic implications, capital cost and NPV, for each of the energy system options considered for Cranbrook, site-wide and town centre systems. Also tabulated are the Code for Sustainable Homes levels achieved and the annual CO₂ savings delivered. (Note that the CO₂ savings tabulated here are relative to a base case of biomass boilers in the commercial development)

The only option assessed that offers the chance of a zero carbon development at Cranbrook is a 2.5 MWe biomass CHP system, operated at high load factor to maximise electricity generation. This is the lowest cost-route to achieving Code Level 6. Indeed, as none of the other site-wide options achieve better than Code Level 4, a solution such as the electrically-led steam-based system would also need to be considered to achieve Code level 5.

The capital cost of achieving the various Code for Sustainable Homes levels by site-wide measures can be compared with the costs of doing so by implementation of microgeneration measures (as discussed in Section 4.2). This is not an entirely like-for-like comparison, as the investment in the site-wide district heating system provides heat to the whole development, including all non-residential buildings. However it illustrates an important point about the relative cost of delivering high code level compliant developments by site-wide and microgeneration measures. The capital cost comparisons for each Code level are shown in *Figure 34*.

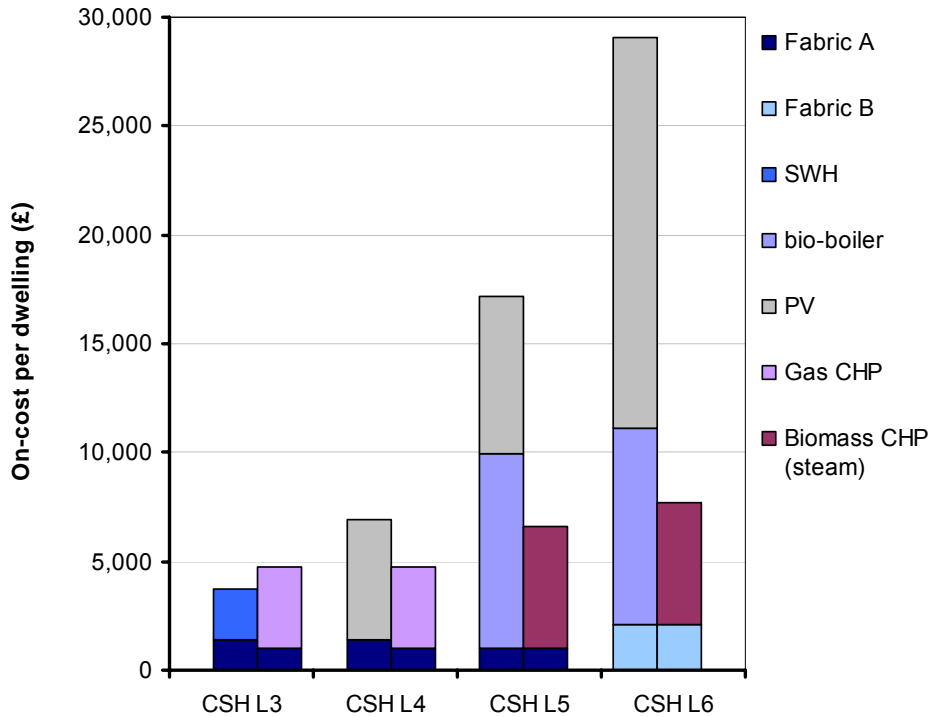


Figure 34, Comparison of the capital on-cost per dwelling of achieving various Code for Sustainable Homes levels by individual building measures (Left columns) and site-wide systems (Right columns).

As indicated by Figure 34, the site-wide system is a lower cost means of achieving all but Code Level 3. On the basis that after 2011 all residential developments should comply with Code Level 5 and a 34% reduction in Part L emissions should be achieved in commercial buildings (RSS Policy G), this cost comparison should provide a compelling argument for implementation of a site-wide system at the outset in Cranbrook. As discussed in the following section, this will also facilitate meeting carbon reduction policies in the further phases of the Cranbrook development.

Notwithstanding the fact that the Site-wide CHP / DH system is a substantially lower cost means of achieving Code Level 4 or above than measures applied at the individual dwelling level, the up-front capital outlay is large and the economics of operating the system are not attractive. Also the risk of such an investment is very high; delays in the development schedule would result in assets being stranded, and revenues deferred. High capital expenditure, at relatively high risk, combined with the ongoing maintenance role mitigate strongly against the commercial market investing in these technologies, despite the lower on cost per dwelling. For these reasons, substantial capital funding would need to be sourced in order to finance development of a site-wide system, not only to reduce cost to the subsequent developer, but also to send a very strong signal that site energy systems will be supported by the Growth Point.

It should be noted in this context that the existing planning permission for the first 2,900 homes demands no better than Code Level 3 standards, and at this CSH level, site energy systems are more costly than building level measures. Investments are required in the near term to ensure the lowest whole-life cost of development.

4.5 Further phases of the Cranbrook development

The 2,900 homes and commercial / community buildings considered in the foregoing appraisal of site-wide options is the confirmed extent of the Cranbrook New Community. The Regional Spatial Strategy identifies an aspiration for the size of this development to grow to between 6,500 to 7,500 dwellings.

Outline planning permission has been granted for the development of 2,900 homes on the basis of the existing sustainability strategy, which commits to achieving Code for Sustainable Homes level 3 in the residential development and installing biomass boilers throughout the commercial / community buildings.

On the basis of the analysis of site-wide options, it will be difficult to convince developers to go beyond these commitments for the initial 2,900 dwellings, as there is no compelling financial case for the site-wide alternatives. It is likely that significant capital funding (of the order of £ 8 to £ 10M) would be required to incentivise developers to implement a complete site-wide system for the first phase of 2,900 homes.

There is however still scope to influence the standards that are achieved in the next stage of the development, i.e. the further 3,600 – 4,600 dwellings required to achieve the targets of the RSS. Indeed, if these additional dwellings are constructed after 2011, then, in line with the regional objective to introduce the Code for Sustainable Homes on an accelerated programme, these dwellings should be built to Code level 5, which can be achieved in a far more cost-effective manner by the implementation of site-wide systems.

The energy strategy adopted with respect to the further phase of the Cranbrook development will be affected by the location and density at which the additional developments are built. This is as yet undecided, however client discussions have identified the possibility of increasing the density within the existing Cranbrook site boundary, extending the development to the East and extending the development to the South of the existing site. The ramifications of this decision on the energy strategy are discussed below.

4.5.1 Density

The planned density for the first phase of the Cranbrook New Community is, on average across the 3 parcels, around 35 to 40 dwellings per hectare. The analysis of site-wide options has shown that the heat density corresponding to this density of domestic development is not sufficient for the economics of a district heating system to be attractive.

A typically quoted rule-of-thumb for the required density of residential developments for the economics of district heating systems to be viable is 50 dwellings per hectare. This guideline is somewhat out of date and does not account for the reduced heat demand of dwellings built to (recent) high standards of energy efficiency. Code Level 3 of the Code for Sustainable Homes stipulates a 25% reduction in the dwelling's CO₂ emissions compared to a Part L (2006) compliant building (excluding emissions related to electrical appliances). If this reduction is achieved by reduction of the heat load alone, this corresponds to a 63% reduction of heating load compared to Part L. In order to maintain the same heat density as energy efficiency standards are improved from Part L (2006) to CSH L3 will require the density of dwellings to increase proportionately. On this basis, a 50 dwelling per hectare rule-of-thumb density of dwellings becomes a density of 80 dwellings per hectare.

The implication of this analysis is that to improve the viability of district heating schemes in the following phase of Cranbrook it will be beneficial to build at a substantially high density than that proposed for the initial 3 parcels.

4.5.2 Location

One option for locating the additional dwellings is to build within the existing site boundary to increase the density. However, if the initial development of 2,900 homes have been constructed to achieve Code Level 3 by energy efficiency measures or a mixture of energy efficiency measures and renewable generation options (such as solar hot-water heaters or PV), rather than implementation of any site-wide systems, then this will constrain the measures that can be practically applied to the further phase of dwellings. In practice, it is likely that the measures that could be applied to these further dwellings would be limited to energy efficiency and microgeneration measures (as discussed in Section 4.2).

If Cranbrook is to be developed beyond the existing site boundaries, it is likely to be extended to the East or to the South. Considering the relative positions of the development sites, specifically Cranbrook with respect to Sky Park and the IMFF, greater opportunities for site-wide systems would appear to be presented by extension of Cranbrook to the South (see *Figure 35*). Discussion of the opportunities presented by Sky Park and IMFF is given in Section 6.2. Sky Park may be an opportunity for a district heating system, given the higher heat density associated with the accommodation of substantial office and workshop space, together with a large hotel complex, on a relatively compact site. There may be an opportunity to extend a heat distribution network from Sky Park to also serve the IMFF (depending on whether the buildings on this site have any substantial demand for heat) and the Airport terminal. A further opportunity for a joined up system could be presented if Cranbrook were extended in a south / south-westerly direction such that it approaches the Sky Park and Airport Terminal (clearly there may be planning issues related to extension of a residential development too close to the airport).

4.6 Strategic options for Cranbrook energy system

Based on the preceding analyses, there are essentially 3 options for the Cranbrook energy strategy, with differing cost and CO₂ reduction implications.

1. **Site-wide CHP (steam-cycle) and district heating** – this ensures Code level 6 is achieved across the first phase of 2,900 dwellings and further CO₂ reduction from the commercial / community sector (even compared to the base case of individual biomass boilers for each non-resi property). The adoption of this system at the outset will facilitate future extension to achieve similar low-carbon standards in subsequent phases of the development. The initial phase is likely to require funding of around £8 – 10 M.
2. **Town centre DH system** – a town centre DH system will deliver CO₂ reductions in the bulk of commercial / community buildings and in the limited part of the residential development connected to the system. The system could be based around biomass boilers in the initial phase, with scope to add a CHP system at a later date, if the DH system can be extended to serve further phases of the development (i.e. if the further phases are developed to the south of the existing site boundaries). Additional funding of £2 – 4 M required.
3. **Influence later phases through planning requirements** – the initial phase of 2,900 dwellings is built in line with the existing planning consent and sustainability strategy, i.e. Code level 3 in domestic properties and biomass heating in the non-residential boilers. A site-wide energy approach for the subsequent phases is a natural corollary of requirement for homes to be built to Code level 5 from 2011 and should be promoted. Development at higher densities should be encouraged to improve the economics of site systems. Depending on the energy strategies

selected at the nearby commercial developments – Sky Park, IMFF and airport – there may be scope for a wider district heating system.

Summary

- The existing sustainability strategy for the first phase of Cranbrook, for which planning permission has been granted, commits to Code Level 3 in the residential developments and biomass boilers in all commercial buildings. This results in a 10.5 % CO₂ reduction from current Part L and is adopted as the baseline for the assessment.
- The most cost effective means of achieving Code Level 3 is likely to be implementation of basic energy efficiency measures plus a solar water heater.
- Site-wide energy systems – CHP and district heating – provide a more cost-effective means of achieving Code Level 4 and above than combinations of energy efficiency and microgeneration measures (basic energy efficiency improvements are assumed in all scenarios).
- To achieve deep CO₂ reductions – potential for Code Level 6 in the domestic dwellings and reduction of commercial/community emissions to one-third of Baseline emissions – a biomass CHP system is required (2.5 MWe and high load factor operation).
- Site-wide systems are the most cost-effective means to reach high Code Levels and deliver the lowest cost carbon savings (£/tonne). However they are not economically attractive on a commercial basis. Funding of approx £8M is required to attract a commercial operator.
- In line with Draft RSS policy, further phases of Cranbrook are likely to be required to achieve Code Level 5. Site-wide measures will provide significantly the lowest cost means of achieving this. The overall cost of compliance will be reduced by implementing a site-wide system in the first phase and district heating economics will be improved by developing further phases at higher density.

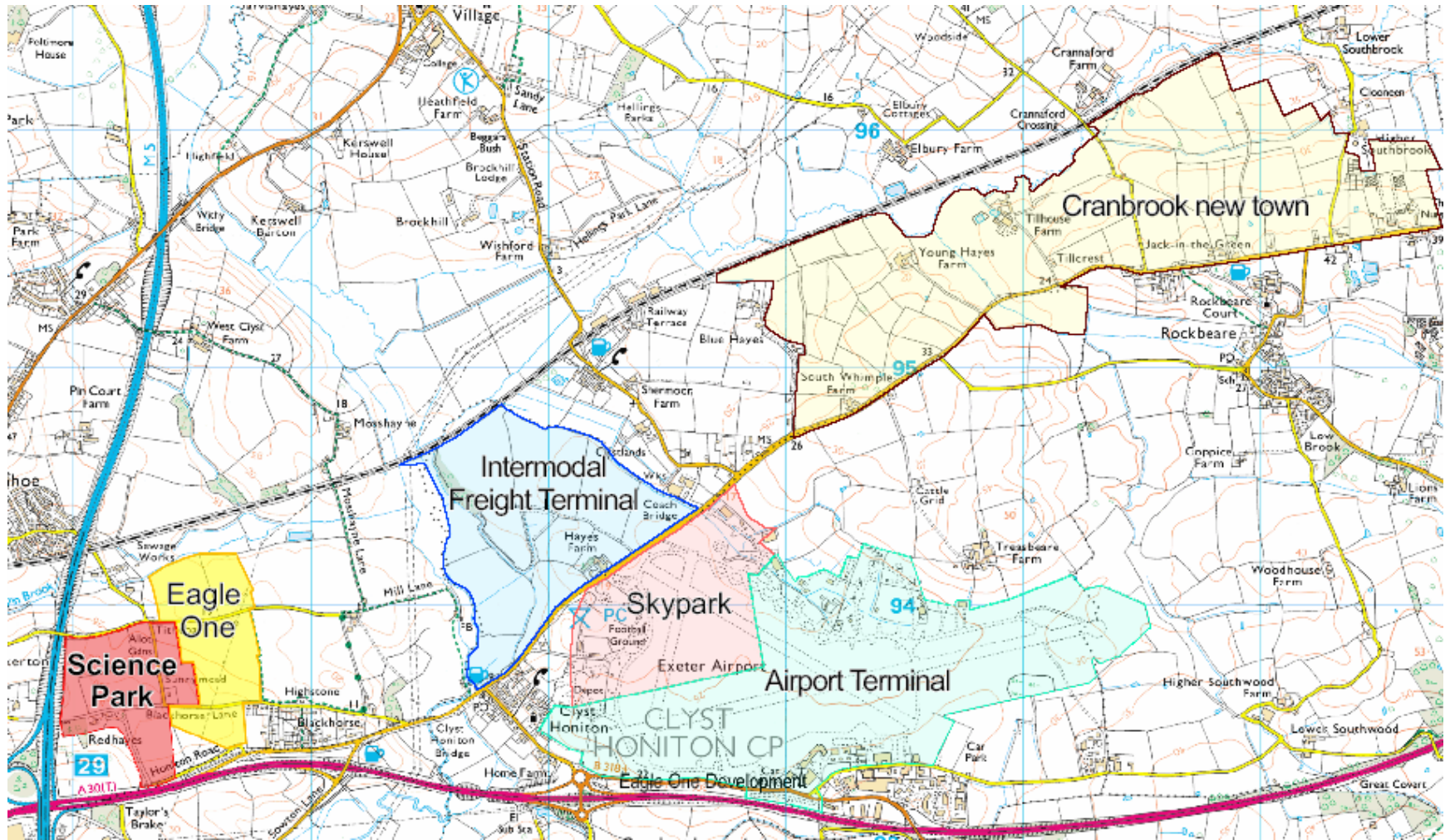


Figure 35, The major development sites to the East of the M5 in the EoENGDP. Extension of Cranbrook new town to the South is may create opportunities for more extensive site-wide systems, connecting Sky Park, Intermodal Freight Terminal (depending on heat loads), Airport new terminal and the extension to Cranbrook (if developed at higher density than the initial phase of 2,900 dwellings)

5 ENERGY STRATEGIES FOR THE DEVELOPMENTS TO THE WEST OF THE M5

The M5 motorway delineates Cranbrook and a number of commercial developments to the east, with the mainly residential developments to the west. As shown in *Figure 1*, these include (with housing figures taken from the Growth Point delivery plan):

- Alphington: 400 homes planned around the village of Alphington
- Exeter city centre: 1550 dwellings
- “Rest of Exeter City”: 4100 dwellings to be built on mainly brownfield sites/urban infills.
- East of Exeter: A wide strip of land adjacent to the M5 motorway with plans for over 4600 dwellings. Specific areas are already identified including:
 1. the Royal Navy Stores Depot: 200 dwellings
 2. ORLN: over 700 dwellings
 3. Joint Area Action Plan: 3000 dwellings on mainly Greenfield sites throughout the eastern edge of the city.

This chapter is concerned with developing an appropriate energy strategy for the sites identified above.

It should be noted that while commercial developments are planned within these areas, at the time of writing there is insufficient information to permit a useful energy analysis to be undertaken²³. Energy analyses on a project by project will be appropriate and necessary as more detailed information becomes available on each site.

5.1 Residential developments

Plans for the development of Cranbrook are very much in advance of any of the sites discussed here. For each site the data available is limited to:

- Total number of houses to be built: see above
- Breakdown of house types: this does differ between sites. Typical flat size is 60m²; typical house size is 90m².
- Construction dates – build rates are assumed to be constant in time
- Build density – although there was not site specific information, Exeter planners advised that a density similar to Cranbrook (34-40 dwellings per hectare) would be typical for these sites.
- The accelerated introduction of CSH levels, as outlined in the draft RSS, is used to define the required code level.

The analysis methodology developed for Cranbrook is repeated for each of the developments identified above. For building mounted technology (such as individual biomass boilers or roof mounted technologies such as photovoltaics) the costs of compliance with the full set of CSH levels, for a range of dwelling types, has been ascertained.

For site energy systems such as district heating, while the lack of masterplanning data for all sites prevents bespoke DH system costing, nevertheless costs may be scaled from Cranbrook and applied pro-rata to each development. This is a valid approach as early stage analysis of DH systems often use rules of thumb based on costs-per-dwelling. Specifically, the cost of CHP/DH systems is split into the network cost and the energy centre cost; this increases the accuracy of the methodology and allows it to be applied widely, including smaller sites such as Alphington and the RNSD.

²³ ‘Core strategy issues and options’, November 2005, <http://www.exeter.gov.uk/index.aspx?articleid=4594>

Supported by the Cranbrook analysis, we can make the following assumptions for energy centres/DH systems:

- If a DH scheme is proposed, it is installed during the 1st phase of development and all homes are connected.
- Cost of DH system (distribution system and connection), per house: £3000
- Energy Centre (biomass boiler)
 1. Development of 500 homes £2500/house
 2. Development of 1000 homes £1500/house
 3. Development of 2000 homes £1000/house

Further assumptions required for the analysis are:

- At high code levels, renewable electricity is a key requirement. Therefore, photovoltaic panels are the preferred technology for building mounted renewables. As a result, building-by-building energy strategies generally represent an upper bound on costs.
- The maximum PV capacity for flats is 2kW, and for houses is 3kW²⁴.
- Where a code level cannot be attained on a house-by-house basis, the model uses the maximum capacity of renewables (PV) available on the building, then a site energy system is sized and used to make up the shortfall.

Given that the same methodology is relevant to all sites, the sections below are focused on site-specific issues, outputs and conclusions. On costs are those related to the draft RSS strategy of accelerated introduction of the CSH.

5.2 Alphington

All dwellings in Alphington will be houses. The planned build rates means that CSH level 5 will be applied.

Compliance via a building-by-building strategy

CSH level 5 achieved with a combination of:

- Fabric measures A
- Micro-biomass boilers
- Photovoltaic capacity as required to meet CSH 5.
- On cost for site cap ex. is £4.53M

Compliance via a site energy strategy

CSH level 5 achieved with a combination of:

- Centralised biomass boiler
- Photovoltaic capacity as required to meet CSH 5.
- On cost for site cap ex. is £4.8M

The on-cost (i.e. above regulatory requirements) for both systems is very similar. However it should be noted that the building-by-building approach requires the use of micro-biomass boilers. This would require each house to be equipped with its own boiler and wood store. This would

²⁴ For flats, this assumes: 60m2 floor area, divided over 3 floors, with 70% of roof area free for PV installations, and with PV panel power density at 130W/m2. For houses this assumes 90m2 divided over two floors, subsequent assumptions are the same as for flats.

have a substantial footprint, and the space (and cost) implications could make this a marginally feasible technology. The heavy traffic movements associated with biomass delivery might not be acceptable. Furthermore, a centralised system would make use of cheaper wood chip, while the micro-biomass boilers would require more expensive wood pellets. Maintenance costs for micro-biomass boilers would also be higher than with a centralised system

For these reasons, while the capital cost implications are secondary, the marginal feasibility and higher on-costs of the building by building approach means that the site energy approach is recommended.

Finally it should be noted that it was not possible to make the building by building model achieve code level 6 compliance; the roof area available for PV is insufficient. The site energy approach effectively future proofs the site against future CO₂ reduction requirements (biomass boilers can be replaced by small biomass CHP systems when this technology matures).

5.3 Exeter City Centre

The dominant development type in Exeter City Centre will be small; the opportunity for large numbers of new build dwellings in a single development are limited. Due to this, site-wide energy systems will be more difficult to implement, as they would require retrofitting to existing developments²⁵. Therefore, building-by-building energy strategies are more appropriate. As noted above, this approach represents an upper bound on costs and all opportunities for reducing this should be investigated for each development.

Build rates imply that code levels 4, 5 and 6 will be required to be met.

Compliance via a building-by-building strategy

- Code level 4 can be achieved using a combination of basic fabric improvements, plus PV. Fabric measures A.
- These dwellings are predicted to struggle to achieve code level 5; adding basic and advanced fabric measures, with whole house ventilation and heat recovery, and a 2kW (max) PV system is required to minimise CO₂.
- The additional cost (over legislation) for all city centre developments is £4.7M

The analysis highlights the challenge smaller developments may have in achieving the highest code levels. CSH level 4 can be achieved effectively, but the difficulty in achieving higher code levels suggests that homes should be built to high levels of fabric efficiency (including reducing external wall air permeability to 3m³/m²/hr and implementing whole house mechanical ventilation and heat recovery) and then supplemented with as much PV as possible. In this way dwellings can achieve substantial carbon savings, even if the required CSH level compliance cannot be achieved.

These developments are expected to rely heavily on photovoltaics as a key compliance technology and available roof areas will need to be maximised to increase PV capacity on each development. Nevertheless this is an expensive way of achieving compliance and there may be alternatives available at each site. Examples include requiring new developments to analyse the feasibility of “assembling” all nearby heat users to develop a localised, communal heating scheme. This would give double dividends; reducing the CO₂ impact of the new development, and also reducing it in existing developments.

²⁵ Note that Element Energy is not advising against this; all opportunities for connecting existing heat users together should be examined, as it is a key technology for reducing CO₂ emissions in existing dwellings.

5.4 Royal Naval Stores depot/ONSD

The construction of 930 dwellings is envisaged for these sites. The phasing of this development suggests that properties will be required to achieve CSH levels 4 and 5. Master planning data was available for the sites and indicates that the sites are to be built to build densities of approximately 35-40 dwellings per hectare. Dwellings are projected to be a mixture of houses (71%) and flats (29%).

Compliance via a building-by-building strategy

- CSH level 4 requires basic fabric measures, plus PV as required.
- CSH level 5 in houses requires basic fabric, micro-biomass boiler and PV as outlined in section 5.2.
- CSH level 5 in flats is not quite achievable, for the reasons outlined in section 5.3. Advance fabric measures, whole house mechanical ventilation and heat recovery, with the maximum available area for PV, should be encouraged.
- On cost (relative to legislation) for the building by building approach is £5.28M.

Compliance via a site energy strategy

- CSH level 4 achieved with a biomass boiler.
- CSH level 5 requires this to be supplemented with PV.
- On cost for site cap ex. is £5.8M

As with Alphington, the analysis shows that capital on-costs are similar between the building-by-building approach and the site energy approach. For the reasons outlined in 5.2 (better feasibility and lower on costs), the site energy approach is recommended.

5.5 JAAP

3,000 dwellings are planned for green belt land under the Joint Area Action Plan. Phasing projections in the EEDNGPDP suggest that virtually all the properties will be built to CSH levels 5 and 6. Master planning data is unavailable, however it is envisaged that the sites will be low rise (mainly houses) and built to low spatial densities similar to the densities at the RNSD/ORLN and Cranbrook sites (in keeping with the nature of the area).

In contrast to Alphington and the RNSD, the greater house numbers implies that a site-wide biomass CHP system with DH may be suitable. This point is strengthened if significant numbers of properties are built in close proximity to the Digby and RNSD/ORLN sites, which could also be connected to the system. Biomass CHP systems would operate in a similar way to those suggested at Cranbrook and would allow the attainment of the highest code levels (possible PV supplementation required for smaller flats at CSH 6). However, the economic viability and logistical suitability of the system is entirely constrained by the accurate geographical layout of the sites to be served by the system, and unfortunately little data is available in this regard.

Compliance via a building-by-building strategy

Flats

- As described in previous sections, code 4 can be achieved with basic fabric measures plus PV.
- Code levels 5 and 6 cannot be met. Advanced fabric measures + maximum roof space for PV is required.

Houses

- Code 4 achieved with basic fabric measures and PV
- Code 5 achieved with the addition of micro-biomass boilers

- Code 6 is not achieved

Projected on cost for the building by building approach is £8.1M

Compliance via a site energy strategy

- Code 4 achieved with a site wide biomass system
- Code 5 achieved with an addition of building mounted PV as required to meet the target
- Code 6 may be achieved with centralised biomass CHP systems.

Projected on cost for the site energy approach: £8.2M

Ultimately, the strategy here is similar to that for Alphington (up to code 5) and then Cranbrook (to get to code 6), in that a key technology is a district heating network. The main technology difference between the two is that a centralised CHP system is required for code 6 instead of a centralised boiler. As shown in the analysis for Cranbrook, the largest cost element is the district heating system and replacement of a biomass boiler by a CHP system is the most cost effective means of achieving compliance with very high code levels.

5.6 Rest of Exeter City

Developments falling under this heading are projected to be mainly smaller in size and therefore (from an energy perspective) similar to the developments in section 5.3 (city centre). Hence site energy strategies are not included here (although all opportunities to develop site systems and integrate with existing properties should be investigated on a case by case basis.

Dwellings are required to meet CSH levels 4-6 depending on the year of development.

Compliance via a building-by-building strategy

Flats

- As described in previous sections, code 4 can be achieved with basic fabric measures plus PV.
- Code levels 5 and 6 cannot be met. Advanced fabric measures + maximum roof space for PV is required.

Projected on cost for the building by building approach is £16.4M

5.7 Summary of strategies for residential developments

The suggested low carbon strategies for the residential sites under the EEDNGPDP are summarised below:

Residential site	Number of Homes	Suggested low carbon strategy	Code Level achieved
Alphington	400	Large, centralised biomass boiler + DH + dwelling PV supplementation	5
Exeter City Centre	1,550	Extensive fabric efficiency measures + PV installation to meet Code requirement	4 - 6 depending on time of construction
RNSD (phase 1) + RNSD/ORLN	930	Large, centralised biomass boiler + DH + dwelling PV supplementation	4 - 5
JAAP	3,000	Large, centralised biomass boiler + DH + dwelling PV supplementation	5
Rest of Exeter City	4,100	Extensive fabric efficiency measures + PV installation to meet Code requirement	4 - 6 depending on time of construction

Figure 36, Summary of the low carbon strategies proposed for each of the residential developments in the Growth Point to the west of the M5.

Summary

- For the purposes of an energy strategy, developments west of the M5 fall into two categories, those that will comprise mainly small developments and flats, and those where a substantial (i.e. many hundreds) of dwellings are projected.
- In most cases, the capital cost of complying with the regions accelerated CSH introduction is predicted to be similar, whether a building-by-building approach or site energy approach is taken. However a site energy approach is likely to have lower running costs and also avoids a number of barriers related to feasibility.
- For Alphington, RNSD and JAAP, centralised biomass boilers with district heating is recommended as the core of an energy strategy, supplemented with PV where needed.
- For Exeter city centre, and the “east of Exeter” sites, a building-by-building approach requires very high standards of fabric design and maximum roof area for PV. All options for reducing cost of compliance, such as using new developments to bring together existing heat users into small localised networks, should be examined.

6 COMMERCIAL DEVELOPMENTS

6.1 Science Park

The Science Park development is a key plank in the economic development strategy for the Exeter area. The intention is to create a hub for innovation that will foster new business opportunities and create local employment. The Park will be closely aligned with the strategic objectives of the University and the Met Office, both of which seek commercialisation opportunities for their core research activities.

Local planning policy stipulates that employment developments of over 1000 m² should incorporate sufficient renewable energy generation to provide at least 20% of the site's energy needs. However, there is an aspiration to go well beyond this target at the Science Park and create an exemplar, zero carbon business park. The technological solutions required and financial implications of achieving these aims are discussed in this section.

6.1.1 Development plan

It is intended that the Science Park will occupy a 50 hectare site located immediately to the north-east of the intersection between the M5 and A30. The site will host a combination of approximately 77,000 m² of office / laboratory space (split between two phases), a hotel and the Eagle One Employment site, which will provide a further 90,000 m² of office and light industrial space.

The breakdown of building uses proposed across each phase of the development is tabulated below:

	Net internal floor area (m ²)	Known scheduled completion dates
Phase 1		
Office / laboratory	12,620	Feb 2013
Hotel	8,640	April 2010
Phase 2		
2a	51,450	
2b	12,500	
Eagle One employment site		
Office	54,000	June 2010
Light industrial	36,000	

Figure 37, Table of proposed floor areas for each building type in the Science Park and Eagle One employment site.

The growth in energy demands on the Science Park site has been projected based on an estimated 10 year build programme for the site and good practice benchmarks for energy consumption, as shown in the chart below.

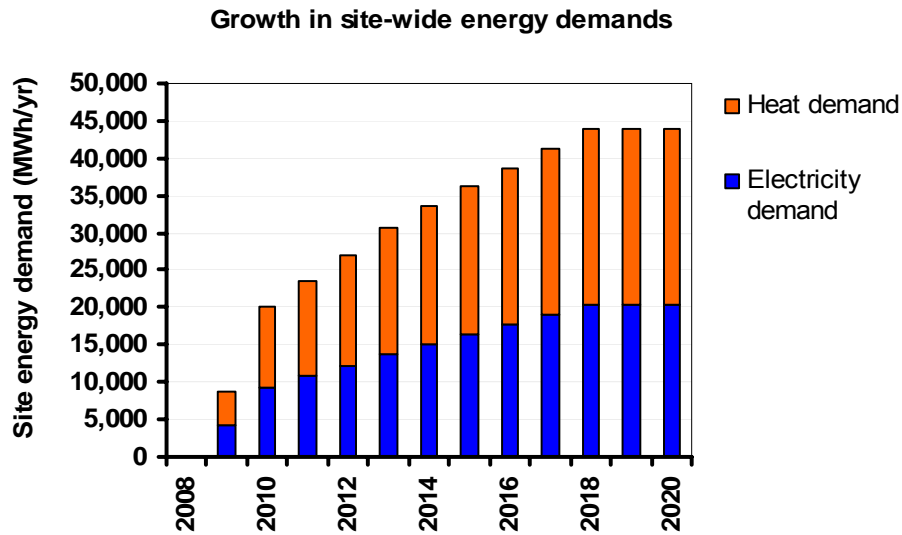


Figure 38, Growth of heat and power demands on the Science Park site as the site is developed.

The total (baseline) energy demand of the site once the build has been completed is slightly less than 45,000 MWh/yr, approximately 55% of which can be attributed to thermal energy demand.

The corresponding growth of CO₂ emissions generated by the site is shown in the chart below.

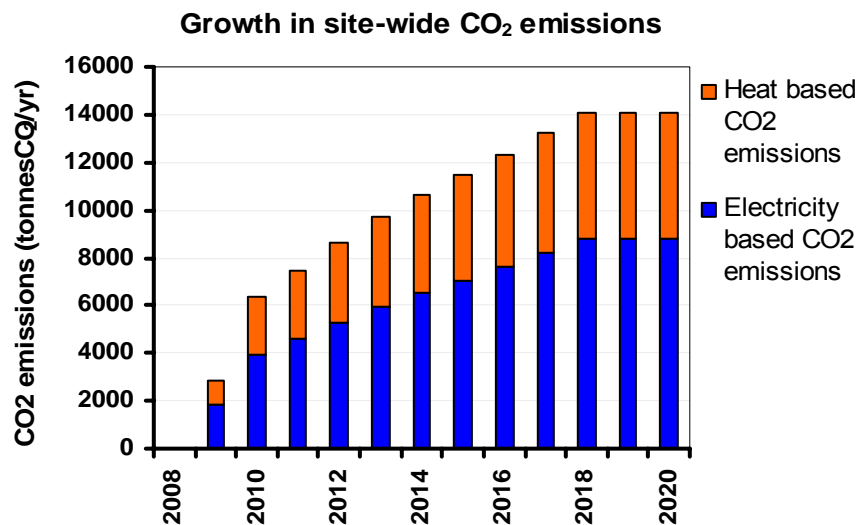


Figure 39, Growth of CO₂ emissions assuming a 10 year build of the Science Park site.

Based on the energy demand projections above, sufficient renewable energy must be generated on site to reduce CO₂ emissions by 2,800 tonnes/yr in order to meet the 20% policy. In order to achieve the aspiration of a zero carbon development, sufficient renewable generation will be

required to offset just short of 14,000 tonnes CO₂ per year (once the site is fully developed and occupied).

The implications of meeting these renewables targets are explored in the following section.

6.1.2 Renewables options appraisal

6.1.2.1 Wind energy

Installation of a wind turbine array is potentially one of the most cost-effective means of generating a substantial fraction of the site’s energy requirements. The approximate required generating capacity to make a 20% renewable energy contribution to reduction of the site’s carbon emissions are tabulated below, together with some indicative costs.

In the absence of monitored data a load factor of 0.3 is assumed. Capital costs for wind turbines have been rising, the analysis below reflects this with an installed price of £1500/kW for a single MW scale turbine. Large groups of turbines would be able to dilute infrastructure costs.

	Installed wind capacity	Indicative capital cost	Annual CO ₂ saving (tonnes/yr)	NPV
20% renewables contribution	2.5 MW	£ 3.75 M	2785	- £ 0.97 M
Zero carbon development	12.3 MW	£ 18.35 M	13,600	- £ 4.7 M

Figure 40, Required wind capacity and cost implications of the two levels of renewable energy contribution to the site.

The installed capacities and costs tabulated above assume that relatively large-scale turbines are installed (around 1 MW capacity turbines). The South West Renewable Energy Atlas²⁶ (which includes a 5km exclusion zone around Exeter Airport) suggests that there are few of any suitable sites for large scale wind turbines in the EEDNGP developments. As the atlas is only a screening tool, more detailed analysis (outside the scope of this work) is needed to confirm this conclusion. An extensive wind energy assessment accounting for local constraints and wind speeds would need to be carried out to assess feasibility.

A larger array of smaller-scale turbines could be installed, however these small-scale turbines have higher capital costs (on a £/kW basis) and lower efficiencies, hence the overall economics are considerably poorer than for larger scale turbines.

6.1.2.2 Photovoltaics

It is not feasible to attempt to create a zero carbon development through the installation of photovoltaics alone. The installed capacity of PV required to offset the nearly 14,000 tonnes CO₂/yr that the site will create is approaching 40 MW.

A sensible constraint on the capacity of PV that could be installed on the site is the availability of roof area. At the current time there are no site plans for the Science Park development from

²⁶ Wardell Armstrong, commissioned by Regen South West and Government Office for the South West.

which roof areas can be measured, however, based on the total net floor areas and some assumptions regarding the number of storeys, it is possible to make a very rough approximation of what roof area will be available. Based on these approximations, the following estimation of the potential contribution of PV to the site’s energy demands have been made:

Roof area available for PV (m ²)	Peak installed capacity (MW)	Annual electricity generation (MWh)	Annual CO ₂ saving (tonnes)	Contribution to site’s energy requirements	Capital cost of PV	NPV
44,000	5275	4,485	1,900	10%	£ 23-24 M	- £16.75 M

Figure 41, Estimates of the annual renewable electricity contribution that photovoltaics could deliver, assuming blanket coverage of the site’s roof space (assuming flat roofs).

A maximum contribution from PV of around 10 % of the site’s requirements has been estimated. However, the costs associated with achieving this level of renewable contribution through PV installation alone are very high.

6.1.2.3 Ground source heat pumps

Ground source heat pump systems collect low-grade heat from the ground (average ground temperature is 8 – 13 °C), increase it in temperature via a heat pump and exchange the heat with a building’s internal heat distribution system. The heat pump system can meet a significant fraction of the building’s heat demand, but increases electricity demand as electricity is required to drive the pump. The system reduces overall energy requirements as some ‘free’ heat is being taken from the ground (typically co-efficients of performance for well-designed systems are between 3.5 to 4).

The ground coupling can be done in a variety of ways. For closed loop systems, which circulate heat transfer fluid around pipes buried in the ground (the alternative open-loop systems extract and re-inject ground-water), the two main options are slinkies, which are long-lengths of coiled pipe buried in shallow trenches, or vertical boreholes. The selection between slinkies and boreholes is dependent on space availability, soil conditions and local geology among other factors. On a site such as Science Park, where a substantial number of units are to be built on a relatively compact site, boreholes may be more appropriate than slinkies. These boreholes can be to depths of 50 to 100 m, depending on the geological conditions, and can be expensive to drill (£5-10k per hole). The number of boreholes depends on peak thermal requirements and depth of holes.

Ground source heat pumps could make a useful contribution to the site’s energy needs, however would need to be installed in conjunction with other technologies (e.g. PV or wind) in order to address the CO₂ emissions from the site’s electrical loads.

6.1.2.4 Biomass

A more appropriate renewable resource from which to generate a substantial contribution of the site’s energy demand may be biomass. Investigation of the local biomass resource (see Appendix C) has indicated that there is adequate potential for supply of wood fuel from sustainable forestry and potential to establish energy crops such as miscanthus to supply biomass energy projects of significant scale in the area.

There is scope for biomass to be used in a variety of ways in the Science Park development, resulting in varying renewable contributions to the site’s energy demands and with varying implications for the biomass resource requirements. In this section, the installation of biomass boilers in individual buildings is considered as a means of meeting the renewables targets laid out in planning policy. In the following section the opportunities for site-wide biomass projects are considered.

If biomass boilers were to be installed in individual buildings, the appropriate capacity of plant (based on estimations of the floor area of each unit) is likely to be in the 100 – 200 kW range. Some budget cost estimates for wood-fuelled boilers in this size range have been obtained. The capital costs of the systems depend on the type of fuel, i.e. wood pellet or wood chip, and type of fuel storage system that is installed. Some indicative capital costs are tabulated below.

Capacity	100 kW		200 kW	
	Wood pellet	Wood chip (up to 50% wet)	Wood pellet	Wood chip (up to 50% wet)
Pellet silo (blown in)	£ 38 k		£ 58 k	
Subterranean (tip in)		£ 74 k		£ 84 k
Container (hook lifted)		£ 110 k		£ 120 k

Note: the budget costs above exclude a number of significant cost elements, including civils, craneage and offloading, electrical installation and flues.

Figure 42, Budget capital costs for wood chip and pellet boilers (from Wood Energy)

Pellet boilers tend to be favoured for small-scale systems, due to their lower capital costs, less bulky and more easily handled fuel. However, the cost of wood pellets (circa £180/tonne) is significantly higher than typical wood chip cost (£35/tonne), such that wood chip systems become more economic for larger systems. Whole life cost calculations for pellet and woodchip boilers suggests that 100 to 200 kW is around the size range where the cross-over between the most economical technology occurs.

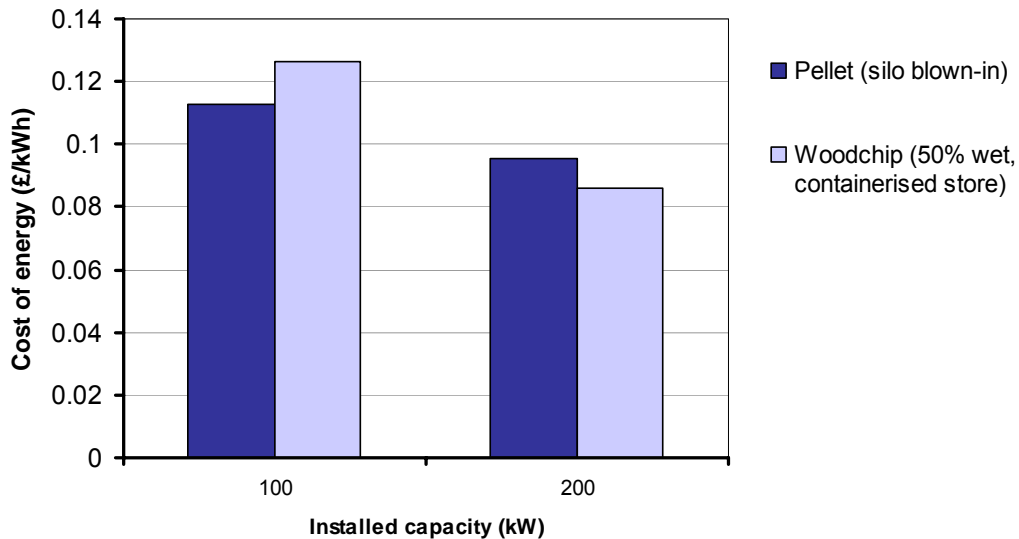


Figure 43, Annualised (whole life) cost of heat delivered by wood chip and pellet boilers in the 100 to 200 kW size range.

Based on the costs of energy presented above, the annual additional cost of reducing CO₂ emissions by 20% via biomass boilers installed in an appropriate fraction of the site’s buildings would be between £ 0.75 M to £ 1.1 M per year.

An alternative approach to provide a larger fraction of the site’s energy requirements would be through a centralised system. This would also be more practical in terms of fuel storage and the logistics of fuel delivery. The site-wide biomass options are explored in more detail below.

6.1.3 Site-wide systems

In order to achieve a higher penetration of biomass into the site’s energy supply and therefore deliver deeper CO₂ reduction it is likely to be more practical and potentially more cost-effective to consider site-wide measures. There are a number of options for how biomass could be used in centralised plant, briefly introduced below:

- Centralised biomass boilers** – In order to meet the heating needs of the site wholly with biomass, approximately 15 MW of centralised boiler plant would be required in combination with a district heating network. This system would address around 55% of the site’s overall energy requirement (responsible for 37% of the site’s CO₂ emissions under base case assumptions, although some CO₂ emissions must also be attributed to the use of biomass fuels, e.g. those related to fuel transport).
- Biomass CHP and district heating** – A larger contribution to the site’s energy requirements may be made with a biomass CHP system, as this would address heating loads and generate renewable electricity. However, the CHP system would not meet the whole heat load (assuming it were sized to operate in a heat load following mode, consistent with achieving good quality CHP accreditation) and so the overall CO₂ reduction would be dependent on the fuel used in the peak load boilers, e.g. biomass or natural gas.

- Biomass power generation** – A biomass electricity generator could be installed and operated at high utilisation to maximise electricity production. Given the proximity of the heating loads, it would still make sense to use as much waste heat as possible to meet the site’s heat loads (via the district heating system), however when operated in this mode, some heat will be rejected. The system could be sized to generate sufficient renewable electricity and useful heat to create a zero carbon development, however the implication of heat rejection is that the efficiency of use of the biomass resource is lower than under the other options.

In each of the technology options described above it is assumed that heat will be delivered from an energy centre to buildings on the business park via a district heating network. This is a significant infrastructure investment, as discussed below.

6.1.3.1 District heating system budget cost

Due to the relatively compact nature of the Science Park site, it may provide a more economically viable opportunity for a district heating system than the largely residential developments (based on the load assumptions, the heat density is more than double that of Cranbrook, for example).

As there is currently no masterplan drawing for Science Park to indicate the layout of buildings on the site, any estimation of the cost of a district heating network must be based on a large number of assumptions and should therefore be treated as only indicative. The estimated network cost, including offsets for avoided boiler plant and natural gas infrastructure, is given below.

Length of distribution pipe	5,000 m
Length of branch pipe	560 m
Number of commercial connections	56 units
Costs	
Distribution pipe cost	£2,500,000
Branch pipe cost	£140,000
Cost of heat exchangers	£560,000
Project management / contingency	£480,000
Total	£3,680,000
Avoided costs	
Boiler plant	£266,875
Avoided natural gas connetions	£140,000
Total avoided costs	£406,875
On-cost of district heating system	£3,273,125

Figure 44, Estimation of the cost of a district heating network for the Science Park site compared to the cost of conventional heating plant and natural gas infrastructure.

The on-cost of a district heating system to serve the whole site, compared to a conventional natural gas network and individual boiler plant, is estimated at around £ 3.25M. This capital outlay is recouped through sale of heat to the site’s tenants over the network. Although the investment in the heating network can be somewhat spread over the early years of the development (as the phases are developed), maximum revenue from heat sale is not generated until the site is fully occupied. Phased development of the network and modularised central

boiler capacity can reduce the economic impacts of this. Nevertheless, it should be recognised that a heat distribution network will have a useful economic life well beyond the period considered in a typical investment appraisal (although major replacements of the central thermal plant will be required at circa 15 year intervals).

6.1.3.2 Technology options

Broadly the technology options for the centralised plant have been characterised as heat only boiler plant, heat-led CHP plant (with either biomass or gas-fired peak boiler plant) and electrically-led CHP (i.e. essentially an electricity generator with use of as much waste heat as possible).

When operated in a heat-load following mode, CHP systems are generally sized such that they will achieve at least 5,000 full load equivalent run hours per year. As discussed in the analysis of site-wide options for the Cranbrook development, although steam-cycle systems are by far the most mature technology option for biomass CHP, there is a lack of available products at less than 2.5 MWe plant capacity. As is the case for Cranbrook, the implication is that available steam systems are over-sized for the thermal demands of the Science Park development. As a result, an organic rankine cycle based CHP technology has been considered for installation at the Science Park²⁷.

In the case of the electrically-led system, a steam-cycle technology has been considered as a capacity of 2.5MWe (or more) is appropriate. A controlled extraction steam turbine could be used in this system, which will allow some high temperature and pressure steam to be extracted at the inlet of the turbine in order to meet the site’s heat loads (this will reduce the plant’s electrical efficiency slightly).

Approximate capital costs have been estimated for each of the main options for the centralised plant, tabulated below.

Technology option				
CHP type	None	500kWe ORC	500kWe ORC	2.5MWe steam
Boiler type	Biomass	Natural gas	Biomass	Natural gas
Cost component				
CHP system	£0	£1,800,000	£1,800,000	£4,999,500
Boiler plant	£2,663,997	£413,997	£1,913,997	£415,108
CHP connections	£50,000	£100,000	£100,000	£100,000
Energy centre	£400,000	£700,000	£700,000	£750,000
Fees / contingency	£467,100	£452,100	£677,100	£1,252,922
Total energy centre cost	£3,581,096	£3,466,096	£5,191,096	£7,517,530

Figure 45, Capital cost estimations for energy centres based on various plant options.

Economic appraisals for each of these options have been performed, based on the capital costs of central plant and heat distribution network described above and assumptions on the growth of thermal loads (see Figure 38). A number of other key assumptions made in the economic assessments are tabulated below. Note that heat and electricity sales would be subject to negotiation with tenants, and indicative figures are used in the analysis.

²⁷ Biomass-fuelled ORC CHP systems are available at 500 kWe capacity (with a peak thermal output of approx 2.7 MWth)

Biomass cost	£ 35 / tonne (based on wood chip at 50% moisture content)
Heat sale tariff	40 £ / MWh
Electricity sale tariff	40 £ / MWh
Base ROC price	45 £ / MWh
ROC band assumptions	2 ROCs/ MWh for good quality CHP 1.5 ROCs / MWh for biomass electricity gen.
Discount rate	10%
Period	15 years

Figure 46, Key assumptions made in the analysis of site-wide biomass options

The economic appraisals are summarised in the chart below. The chart shows the present value of each of the major cost and revenue items over the 15 years of the project appraisal for each of the systems assessed. The final set of bars (far right of the chart) indicate the Net Present Value of investment in each system (including district heating network), i.e. the sum of present cost of the preceding cost / revenue items discounted at 10%.

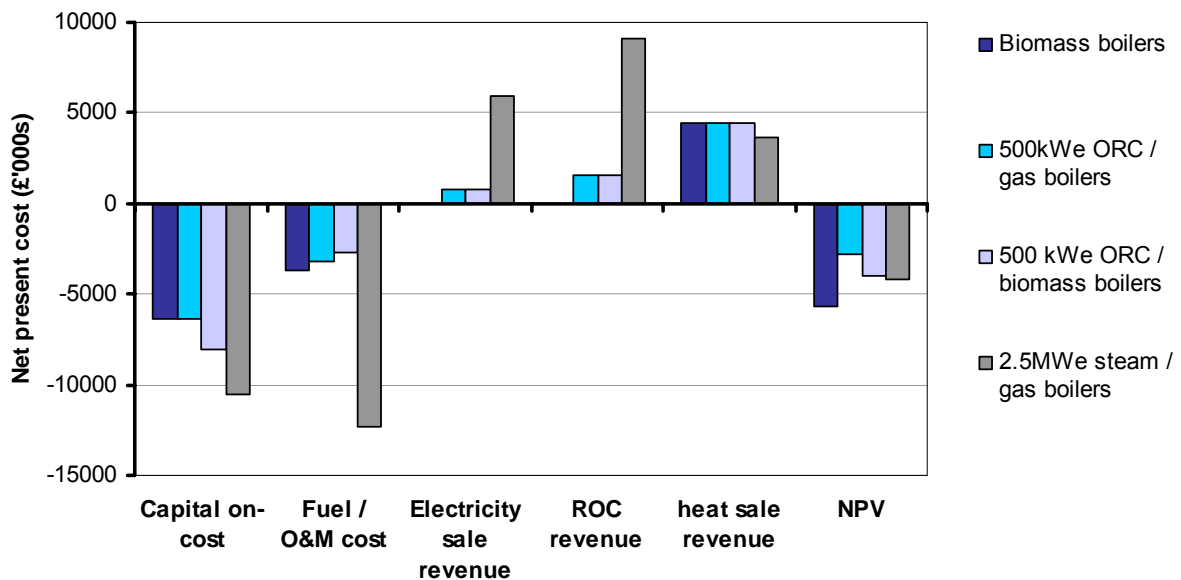


Figure 47, Summary of the economics of each of the site-wide biomass options.

All systems are NPV negative over the 15 year period, ranging from - £ 2.8 M for the ORC CHP with gas-fired peak boilers to - £ 5.7M for biomass boiler plant without CHP.

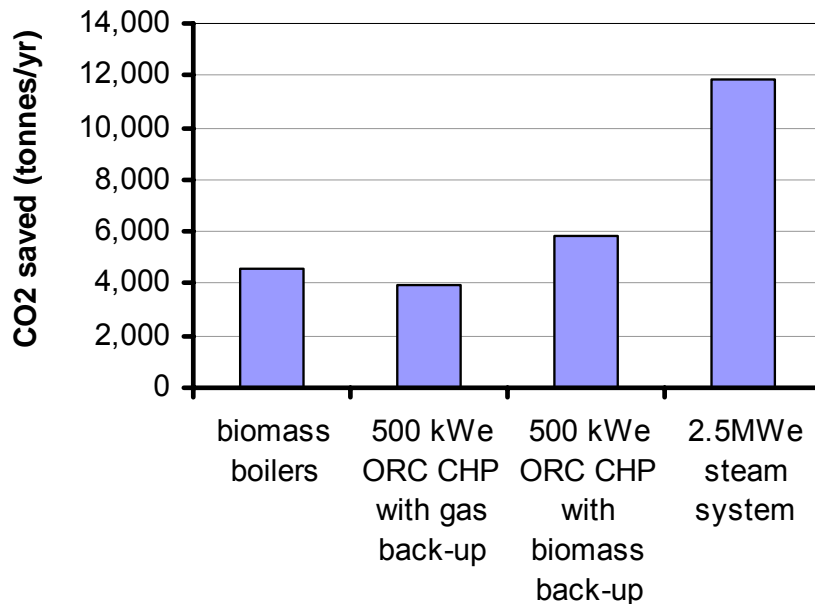
In the case of the heat only system, the revenues through sale of heat are insufficient to pay off the large infrastructure costs. Although the district heating network has a useful life beyond the scope of the appraisal, major costs for refitting of the boiler plant will be incurred.

In the case of the CHP systems, a relatively conservative estimate for the value of sale of electricity has been made of £ 40/MWh. This tariff is based on export to the grid, whereas a

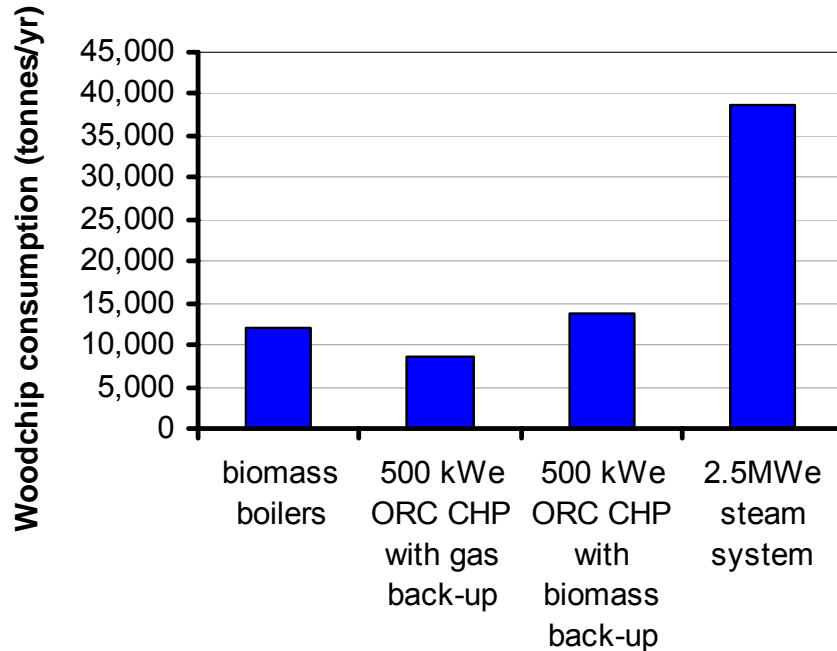
higher value may be obtained if a licence exempt supply company were set-up to supply electricity to the site’s tenants (either over an embedded or private network or over public wires). This may be a significant upside in the case of the 2.5 MWe electricity-led system, although will have diminishing impact on the economics of the ORC systems, where the electricity output is much less.

Overall, the economics will be sensitive to electricity revenues, the value of ROCs (and ROC band, for example the electrically-led generator could be eligible for 2 ROCs/MWh if fuelled by energy crops, such as miscanthus) and to the price paid for biomass fuel, however the net result of these sensitivities is unlikely to change the conclusions on economic viability. In this light, the installation of these site-wide energy systems at the Science Park must be driven by environmental rather than economic benefits. There is currently no regulation in place to enforce such far-reaching carbon reduction initiatives in commercial developments and so public funding may need to be made available to incentivise developers to go beyond planning commitments.

The environmental performance of the four site-wide options are highlighted in the charts below, in terms of annual CO₂ saving and biomass resource consumption.



(a) Annual CO₂ reduction compared to the base case. Figures assume that the whole site is occupied.



(b) Annual resource requirement assuming that each system is fuelled with woodchip at 50% moisture content (assuming whole site is occupied).

Figure 48, Comparison of the annual CO₂ savings and biomass resource requirements of the site-wide biomass options.

The 2.5 MWe system delivers a CO₂ saving of slightly less than 12,000 tonnes/yr, which is around 90% of the projected carbon footprint of the site and approaches the zero carbon aspirations. However, it should be noted that due to the rejection of heat in this system the overall efficiency of use of the biomass resource (i.e. useful energy delivered / total energy content of biomass consumed) is around 45%, compared to 80 to 90% efficiency for the heat-led CHP and heat-only plant (these efficiency figures do not account for losses in the district heating network).

6.1.4 Overall comparison of renewable generation options

The site-wide biomass options have been compared against the other options for delivering significant renewable energy generation for the site. The common metric used for this analysis is the cost of carbon saved, in terms of lifetime £/tonne CO₂.

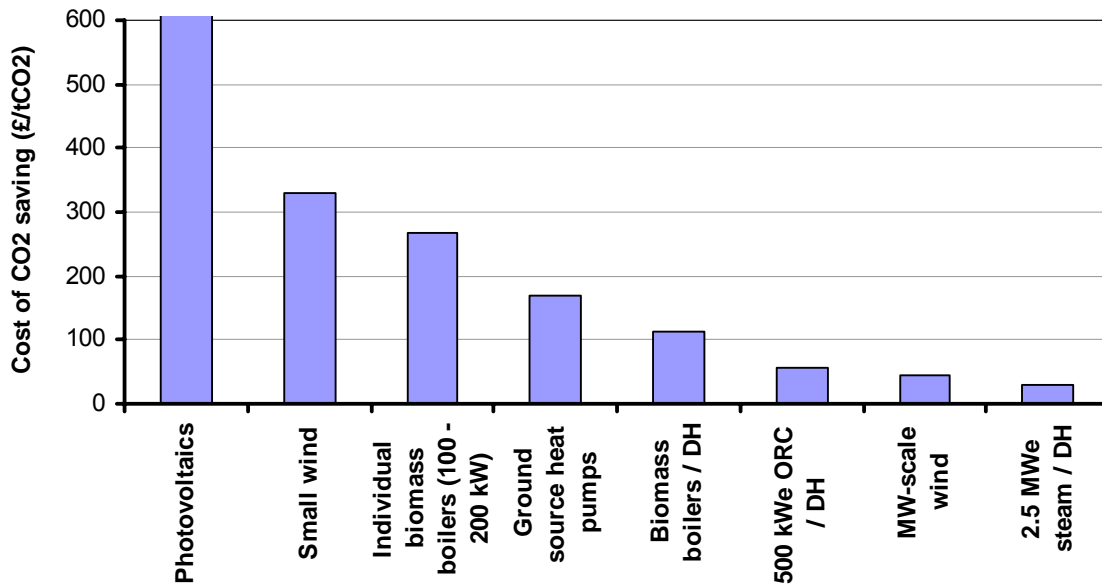


Figure 49, A comparison of all the renewable and low carbon options on the basis of the cost of carbon saved, i.e. lifetime tonnes of CO₂ saved per pound spent.

The lowest cost method of delivering carbon saving is the installation of a biomass electricity generator with use of waste heat via a district heating network. This system can also deliver close to the zero carbon aspiration for the site, however a substantial biomass resource is required and the efficiency of use of the resource is lower than in the other options.

The only other option that could deliver the zero carbon aim is a wind farm, however, planning permission for an array of large wind turbines is not thought likely in this area.

A biomass CHP system with district heating network is the most appropriate method of achieving deep CO₂ reductions on the Science Park site. This could be a heat-led good quality CHP or electrically-led generator with use of some waste heat. The selection between these options may be influenced by availability of capital, a more detailed investigation into the capability of the local biomass supply chain and the importance attached to efficiency of biomass use (relative to CO₂ saving).

The additional capital outlays for the 500 kWe ORC CHP and 2.5 MWe steam systems, including the district heating network, are £ 6.75M and £ 10.75M respectively. The NPV of the systems are - £ 2.8 M for the ORC system (assuming gas back-up) and - £ 4.1M for the steam system.

6.2 Sky Park and the Intermodal Freight Facility

6.2.1 Sky Park

The energy demands and carbon dioxide emissions attributable to the Sky Park development, once completed and assuming traditional fossil fuel energy supplies, are tabulated below:

Use	Benchmarks		Floor areas (m ²)			Annual consumption		CO ₂ emissions	
	Gas consumption (kWh/m ² /yr)	Electricity (kWh/m ² /yr)	Phase 1	Phase 2	Total (m ²)	Gas (MWh/yr)	Electricity (MWh/yr)	Heat (tonnes/yr)	Elec. (tonnes/yr)
Office	120	120	50,320	58,100	108,420	13,010	13,010	2,472	5,490
Light industrial	150	72	27,731	23,700	51,431	7,715	3,703	1,466	1,563
Hotel / leisure	240	80	0	11,126	11,126	2,670	890	507	376
Total			78,051	92,926	170,977	23,395	17,604	4,445	7,429

Figure 50, Breakdown of floor space for various uses and corresponding energy demands for the Sky Park development

The energy demands of the Sky Park site are fairly similar to those of the Science Park development and therefore, the conclusions on the most cost-effective method of making substantial reductions in the carbon emissions are also similar.

The cost of a district heating system for the Sky Park development is expected to be slightly less than that for the Science Park, as the site is somewhat more compact. Based on the masterplan layout and using the same assumptions for heating pipe and heat exchanger cost as previously stated, the estimated on-cost for a district heating system to serve the Sky Park development is £ 1.6 M.

Regional planning policy states that employment developments of over 1,000 m² should incorporate sufficient renewables to provide 20% of the site's energy demands. As discussed in the previous section, the cost of doing this would be significant. An alternative to installation of renewable generation that can also deliver carbon savings is the installation of gas-fired CHP.

A capital cost estimate for a 1.5 MWe gas-fired CHP system is shown below.

Cost component	Cost	Notes
CHP system	£750,000	
Boiler plant	£361,129	
CHP connections	£100,000	Gas and electrical connection
Energy centre	£425,000	Including civils, thermal storage and balance of plant
Fees / contingency	£245,419	
<i>Energy centre sub-total</i>	<i>£1,881,549</i>	
<i>On-cost of DH system</i>	<i>£1,600,000</i>	
Total cost	£3,481,549	

Figure 51, Estimate of the capital cost for a gas-fired CHP system and district heating system for the Sky Park site

Including the on-cost of the district heating system, the gas-fired CHP and heat network requires a capital investment estimated at £ 3.5 M. The 500 kWe ORC biomass CHP system discussed in the analysis of Cranbrook and Science Park would also be appropriately sized for this application. The cost of the biomass ORC CHP energy centre was estimated in Section 4.3.2 at £3.5 M, approximately £1.6 M more than the cost of the gas-fired system.

The economics of the two options have been compared, as shown in the chart below.

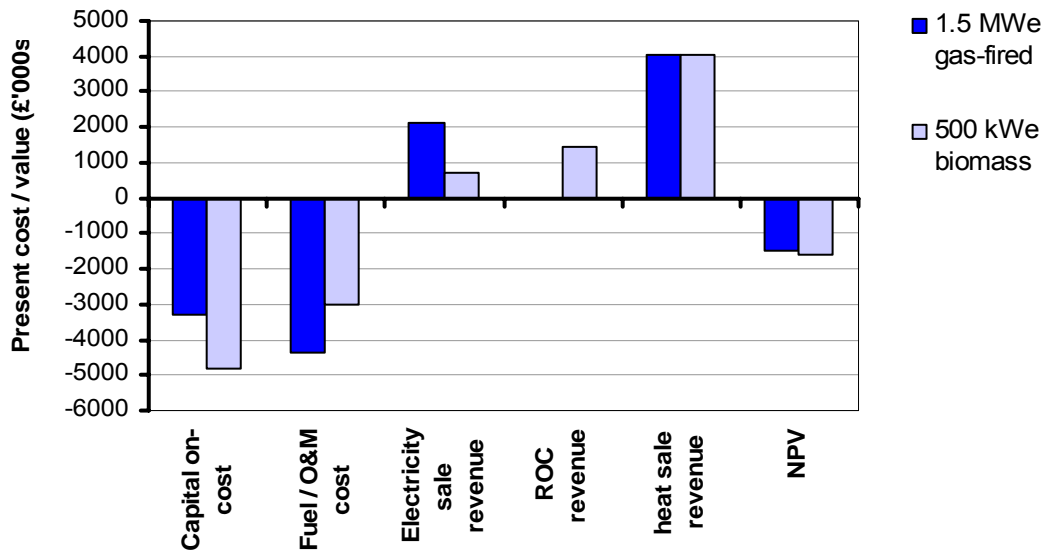


Figure 52, Summary of an economic comparison between a gas- and biomass-fired CHP system (with district heating) to meet the Sky Park heat loads.

Despite the higher capital cost of the biomass system, the overall economics (over a 15 year assessment period) of the two options are fairly close. This is a result of the ROC revenue generated by the biomass system (which compensates for the lower electricity generation by the ORC system) and the lower cost of biomass fuel.

The economics of the biomass system are sensitive to the biomass price assumption, which in the analysis illustrated above was set at £35/tonne (assuming 2.3 MWh/tonne, approximately consistent with 50% moist woodchip). An alternative fuel is miscanthus. BiCal has indicated that a rough price for miscanthus is £ 50/oven dried tonne. Due to the higher energy content of oven dried material this is a lower price than has been assumed in the above analysis and would result in superior economics for the biomass system (NPV of around - £ 1M). However this is an extremely low price for delivered biomass fuel and at this time a more pragmatic fuel price figure is used.

The gas-fired system is predicted to deliver an annual CO₂ saving of 1,885 tonnes/yr at a cost of £53/tonne. This is just over 15% of the CO₂ emissions that the site would be expected to emit under base case assumptions and so falls slightly short of the 20% target. The biomass-fuelled systems is predicted to cut emissions by 3,800 tonnes/yr, which is by just over 30%. Under the current assumptions, the cost of carbon saving by the biomass system is around £30/tonne.

6.2.2 Intermodal freight facility

There is limited information on the use and occupancy of buildings planned for the intermodal freight facility and as a result the appropriate strategy for the site is unclear at present.

The site will provide up to 156,500 m² of storage and warehousing space split between two phases. Outline planning permission has been obtained for phase 1, which will consist of up to 4 storage units providing 65,750 m² storage space (and a railway siding to facilitate the transfer of freight from rail to road). This should be constructed by 2011. Phase 2 is planned to be constructed in 2015/16 and will provide a further 90,740m² of storage space, with some ancillary office space.

The critical factor to the energy strategy for this site will be the level to which these units are serviced, in particular whether they are substantially heated or whether they are largely unheated storage space.

Good practice benchmarks for heating fuel consumption in storage / warehouse space range from 187 kWh/m²/yr for occupied space, which is comparable to that of workshop space, to 54 kWh/m²/yr for unoccupied storage space. Based on the phase 1 and phase 2 floorspace areas, this gives an annual heating fuel consumption range of 8,500 to 30,000 MWh/yr.

Clearly at the upper bound of this range the site would constitute a considerable heat load, comparable to Science Park or Sky Park and would demand consideration of a similar energy strategy, i.e. a site-wide heat network potentially with a biomass fuelled central plant. At the lower end of this range, the heat load would be insufficient to merit investment in a site-wide system.

In the case that the IMFF were to create a heat demand towards the upper end of the range discussed above, then there could be an opportunity for a common heat network to serve both the Sky Park and IMFF sites. Additional investment in the heat network would be required to serve the IMFF site, but the cost of the energy centre would be shared. The additional heat load would allow greater CHP operating hours, with increased heat revenue, electricity revenue and ROC revenue (assuming that the system is biomass fuelled).

The economics of two potential biomass CHP systems to serve the combined Sky Park and IMFF site are shown below. The systems assessed are the 2.5 MWe steam-based system – under upper bound assumptions for the heat load from storage / warehouse space the heat load of the combined sites is just enough to justify this scale of plant – and a 1 MWe ORC CHP system.

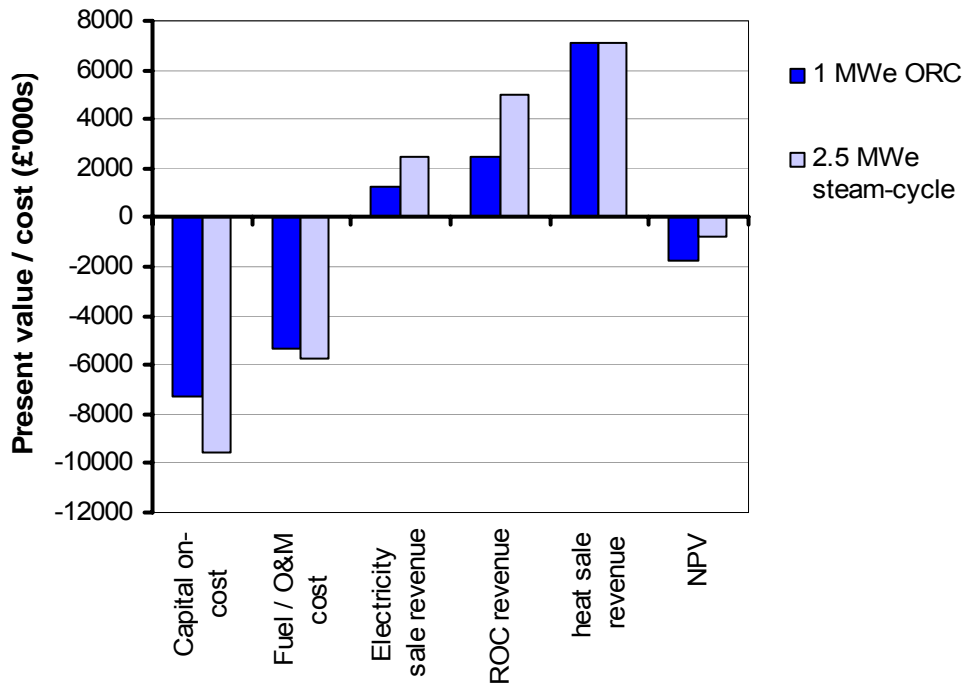


Figure 53, Economics of two options for biomass-fuelled CHP systems with an extended district heating system to serve both the Sky Park and Intermodal Freight facility. The analysis is predicated on the assumption that the IMFF provides a large amount of heated floorspace, rather than unheated warehousing (it is not currently clear that this will be the case).

The additional heat load of the IMFF could considerably improve the economics for a combined system compared to a system serving only the Sky Park site. In the case of the 2.5 MWe biomass system the NPV, although negative, is less than - £ 750,000 over the 15 year assessment period and has a simple payback period of 10 -11 years (assuming the capital costs tabulated in Figure 26).

Clearly these economics are highly dependent on the assumption that the IMFF facility has a substantial heating requirement, which will not be the case if the majority of the floor area is untreated storage space.

6.3 The airport

Exeter Airport is situated to the centre and south of the area analysed in this report.

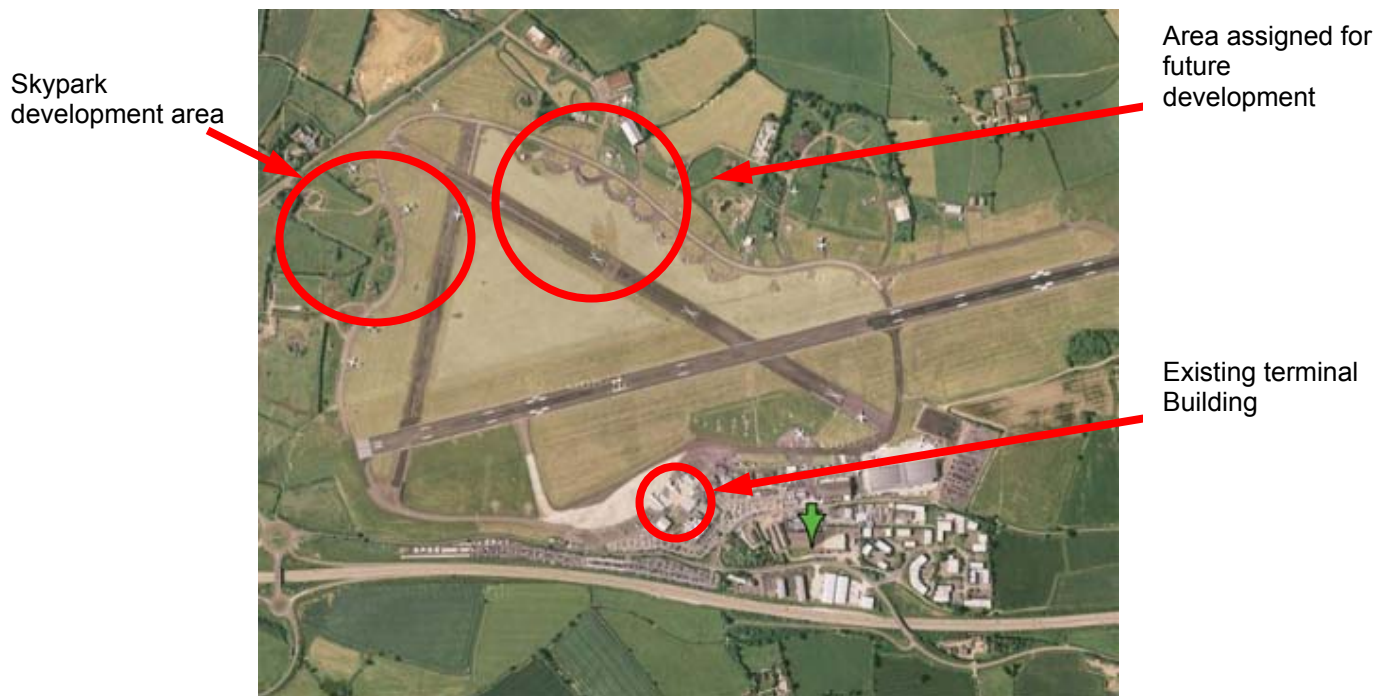


Figure 54, Aerial image of the airport, highlighting the area earmarked of future development and its relationship to the proposed Sky Park site.

As shown in the image above, the existing terminal building is to the south of the main runway. According to the most recent masterplan received, additional passenger numbers will be accommodated by an incremental expansion of the existing terminal building.



Figure 55, More detailed image of the existing airport terminal. The current proposal is to develop a new terminal building on the west side of the existing plot.

A more detailed view of the airport is above, showing the extent of the existing developments at the airport. According to the latest masterplan drawings from Balfour Beatty, the new terminal developments will be grouped around the existing terminal building, which is on the western extent of the airport site.

The Sky Park development area is considered in the preceding section. The area adjacent to the Sky Park, earmarked for future development is large in extent but there is very little information available on the developments planned there. The masterplan developers have indicated that developments on this site would be very different from the adjacent Sky Park, and would most likely include car parking and some industrial buildings.

We are also aware of the potential for a Flybe training academy and administration centre to be set up at the airport. It is believed that this would be of a significant size, however no further information was available at the time of writing. 2

6.3.1 Energy Loads

Exeter airport is currently used by circa one million passengers per annum. The expansion plan for the airport is to have 2 million passengers by 2015, and for 3 million by 2030. Following communication with the masterplan developers, energy data is only available for the existing terminal building. The table below shows the existing and projected energy loads and carbon emissions for the terminal buildings only. By 2015, the new developments are assumed to achieve a 50% energy efficiency increase, relative to the existing buildings. Thereafter, remaining terminal expansions are not thought to be able to achieve significant energy reductions.

	Units	2008	2018	2028
Passenger numbers		1,000,000	2,000,000	3,000,000
Expected efficiency savings		50%	50%	50%
Resulting energy relative to previous period		1.0	1.5	1.5
Annual Electricity consumption	kWh	2,982,184	4,473,276	6,709,914
Annual Gas/oil consumption	kWh	521,797	782,696	1,174,043
Electricity CO2 intensity	kg CO2/kWh	0.422	0.422	0.422
Gas/oil mix CO2 intensity	kg CO2/kWh	0.250	0.250	0.250
CO2	Tonnes per annum	1,389	2,083	3,125

Figure 56, Anticipated growth in energy consumption and related CO₂ emissions with growing passenger numbers at the airport.

6.3.2 Carbon reduction potential

The most important issue arising from the energy loads is the very large electricity load and a relatively small heat load by comparison. This is thought to be due to the number of electrical services required on site, such as extensive airport and runway lighting.

6.3.2.1 Heat producing and co-generation technologies

This very high power to heat ratio greatly restricts the relevance of heat producing technologies in reducing carbon emissions at the airport development. This limits the relevance of CHP, GSHP, solar thermal, and biomass systems. For example, the figures below show data on a CHP system, sized to produce all the heat required at the existing airport development:

CHP system capacity: 50kW electric
 Heat to Power ratio: 2:1
 Overall efficiency: 85%
 Full load run hours: 6000 per annum
 Electricity produced: 240,000kWh/year
 Heat Produced: 480,000kWh/year
 CO₂ offset: 194,400 kg CO₂ per annum
 CO₂ emitted by CHP: 160,941 kg CO₂ per annum
 Net saving: 33,459 kg CO₂ per annum
 CO₂ saving as %: 2% of Terminal CO₂ emissions

The high power to heat load ratio on site limits the size of the CHP system to 50kW, and this small size limits the scale of the potential carbon savings to just 2% of the projected site emissions.

With the current information, it can be concluded that heat producing and cogeneration technologies such as CHP will not contribute to significant reductions of carbon emissions at the terminal building. Please note that this conclusion is specific to the terminal building only, and should other developments of a significant scale proceed at the airport (the Flybe building for example) the analysis would need to be repeated to include them.

6.3.2.2 Renewable electricity technologies

The high power to heat ratio suggests that the focus for onsite renewable energy generation should be via renewable electric technologies. The table below shows the requirements for either photovoltaic or wind turbine technologies to supply the annual electricity requirements.

Electric demand	2,982,184	kWh/annum
PV system size	3,500	kWp
PV system output	2,975,000	kWh/kWp
PV system area	25,926	m ²
PV system cost	14,000,000	£
Wind system capacity	1.1	MW
Wind system output	2,890,800	kWh/annum
Wind system cost	880,000	£

Figure 57, Estimation of the required PV or wind turbine plant capacity to supply the annual electricity requirements and an approximation of the capital costs.

Just over 1MW of wind energy would be required to supply the electrical requirements of the airport terminal, (based on its current level of consumption) at a cost of circa £1million. A 3.5MW PV system would be required to supply the same energy, at a cost of circa £14million.

Development of a large wind system at the airport has questionable feasibility. Also the high cost of the PV system is a significant barrier to deploying this technology. Nevertheless, should the UK government adopt a feed-in tariff system for supporting distributed generation – as is being discussed at present – then this could encourage the development of large scale PV energy farms similar to those in Germany. An array of this size could be easily accommodated on the airport site, although care would need to be taken to avoid glare.

6.3.2.3 Site energy systems

Given the limited data available for the rest of the site, it is not possible to conclude the feasibility of a site energy system linking some or all of the buildings on site. Retrofitting site energy/ district heating systems to existing buildings is very rare, and so the potential for site energy to occur lies with any new large developments on site.

Given that the planned airport terminal developments are to the south of the main runway, and that the terminals heat load is relatively low, this suggests that a southerly extension of a future DH system, originating at the Skypark, to service the terminal building may be unlikely (the heat network would have to traverse the runway).

Summary

- MW-scale wind turbines or district heating systems with biomass CHP plant will provide the most cost-effective carbon reduction for the commercial sites. Detailed wind energy assessments will be required to define if large wind systems are viable.
- District heating systems are closer to commercial viability on business parks such as Sky Park and Science Park as there is a higher heat density and fewer individual points of connection.
- There is currently no strong legislation to deliver CO₂ reductions in commercial developments (akin to the Code for Sustainable Homes). However, enforcement of Draft RSS policy (20% renewable energy contribution to emissions reduction and overall reduction of 34% in 2011 to 2015 and 44% from 2016 onwards) is expected to lead developers to consideration of site-wide systems as these will be amongst the lowest cost solutions.
- To meet policy RE5 (20% reduction of regulated emissions by onsite renewables) by use of biomass in site-wide systems will require an annual biomass resource of approximately 7,500 to 9,500 odt/yr (assuming biomass heating or heat-led CHP). An assessment of local biomass resource (see Appendix C) suggests that this demand could be met by local woodfuel resources or by development of miscanthus supply in the area.
- In order to achieve the very low carbon aspirations of sites such as Science Park (in the absence of large-scale wind power) will require biomass CHP operated in an electrically-led mode. Electrically-led operation results in rejection of heat and therefore less efficient use of the biomass resource.
- The proximity of the Sky Park and Intermodal Freight Facility raises the possibility of a common heat network across the two sites. This would enhance the economic viability of the scheme. To fully assess the feasibility of this, greater detail on the likely usage and heat loads of the IMFF buildings is required.
- The airport expansion presents a different challenge as the energy demand is very heavily electricity led. Installation of PV, both on the new terminal building and retrofit to existing buildings, is one way of providing renewable energy contribution, although the cost implications are significant. The viability of large wind systems requires a feasibility assessment.

7 ELECTRICITY TRADING AND PRIVATE WIRES

In the UK, electricity generators and suppliers have to declare the volumes of electricity they will generate or supply in each half-hour period one hour in advance of that period. If they do not meet these declared positions they are forced to buy additional power or sell the excess at penal rates. Typically therefore the value paid for electricity from distributed generators has been low as the output is unpredictable relative to centralised, dispatchable generating plant (e.g. coal or gas-fired power stations). This is particularly the case for renewable generators such as wind turbines and photovoltaics where the output is dependent on weather conditions and is therefore inherently unpredictable. In the case of a CHP system, particularly as part of a district heating system with buffering by thermal storage, the output can be managed in a more predictable way. For this reason, the electricity generated by CHP systems may attract a higher value when sold to an electricity supply company than would generation from a wind farm or PV array.

The value of electricity generated by distributed generators can be increased if it is sold directly to consumers rather than to an electricity supply company. In particular, sale of electricity to domestic customers can attract the highest prices. An indication of the retail electricity price for different types of consumers is given in *Figure 58*.

Domestic customers	8 – 11 p/kWh
Small commercial	5.5 – 9 p/kWh
Large commercial	4 – 6.5 p/kWh
Sale to the electricity grid	4 p/kWh

Figure 58, Indicative retail electricity tariff for various types of user

Clearly it would be beneficial for the economics of distributed generators if electricity can be sold directly to local customers. There are essentially two ways that this can be done that differ in the way the electricity is distributed from generator to customer:

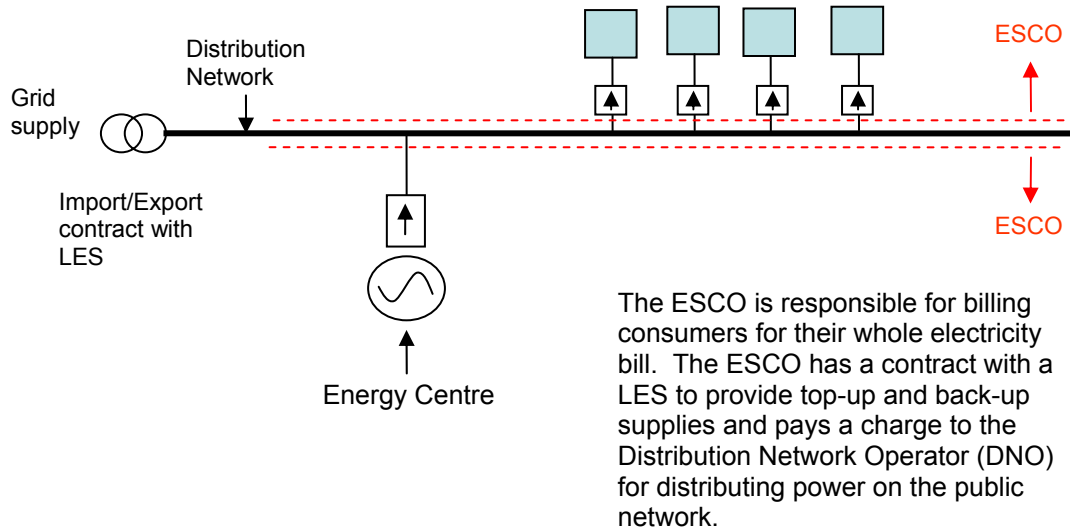
- Distribution via the public electricity network (the 'grid').
- Distribution over a 'Private Wire' electricity network

These two principles are illustrated in *Figure 59*.

In this section the ways in which a higher value could be obtained for the output of distributed generation are explored. As an essential background to this discussion, it is necessary to understand the licensing regime for electricity generation, distribution and supply and, in particular, the exemptions from these licenses that can be granted to small-scale operators.

Options for distribution and sale of distributed generation to consumers

Sale of electricity from a distributed generator using the public distribution network



Sale of electricity to consumers over a Private Wire system

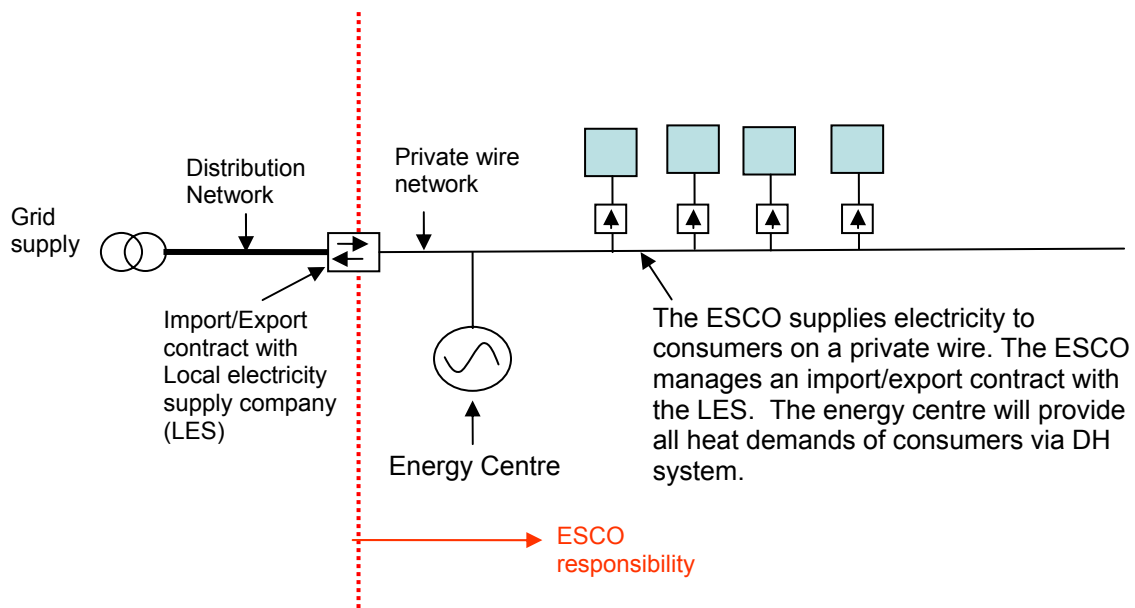


Figure 59, Schematic illustrations of two potential mechanisms for selling electricity from an embedded generator to local customers.

7.1 Licensing regime

The vast majority of electricity that is generated, distributed and supplied in the UK is done so under licence and separate licences are granted for these three activities. This licensing regime is key to the regulation of the UK electricity market. However, in certain circumstances organisations wishing to generate, distribute or supply electricity (or to undertake combinations of these activities) can be granted an exemption from the requirement to hold a licence. Primarily, these licence exemptions are intended to minimise the regulatory and cost burden on small-scale generators, distributors or suppliers, particularly in the following circumstances:

- Small generators selling their output to a local supply company
- Industrial estates with embedded generation, where there is a desire to distribute the electricity via an on-site private wire to other users on the site.
- Industrial suppliers with generating plant at one site that wish to supply excess electricity to one of their other sites using the public distribution network (i.e. via a licensed distributor)
- Local authorities that operate CHP plant at one of their facilities and wish to supply electricity to other sites without becoming a license electricity supplier.

Licensed operators are forced to pay a number of charges, which relate to the operation of the transmission and distribution system, the regulation of the electricity market and the losses associated with transmitting power over large distances. These charges include:

- **TNUoS (Transmission Network Use of System)** – charges levied for the use of the high voltage national transmission system
- **DUoS (Distribution network use of system)** – charges levied for the use of the medium voltage distribution system
- **Balancing charges** – charges relating to the balancing of electricity and demand on the national grid system
- **Transmission and distribution losses** – physical losses of electricity due to the inefficiencies of the electrical distribution system.

Licensed exempt operators of distributed generators, supplying electricity to local consumers can avoid these charges. As less of the retail price of the electricity is swallowed by the various charges, a higher cost of generating electricity can be withstood. In this way, exemption from the licensing regime supports innovative and more expensive electricity generation technologies. This is illustrated in the graphic in *Figure 60*, which shows the make-up of the retail price of electricity supplied by a licensed supplier to that of electricity supplied by a licensed exempt supplier over a private wire network.

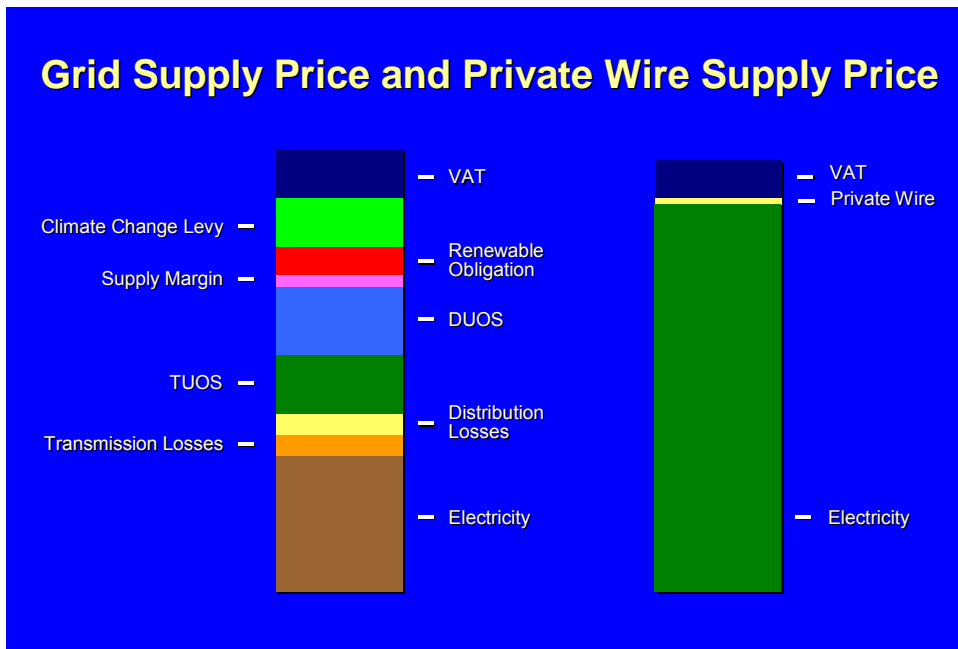


Figure 60, Comparison of the composition of the electricity supply price between a licensed supply company and a license exempt supplier supplying over a private wire.

In the case that electricity were distributed using the public network, the license exempt supplier would pay some DUoS charges, so the cost of generating electricity that could be withstood (essentially the price that can be paid to the generator) is reduced to some extent.

7.1.1 License exemption conditions

In order to qualify for an exemption, certain limits on the amount of electricity that can be generated, distributed or supplied must be adhered to. The limits on generation are not typically relevant to community energy projects (the limit is well above plant capacities typically encountered in these schemes), much more relevant are the limits with respect to distribution and supply, which are particularly stringent with respect to domestic consumers.

A brief summary of the main conditions for exemption from the three licenses is given below:

Activity	Exemption conditions
Generation	The plant does not provide more than 10 MW (or 50 MW where the plant has a net capacity of less than 100 MW). Power supplied to and used by a single consumer (or certain qualifying groups of consumers) on the same site as the plant may be disregarded in calculating the 50 MW figure.
Distribution	Distribution of electricity for supply to domestic customers does not exceed 2.5 MW. Distribution for supply to domestic customers on-site does not exceed 1MW.
Supply	Supply of electricity may not exceed 5 MW in aggregate of which no more than 2.5 MW can be supplied to domestic customers. If electricity is supplied to customers on the site of the generating station or on a remote site via private wires, then up to a total of 100MW may be supplied, of which no more than 1 MW may be supplied to domestic customers.

Note: 1 MW of electricity is roughly equivalent to supplying or distributing electricity to 1,000 households.

Figure 61, Summary of the conditions for exemptions from licenses to generate, distribute and supply electricity

Clearly these limits have some implications for the options for sale of electricity directly to consumers from distributed generation installed within the new developments in the Exeter area.

- **Operation as an exempt supplier using the licensed distribution network** – the relevant limit on the volume of electricity that could be supplied to domestic customers from a single generator, such as a CHP system, is 2.5 MW (around 2,500 households).
- **Operation as an exempt supplier on a private wire network** - In the case that a private wire network were installed to supply the domestic customers, the relevant limit on distribution and supply from the embedded generator drops to 1 MW, or approximately 1,000 households.

7.2 Private Wire and Electricity trading opportunities in EEDNGP

Sale of electricity directly to consumers may enhance the economics of a CHP/DH system, particularly in those developments where the bulk of electricity will be supplied to domestic consumers. The sites where district heating systems with cogeneration might have a role in the East of Exeter developments are Cranbrook New Community, the commercial developments to the East of the M5 and potentially the greenfield developments in the East of Exeter City area (RNSD, ORLN and JAAP sites). Consideration should be given to the potential impact of a private wire electrical system on the economics of community energy systems in these developments.

7.2.1 Private wire costs

There is a large capital expenditure associated with providing electrical connections to all buildings in a new development. This expenditure can be divided between the cost of the on-site electrical infrastructure, i.e. the cabling, transformers, switchgear and meters, and the cost of any off-site reinforcement to the local electricity network required to bring an adequate capacity supply to the site, this can involve new cabling or overhead lines (at 11 or 33kV) and upgrades to transformers and switchgear in the local substation.

Under usual circumstances, without a private or embedded electrical network, the cost of the on-site works will be entirely borne by the developer. The costs of the off-site infrastructure upgrades are split between developer and local distribution network operator (DNO) using a simple apportionment rule, whereby the developer pays a contribution to the off-site costs in proportion to the fraction of the new capacity that is used by their site. The local DNO then takes over responsibility for the on-site system (in most cases the DNO will have installed the system, although some of the works may be contracted out to third parties).

Any organisation, such as an Energy Services Company (ESCO), developing a private wire system would pass on the costs of the on-site infrastructure and off-site reinforcement to the developer, as would the DNO. There will be some additional infrastructure requirements associated to the private wire system and connection of distributed generation to the system – additional metering, switchgear and cabling – that would be borne by the ESCO, however these are likely to be fairly small compared to the overall infrastructure cost. Indeed, the ESCO may be in a position to benefit from some saving in the cost of electrical infrastructure through cross-subsidy with the DH system costs, e.g. laying of cables and DH pipes in common trenches will reduce the costs of excavating and filling trenches. Overall the capital on-cost to the ESCO associated to installation of the private wire system should not be large, although there will be ongoing costs associated with billing, metering and demand balancing (i.e. managing the top-up/back-up contract with the local supply company)

7.2.2 Impact of private wire systems on project economics

In earlier economic appraisals of CHP / DH systems it has been assumed that all electricity generated by the CHP system is sold to the an electricity supply company (at a rate of £40/MWh).

In the private wire case, demands of buildings connected to the private wire network are met by the CHP electricity as far as is possible (attracting retail electricity prices of supply to domestic or commercial customers). Surplus CHP electricity is sold to the local electricity supplier, and top-up electricity required to meet demand additional to the CHP electricity (i.e. in periods for which there is no generation or where demand exceeds CHP generation) is purchased from the local electricity supplier and fed into the private wire network.

The improvement of overall project economics that can be derived by implementation of a CHP system is therefore dependent on a number of factors, relating to the developments electricity load profiles and the characteristics of the CHP system.

Sale value of electricity – Clearly a higher proportion of high value consumers (e.g. domestic) will be beneficial. A more subtle factor is the difference between the sale price to the consumers and the price of top-up supplies charged by the local electricity supply company – on a largely residential development this may be significant, whereas on a commercial development the margin on selling on top-up supplies will be reduced.

Amount of on-site consumption provided by CHP – The largest margins are gained by sale of CHP electricity to consumers, so the best economics will be achieved where a high fraction of the

site’s demand is met by the CHP engine. For CHP systems operating in a heat-matched mode, this will tend to favour low heat to power ratio systems.

Split between on-site consumption and export of CHP electricity – A high proportion of on-site usage, i.e. sale to consumers rather than to the local electricity supply company, is beneficial. When the CHP operates in a heat-matched mode, this will be dependent on the match between the site’s heat and electricity demand profiles.

The interplay of these factors on the economic benefit of private wire has been assessed for a typical residential and commercial development – Cranbrook and Sky Park.

7.2.2.1 Cranbrook New Community

The cashflow analysis of the site-wide (i.e. 2,900 dwellings) CHP/DH system at Cranbrook has been extended to include a private wire network. Scenarios involving a 2 MWe / 2.4 MW_{th} gas system and a 0.5 MWe / 2.4 MW_{th} biomass-fuelled system have been assessed. The results of these economic analyses are presented in Figure 62.

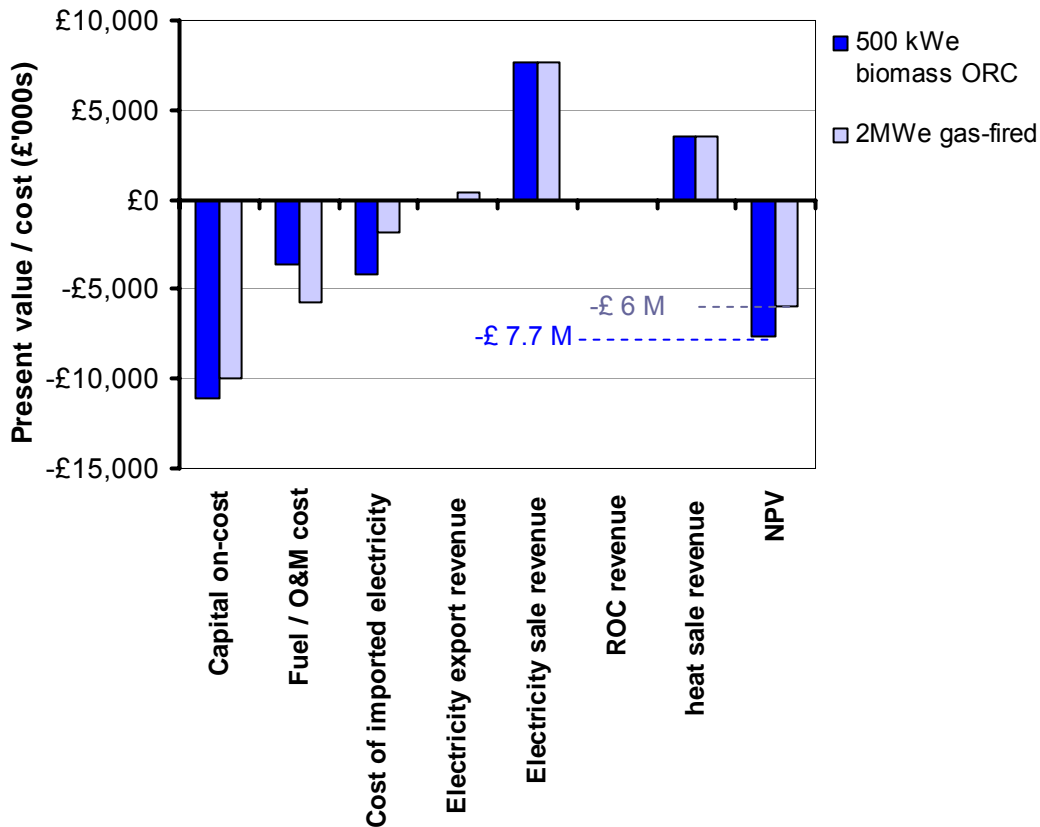


Figure 62, Summary of the economics of the Cranbrook district energy system (Site-wide) including direct sale of electricity to consumers over a private wire.

In both the gas-fired and biomass-fired case, the improvement in overall economics is of the order of a present value of ~£ 2.3M. The 500 kWe biomass system would make a smaller contribution to meeting the overall site electricity load, however as the site is largely residential it

has been assumed that electricity can be sold on to consumers at a margin compared to the price paid for top-up supplies. A higher price for the top-up supplies will diminish the economic benefit of the private wire system more rapidly in the case of the biomass system and the economics will be more vulnerable to fluctuations in the price of top-up supplies.

The analysis suggests that a private wire electrical system will deliver an economic benefit in largely residential sites such as Cranbrook or the JAAP/RNSD & ORLN sites. However the scale of the benefit will not be sufficient to alter earlier conclusions on overall economic viability.

7.2.2.2 SkyPark

The economic benefit from operating a private wire alongside the CHP / DH system has been assessed for Sky Park, a typical commercial development. Similarly to the case for Cranbrook, the economics have been assessed for two scenarios, one involving a gas engine CHP system and one involving a biomass-fired system with a significantly higher heat to power ratio. The economic analyses are summarized in Figure 63.

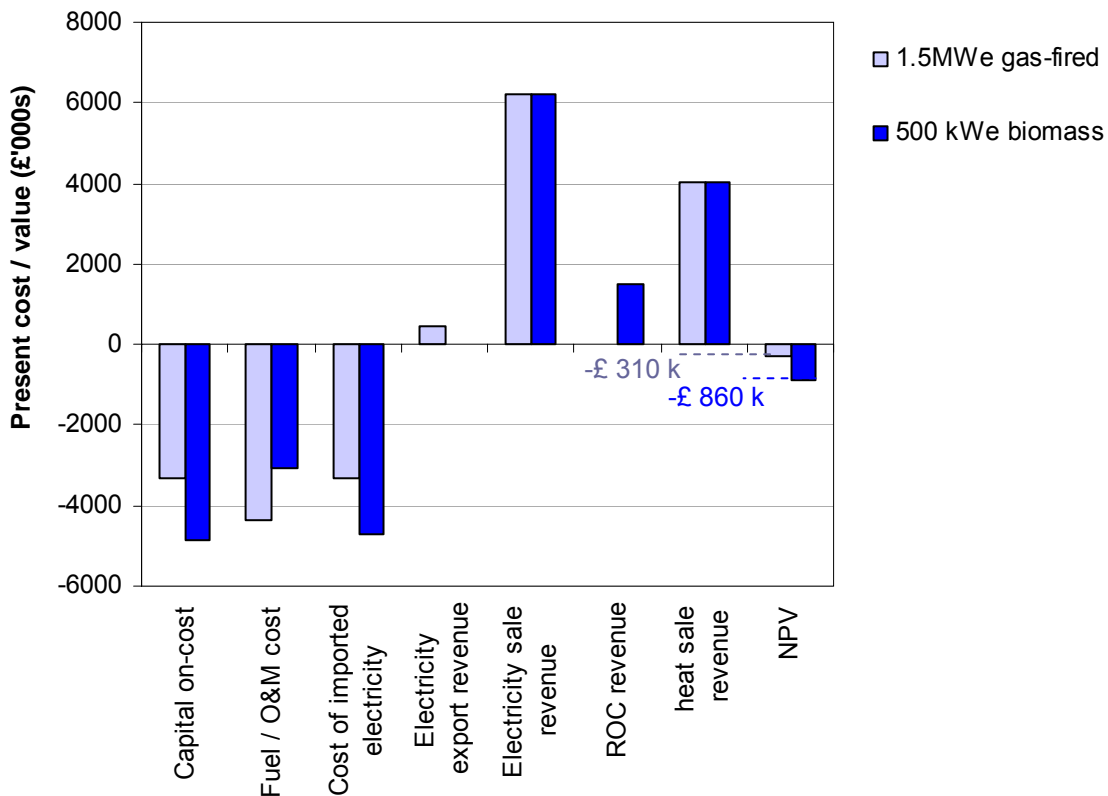


Figure 63, Summary of the economics of a district heating and private wire system for the Sky Park business park.

In the case of the gas-fired system with inclusion of revenues from a private wire electrical network, the overall site-wide energy system is very close to economic viability (assessed over 15 years with a 10% Discount rate). The uplift on the economics of the biomass system resulting from the private wire is less due to the smaller contribution that the system makes to the overall electricity demand of the site. Nonetheless, this is likely to represent significantly the lowest cost

carbon reduction method for the site (and of reaching the 20% renewable contribution to carbon reduction required by Policy RE5 of the RSS).

7.2.3 Electrical infrastructure at Cranbrook

Discussions with Western Power (the DNO responsible for the public system in the South West) have revealed that there are already plans for an unconventional electricity network at Cranbrook. It is planned that the electricity distribution infrastructure for Cranbrook will not be installed, owned or operated by Western Power but instead will be installed and operated by an Independent Network Operator (IDNO) – Connect Utilities. IDNOs are still licensed network operators (they do not operate under an exemption as described above), but they are not one of the 7 distribution network operators responsible for the public distribution network across the country. IDNOs are able to compete with DNOs to provide certain ‘contestable works’, which can include installation of new infrastructure that does not require access to the existing infrastructure in the DNO’s operational area, for example this can include installation of electrical infrastructure for a new site (the work that can be performed by IDNOs is limited to systems not exceeding 32kV). In these circumstances the Cranbrook electrical network is known as an embedded network.

The involvement of an IDNO at Cranbrook does not exclude any of the options for trading electricity discussed in the preceding sections. Clearly the case of selling the electrical output from the generator to a licensed electricity supply company remains straightforward. In the case that an organization, such as an ESCO, is established (or contracted) to operate the generation plant and sell the electricity directly to customers over the licensed distribution system, that ESCO would have a relationship with the IDNO involving payment for the distribution services. The flows of payments in this scenario are illustrated schematically below:

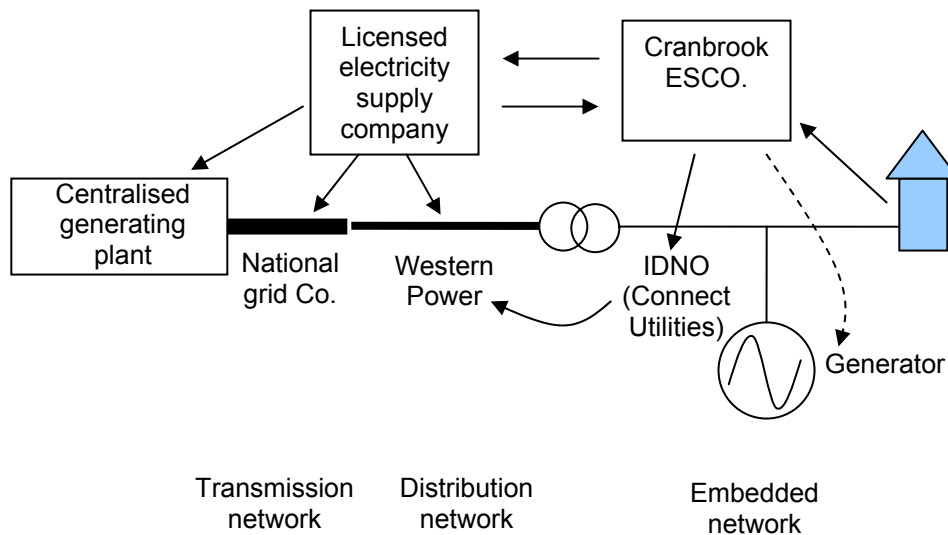


Figure 64, Schematic illustration of the commercial arrangements (i.e. flow of money) between the main players in a Cranbrook energy system, based on the current proposals for the site’s electricity infrastructure to be operated by an IDNO.

In the scenario illustrated, the Cranbrook ESCO could supply electricity to 2,500 households from a single CHP scheme as an exempt supplier. This electricity could be sold at a higher value than

if sold to the grid, although the ESCO would incur metering and billing charges, costs for demand balancing and would pay a use of systems charge to the IDNO.

It may be possible for the Cranbrook ESCO to take ownership of the distribution infrastructure and operate it as a private wire, which would further enhance the value of electricity supplied to consumers on the network (avoids use of systems charges, although costs will be incurred for maintenance of the network).

7.2.4 Extended private wire systems

The preceding analysis has considered the potential benefits of private wire systems in individual developments, or clusters of adjacent developments such as RNSD, ORLN and neighbouring JAAP developments. A more extensive private wire network that links between developments is unlikely to be cost-effective, due to the high cost of excavating trenches and laying cable (the costs of linking between developments would largely be borne by the organisation that will operate the private wire, as this cost would not fall to either the developer or the DNO under normal circumstances). This rationale for an extensive private wire may be stronger if there were constraints on the local public electricity network, such that the grid reinforcement costs associated with connection of developments were likely to be high. This is not the case in Exeter, where there appears to be a relatively strong infrastructure (as shown in Figure 65)

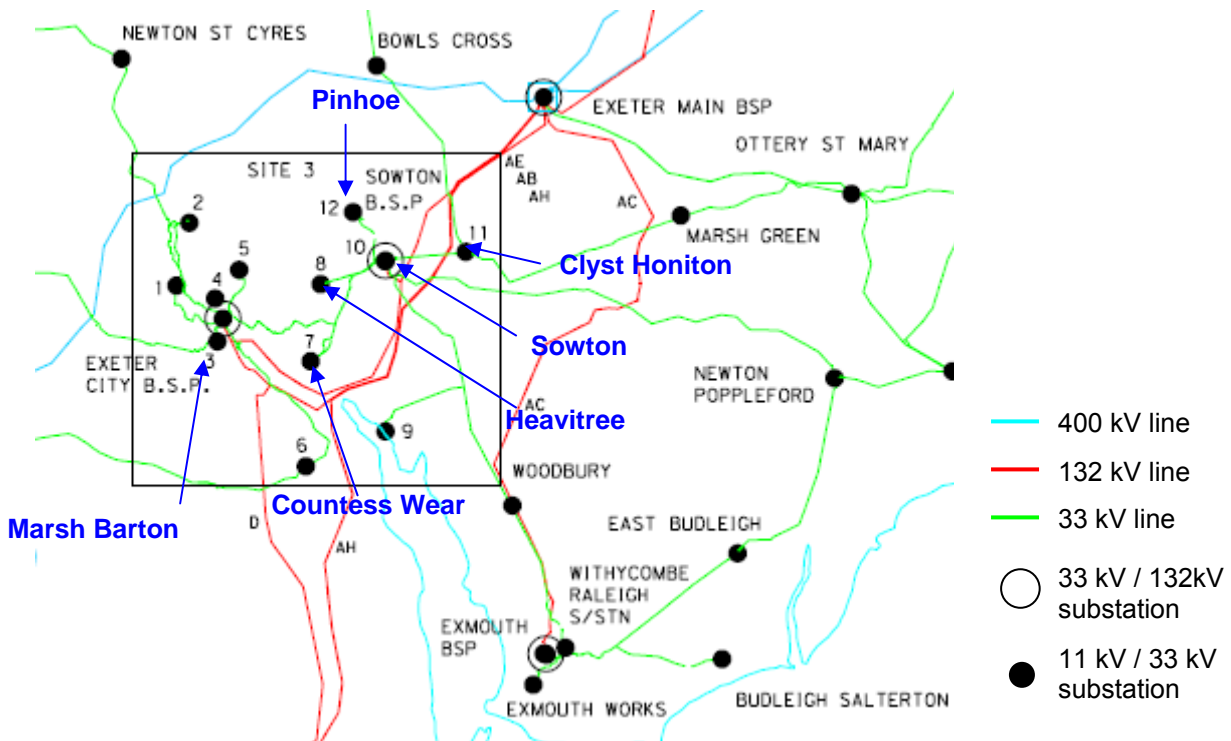


Figure 65, Electrical grid infrastructure (400 kV to 33 kV infrastructure) in the Exeter area.

The exceptions to this logic may be the case of Sky Park and the IMFF and the extension of Cranbrook. If the nature of the buildings at the IMFF were to provide adequate heat load to provide an economic case for extending a DH system across both sites, then the same reasoning would be likely to extend to the private wire network. Further, if the next phases of Cranbrook were to be constructed to the south west of the existing site, then there may be an economic case

for a private wire network across these developments, which would be close neighbours. Without further detail on plans for the further phases of Cranbrook or on the IMFF facility, it is not possible to assess this in detail at the current stage. However, it is recommended that a further analysis of DH / private wire across these sites is undertaken once more data becomes available.

Summary

- Private wire electricity networks can improve the economic viability of site-wide energy schemes but are unlikely to make these schemes a commercially attractive investment.
- Private wires should particularly be considered where a substantial electric capacity plant is to be installed, e.g. a 2.5 MWe plant to serve a Cranbrook site-wide system. The benefit diminishes with decreasing contribution of the on-site plant to the site's electrical load, as more import is required and balancing costs with the local electricity supply company increases.
- Given a relatively robust local grid infrastructure and high cabling costs for laying private wires, there is not a strong case for an extensive private wire linking discrete developments. There are mechanisms whereby excess generation at an on-site generation at one plant can be supplied to remote customers using the public grid (with incurrence of some distribution and transaction costs).

8 ENERGY FROM WASTE

8.1 Waste planning in Devon

In 2007, over half a million tonnes of municipal solid waste (MSW) and approaching one million tonnes of Commercial & Industrial (C & I) waste were generated across Devon. As new households are built in the county and as a result of increased economic activity, the waste arisings are projected to grow at an annual rate of 1% for MSW and 0.5% for C & I waste. The Devon County Council Waste Local Plan, published in June 2006 sets out the strategy for management of this waste.

One of the principle challenges facing waste planners is the need to reduce the amount of waste, in particular MSW, that is sent to landfill. This is necessitated by the escalating cost of landfilling and the Landfill Directive, which seeks to reduce the amount of biodegradable municipal waste that is sent to landfill via a cap and trade system. Over recent years Devon has achieved a large increase in the amount of MSW that is recycled and composted. In 2007, 35% of total MSW arisings was recycled or composted. The County Council has aggressive targets to increase this to 50% by 2015 and 65% by 2026. Currently the remainder of the MSW – the residual waste – is sent to landfill.

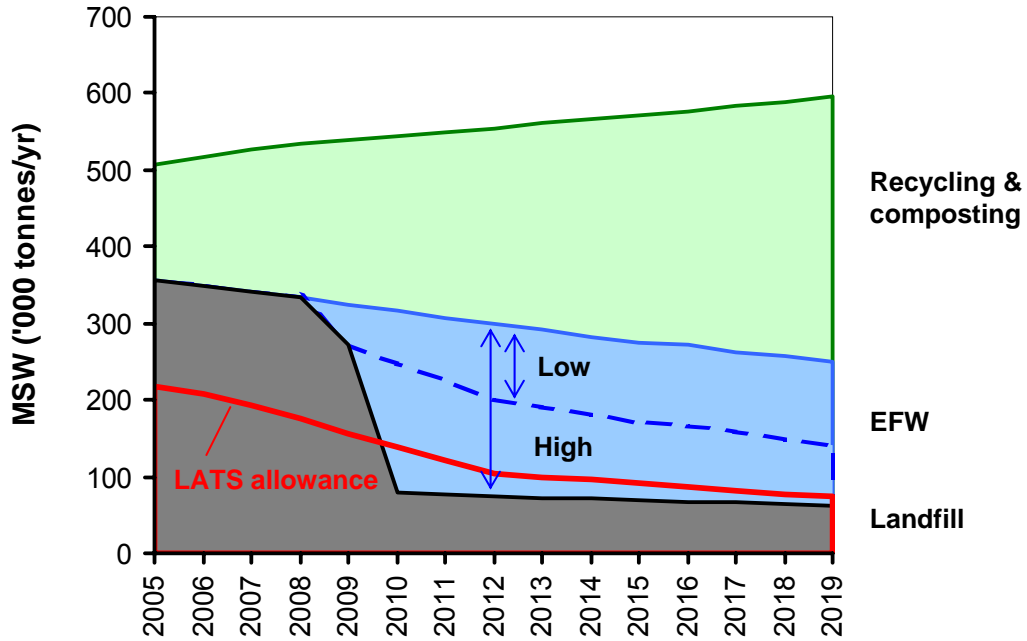
Under the Landfill Directive, each waste disposal authority (WDA) in England is allocated a number of tradeable Landfill Allowances each year. Each allowance permits the WDA to landfill one tonne of biodegradable municipal waste in that year. The number of allowances allocated to each authority decreases year-on-year until 2020, when the amount of biodegradable waste each authority will be permitted to landfill will have been reduced to 35% of the amount they landfilled in 1995 (the Base Year). Each authority can trade its allowances with other authorities, bank them for use in future years or use some of its future allowance in advance, thus allowing them to use their allowances in phase with their investment strategies. The overall result however, is the requirement to divert a significant amount of MSW from landfill to recycling, composting or other means of recovery or disposal.

The Devon Waste Local Plan has identified energy from waste (EFW) as key to the landfill diversion strategy across the county. The projected increase in MSW arisings and the intended contributions of recycling & composting, EFW and landfill to the management of that waste is shown in *Figure 66*. The Waste Local Plan describes two scenarios for uptake of EFW. In the Low scenario, only enough MSW is diverted from landfill to meet the LATS allocation (assuming that residual waste is around 50% biodegradable following recycling & composting). In the High scenario, all residual waste is treated by EFW plants and only the residue from the EFW process is landfilled. In the High scenario, the amount of biodegradable waste sent to landfill would be zero, presenting a significant revenue opportunity from the trading of Landfill Allowances.

The High scenario for diversion of MSW to EFW plants requires around 300ktpa capacity of EFW plants. The Waste Local Plan is not prescriptive about the EFW technologies employed, but envisages that the total capacity will be provided by 4 to 6 plants of 50-75 ktpa capacity. Exeter is one of the locations designated for an EFW plant.

The C & I waste arisings are currently managed via a combination of recycling, disposal to landfill and 'other' means, which includes biological and thermal treatment, land recovery and waste transfer. The Plan infers that the recycling rate is expected to increase at around 1% per annum and the quantity of waste landfilled to decrease at a rate of around 1.5% per annum. The Plan identifies the need for a significant increase in sorting capacity for C & I waste, in order to separate recyclate and materials for subsequent biological and thermal treatments. This capacity is to be provided via 6 materials recovery facilities (each of 50,000 tonnes/yr). Two facilities exist or are permitted (at Lee Mill and Kingstiegnon), so locations for an additional four facilities are required.

Projected MSW arisings in Devon



Projected C & I arisings in Devon

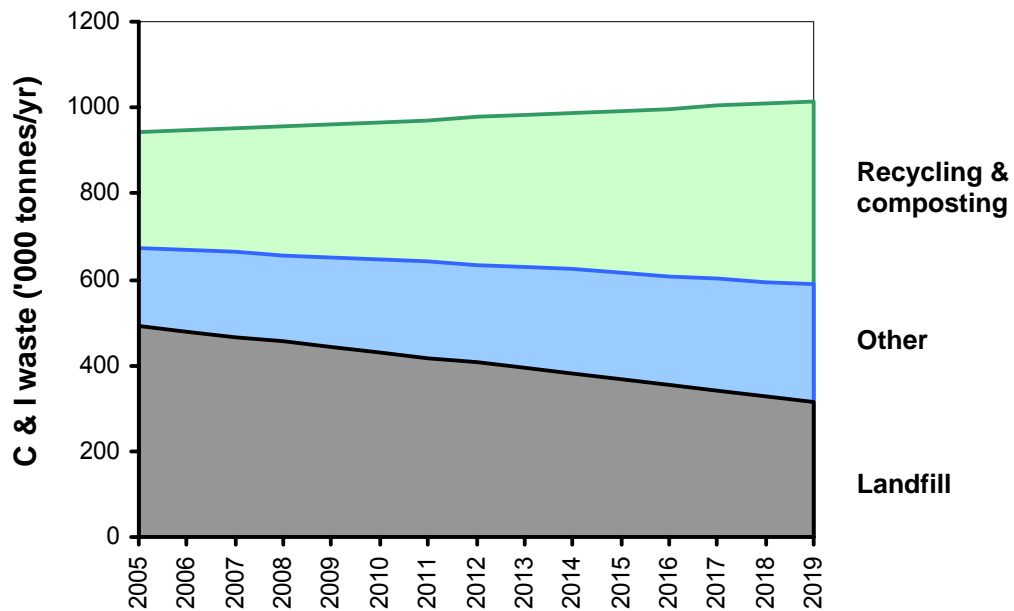


Figure 66, Projections of waste arisings in Deveon and expected treatment and disposal routes

8.2 EfW in Exeter

8.2.1 Marsh Barton

The Marsh Barton site to the south west of Exeter city has been designated as the location for a permitted development of the Exeter EfW plant identified in the Waste Local Plan. The site is industrial in nature and is currently host to a waste transfer station, where material is bulked up for onward transportation to either Heathfield or Broadpath landfill sites. The station currently handles in excess of 100 ktpa of MSW and C & I waste.

The County Council has undertaken a Best Practice Environmental Option analysis of potential EfW treatment technologies. The options considered include:

- Mechanical Biological Treatment (MBT) with Anaerobic Digestion (AD) or, alternatively, MBT with AD and production of refuse derived fuel (RDF) for subsequent thermal treatment or landfill.
- Advanced thermal treatments – gasification and pyrolysis
- Conventional energy from waste – incineration with combined heat and power

MBT was discounted due to the large footprint required and the concern that 60ktpa capacity is smaller than the optimum size for such a facility. There were also concerns there are no reliable markets for the digestate produced by the AD process or for the refuse derived fuel, unless a further thermal treatment plant were to be built .

Gasification and pyrolysis was also discounted, largely on the basis that it is not considered to be commercially mature and therefore unlikely to attract investment.

The selected technology therefore is conventional energy from waste. These plants are compact, can accept un-sorted municipal waste and meet the emission targets set out in the Waste Incineration Directive (WID). A plant treating 60 ktpa of waste is expected to use the heat produced to generate around 3 MW of electricity, which will be fed into the local grid. There may be some use of waste heat in buildings in close proximity to the plant, but there are no plans to integrate the plant with a more extensive district heating system. Viridor Waste Management are expected to build and operate the Marsh Barton EfW plant and have submitted a planning application to Devon County Council.

8.2.2 Opportunity for additional EfW capacity in Exeter

The existence of the Marsh Barton EfW plant will constrain the availability of waste resource for further EfW initiatives in the area. According to the Waste Local Plan's High EfW scenario, all of Devon's residual waste will be treated in the 4 to 6 EfW plants to be built in the county. It can be inferred from this that all of Exeter and East Devon's residual waste will be treated in the Marsh Barton plant.

The projected MSW arisings and residual waste in East Devon following recycling and composting, assuming the Waste Local Plan targets are met is shown in *Figure 67*. The projected increase in waste arisings is adjusted to take account of the more rapid increase in population in the area as a result of the residential developments in the EEDNGP developments.

The figure suggests that there will be adequate capacity to cope with the residual waste arisings at the Marsh Barton facility.

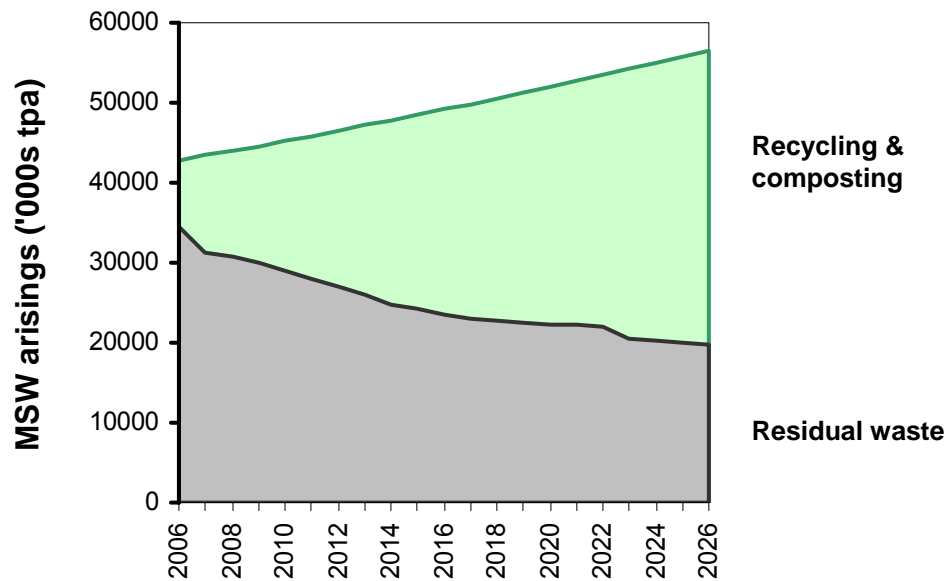


Figure 67, Residual municipal waste in East Devon following a projected increase in overall MSW arisings and enhanced recycling and composting.

Not only is there expected to be adequate capacity at the Marsh Barton site to treat the MSW arisings in proximity to the site, an area which includes the EEDNGP developments, but it is also unlikely that any other EfW plant in the area would be able to compete for resource on commercial terms, e.g. through competitive gate fee pricing. In order for Viridor to commit to building the Marsh Barton Plant, at a budgeted cost of £32 M, it can be presumed that they have arranged long-term contracts with Devon County Council (the Waste Disposal Authority) for the MSW arisings in the area.

Commercial and Industrial waste is not under the control of the waste disposal authority and its treatment is not provided for by the 300 ktpa of EfW capacity that is planned for in the Waste Local Plan. Significant quantities of C & I waste arisings will be generated by the commercial developments in the East of Exeter developments. A further EfW plant in the Exeter area may be supported by C & I waste arisings, however a further detailed assessment of the likely resource availability would be required.

8.2.3 Economics of EfW

The economics of conventional energy from waste plants tend to improve with increasing scale. The 60 ktpa plant currently under consideration for the Marsh Barton site would be considered to be relatively small. As discussed in the preceding section, it is unlikely that there would be sufficient waste resource for a further EfW plant of this type in the Exeter area.

Advanced thermal treatment technologies, based on gasification and pyrolysis, are currently at a developmental stage and have not been widely tested in the U.K. Nonetheless they are currently the focus of considerable attention. This is in part because they offer the potential for very clean waste treatment but also because they promise greater modularity and therefore may be more appropriate for distributed, community-scale energy from waste facilities.

A further key driver for interest in advanced thermal technologies for treatment of waste is the proposed modifications to the Renewables Obligation (RO)²⁸, which are planned to come into force on 1st April 2009. Under the proposed reforms the RO will become banded such that differentiated levels of support are provided to different technologies. While more commercial technologies will either continue to receive 1 ROC per MWh (or less in some cases, for example landfill gas), technologies that are considered to be further from commercial viability will receive enhanced support, up to 2 ROCs/MWh. Advanced thermal treatment of waste is one of the technologies that it is proposed will fall within the 2 ROCs/MWh band.

The smallest scale pyrolysis / gasification plant currently under commercial development has a capacity of around 15 ktpa. Based on the preceding discussion of waste resource constraints and the anticipated reliance of any additional EfW plant on C & I arisings, this is an appropriate scale to select in the economic analysis.

The economics of a 15ktpa energy from waste plant are considered in *Figure 68* below. In this analysis it is assumed that no investment in heat distribution infrastructure and no value attached to the thermal output. The electricity generated is sold to the grid.

Plant capacity	tpa	15000
Energy content of waste	MWh/tonne	3.06
Annual electrical output	MWh	10542
Annual thermal output	MWh	15813
Plant capex	£k	7,500
Discount rate		10%
Period	years	15
Annualised capex per tonne	£/tonne	66
O&M cost	£/tonne	40
Electricity revenue ¹	£/tonne	28
ROC revenue ²	£/tonne	22
Process cost	£/tonne	55

¹ Based on sale to grid at £40/MWh

² Based on a ROC price of £45/MWh and biodegradable fraction of 35% of input waste (Ofgem figure)

Figure 68, Economic analysis of a 15 ktpa EfW plant based on advanced thermal treatment processes (no value assigned to heat).

The analysis in *Figure 68* has shown that the cost of processing a tonne of waste in the advanced thermal treatment plant is approx £55/tonne. This is the gate fee required for the plant to operate at an IRR of 10% over a 15 year investment period. Discussion with Devon County Council has indicated that the gate fees currently charged for disposal of MSW are considerably higher, between £95 to £115/tonne. The gate fee for C & I waste is not known, but assuming it is

²⁸ Reform of the Renewables Obligation, DTI, May 2007

equivalent to that paid for municipal waste disposal, a small EfW plant based on advanced thermal technology could present a good economic opportunity.

8.2.4 EfW with district heating

On the basis that the EfW can operate profitably at a gate fee well within the range that is currently paid for waste disposal in Exeter, there may be an opportunity for integration of the waste plant with a district heating system. In this scenario, a combination of the revenue from heat sales and from the gate fee could be used to finance the investment in the district heating infrastructure.

The Cranbrook site-wide district heating system was used as a potential scenario for integration of an EfW plant with district heating. The 15 ktpa EfW plant is assumed to operate at 1.3 MWe / 2 MWth peak capacity. It is further assumed that the plant operates at high load factor (~ 90%), as its operation will be dictated by waste processing, not to follow the heat load. The implication of this is that some heat from the plant will be rejected.

The analysis in *Figure 68* indicates that the EfW plant breaks even (at a 10% Discount rate over 15 years) at a gate fee of £55/tonne. At this gate fee the heat is essentially free, however it can clearly be seen from the analyses in Section 4.3 that the revenue from heat sales alone is not sufficient to pay-off the on-cost of the district heating system of ~ £ 8.5M and ongoing O&M costs. An increase in gate fee will therefore be required to finance the DH system.

The net present value of investment in the DH system is shown in the plot in *Figure 69* for a range of gate fees. If electricity were to be provided to the residents over a private wire, rather than being sold to the grid, there would be an additional revenue from electricity sales compared to that shown in *Figure 68*. The variation of NPV of the investment with gate fee including electricity sales over a private wire is also shown in *Figure 69*

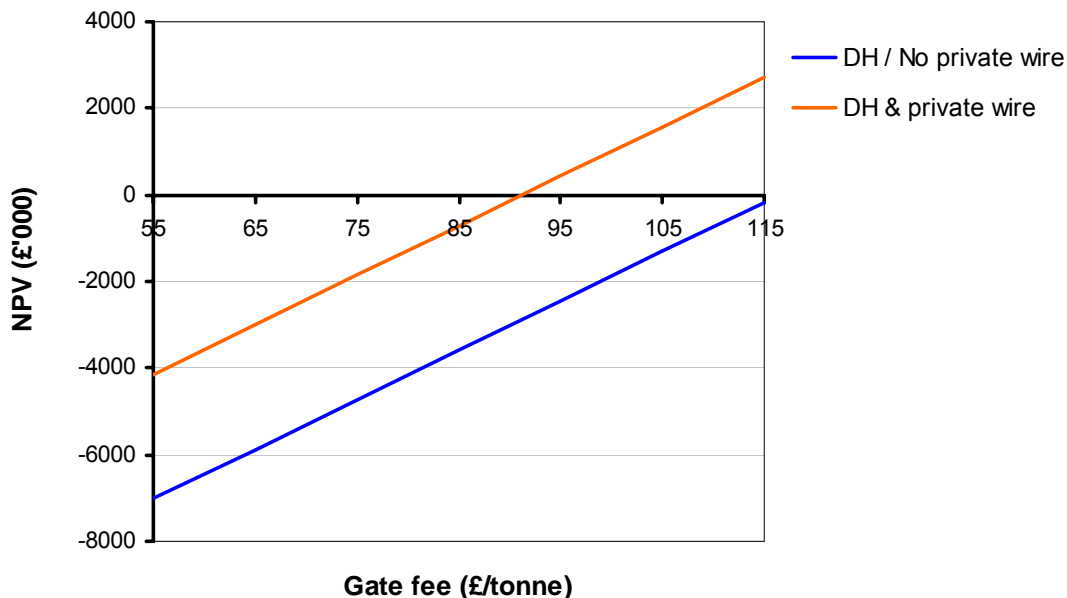


Figure 69, Variation in NPV (10% over 15 years) with gate fee for a district heating system served with heat by a 15 ktpa ATT plant. The sensitivity of economic viability to a private wire electrical infrastructure is shown.

In the absence of a private wire, a gate fee of £115/tonne is required for the overall system to be economically viable (at an Discount rate of 10% and over a 15 year period). This is at the upper end of the range of gate fees currently being paid for MSW disposal. With the inclusion of a private wire and as a result of the higher revenue from electricity income that results, the system becomes economically attractive at a gate fee of around £87.5/tonne. Based on a comparison with gate fees currently paid for MSW disposal and compared to the costs of landfilling (landfill tax alone will increase to £35/tonne by 2010/11) this is likely to be an attractive gate fee for disposal of C & I waste.

Summary

- There are well advanced plans for an energy from waste facility at Marsh Barton, as required by the Devon Waste Local Plan. This will limit the availability of MSW for any further energy from waste plant in the area.
- The Marsh Barton plant is not sized to treat commercial and industrial waste arisings. This may provide a resource for a small energy from waste facility if the facility can offer an attractive gate fee.
- The banding of the Renewable Obligation will support energy from waste by advanced thermal treatment such as pyrolysis / gasification. Given the 2 ROC/MWh banding, the break-even gate fee for a small plant (15ktpa) is estimated at £55/tonne (assuming no sale of heat).
- The current gate fee for MSW disposal is £95 – 115/tonne. At these gate fees and including sale of heat (and potentially increased electricity sale revenue by implementation of a private wire), an EfW plant and DH system, for example the Cranbrook site wide system, could be an economically attractive opportunity.

9 SUMMARY

Currently available data on the residential developments within the EEDNGP has shown that many of them are similar in nature (e.g. type of housing and density) and it is therefore expected that there will be commonalities between them with respect to the most appropriate energy systems. There are differences in the timing of the developments and therefore the particular energy and CO₂ reduction regulations that will be in force, which has implications for the choice of energy system likely to be made by developers.

A generic approach is developed with is relevant to all of the sites within the Growth Point. However, much more information is available for the Cranbrook New Community development compared to the other residential developments. Cranbrook has therefore been used as a model for detailed analysis. This analysis has then been interrogated in order to draw out conclusions for the other residential developments in the EEDNGP.

The commercial developments / business parks are more distinct and so a detailed energy assessment has been performed for each.

9.1 Baseline Emissions

The estimated baseline emissions from all of the developments within the EEDNGP are shown below. By 2020, energy consumption in the new developments will result in the production of over 50,000 T CO₂/annum. Emissions from electricity loads (lighting, appliances, etc.) are predicted to dominate both the commercial and residential sectors.

With regard to CO₂ emissions, the most important and far reaching legislation yet considered is the government’s Code for Sustainable Homes (CSH). Government policy states that energy consumption during use will need to be net zero carbon in all new homes built from 2016. The projection of CO₂ emissions below assume the code will be implemented according to the timetable currently proposed by government. If this legislation is not adopted, or if it is delayed, baseline CO₂ emissions would be higher.

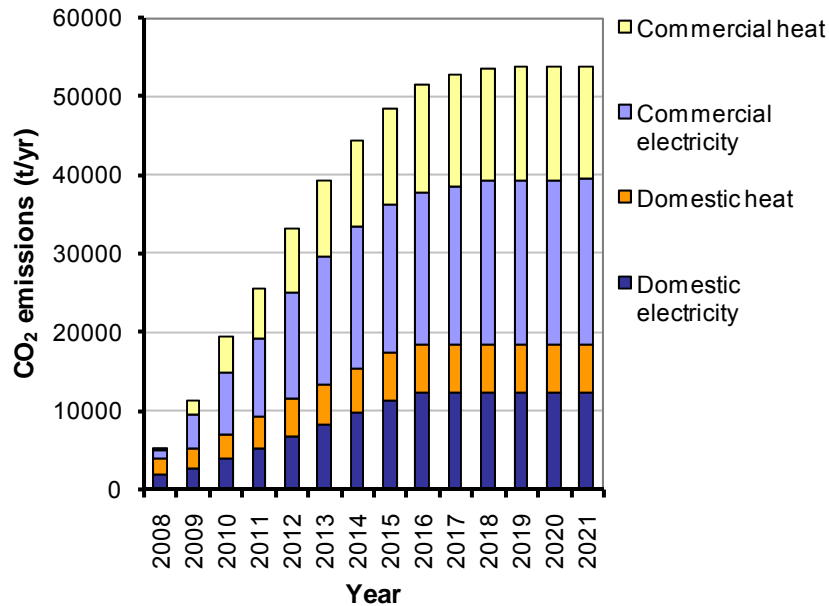


Figure 70, Projection of the annual CO₂ emissions arising from the EEDNGP developments assuming that CO₂ reduction targets are introduced according to currently stated government CSH implementation timetable

9.2 Least cost method of achieving compliance with the Code for Sustainable Homes

In order to comply with the anticipated tightening of the Building Regulations, e.g. to mandated Code for Sustainable Homes standards, and therefore limit the CO₂ impact of the developments in the EEDNGP to that shown in *Figure 70*, substantial energy demand reductions and provision of renewable energy supply are required.

The key demand reduction and renewable supply options considered here are summarised below:

- Energy efficiency: via the adoption of increased insulation, reduced infiltration etc.
- Microgeneration: photovoltaics, solar water heaters, micro-biomass boilers etc.
- CHP and site energy: Combined heat and power systems and district energy networks (this can improve efficiency of use of energy supply, compared to conventional heating and the electricity grid, and can also provide renewable energy if fuelled from a renewable source).

Large, MW scale wind turbines may in appropriate locations, represent one of the most cost effective CO₂ reduction technologies. However, the South West Renewable Energy Atlas²⁹ suggests that there are few of any suitable sites for large scale wind turbines in the EEDNGP developments. As the atlas is only a screening tool, more detailed analysis (outside the scope of this work) is needed to confirm this conclusion.

As stated above, Cranbrook can be used as a proxy for most of the other residential developments in the EEDNGP. The cost of achieving compliance with each level of the code for sustainable homes at Cranbrook has been assessed (in terms of additional cost per dwelling). The assessment has considered both microgeneration measures and site-wide energy systems, i.e. CHP and district heating (it is assumed that basic energy efficiency measures are applied in all cases and to achieve Code Level 6, high standards of energy efficiency must be adopted). In *Figure 71*, the least cost approach to meeting each relevant Code Level (i.e. Level 3 and above) via microgeneration and site-wide energy systems is shown.

Code Level 3 may be achieved through a combination of basic efficiency measures and a roof mounted solar water heater at an additional cost circa £4,000 per dwelling.

Code Level 4 may be achieved through a combination of basic efficiency measures and a PV system, at a cost of circa £7,000 per dwelling. Alternatively, Code Level 4 could be achieved more cost effectively with the same efficiency measures and a site wide district energy scheme, with heat and electricity provided by a natural gas fired CHP system (note that in this case the basic efficiency measures do not include a high efficiency boiler).

To achieve code 5 or 6 without district energy systems is relatively expensive; the least cost methods require larger PV systems and micro biomass boilers at an on-cost of circa £20-30,000. Alternatively, a site energy system using biomass fired steam CHP could be much less capital intensive, with an estimated capital on cost per dwelling of circa £7,000.

²⁹ Wardell Armstrong, commissioned by Regen South West and Government Office for the South West.

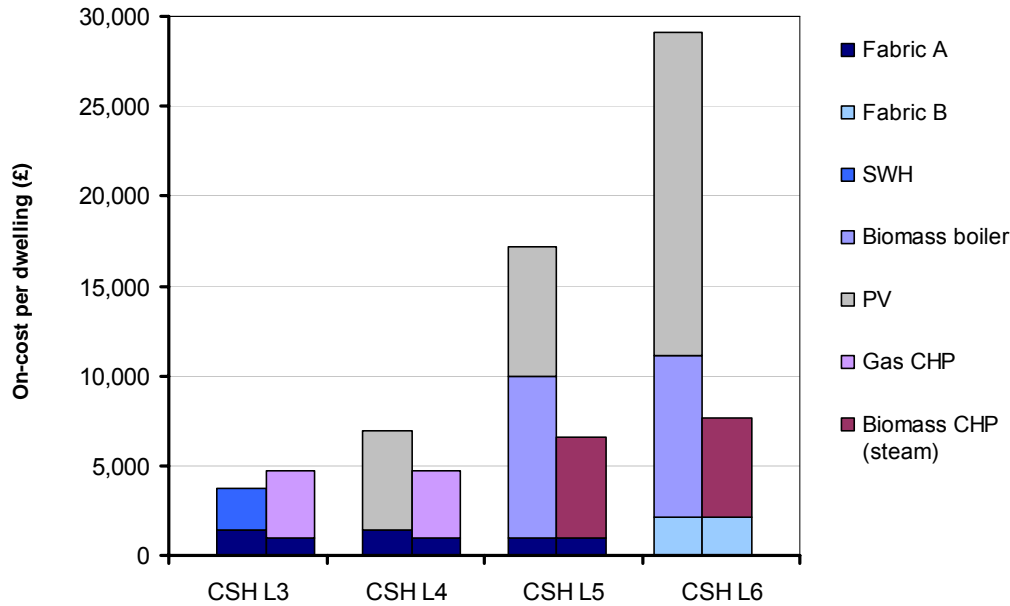


Figure 71, Comparison of the cost of meeting code for sustainable homes levels by microgeneration (bars on left) and site-wide measures (bars on right).

Site-wide energy systems are shown to represent the lowest cost route to meeting the code for sustainable homes compliance at level 4 and above. In other words, they are more economic than the alternative which is heavily reliant on building mounted renewable systems. Despite this there are a number of real and perceived barriers which would inhibit the development of site energy systems (see section 9.8) and these issues will need to be addressed.

9.3 CO₂ reduction strategies at other residential developments

The available data shows that the main characteristics driving choice of technology, such as housing mix and development density, exhibit substantial commonalities across many of the EEDNGP sites, including Cranbrook. Therefore, the technology solutions identified at Cranbrook for each of the Code Levels will be relevant to these other sites.

There are exceptions to this however, such as the developments within “Exeter city centre” and “Rest of Exeter city” which have markedly different characteristics. The new housing provision in these areas is predicted to comprise mainly of smaller sites and utilisation of space in prior developed areas, such as space above commercial premises. In such circumstances, district energy systems supplying only the new developments will not be practical. For these dwellings, in order to reach low carbon standards (e.g. Code Level 4 and above) extensive use of energy efficiency measures and photovoltaics could represent an upper bound on costs. The high costs that may arise could potentially be mitigated by the development of shared local energy infrastructure retrofitted into adjacent existing buildings.

The low carbon energy strategies identified in each of the residential developments to the west of the M5 to achieve the CSH level in the RSS timetable are summarised in *Figure 72*, below.

Residential site	Number of Homes	Suggested low carbon strategy	Code Level achieved
Alphington	400	Large, centralised biomass boiler + DH + dwelling PV supplementation	5
Exeter City Centre	1,550	Extensive fabric efficiency measures + PV installation to meet Code requirement	4 - 6 depending on time of construction
RNSD (phase 1) + RNSD/ORLN	930	Large, centralised biomass boiler + DH + dwelling PV supplementation	4 - 5
JAAP	3,000	Large, centralised biomass boiler + DH + dwelling PV supplementation	5
Rest of Exeter City	4,100	Extensive fabric efficiency measures + PV installation to meet Code requirement	4 - 6 depending on time of construction

Figure 72, Summary of the low carbon energy strategies recommended for each of the residential developments in the EEDNGP to the west of the M5

9.4 CO₂ reduction strategy in commercial developments

Each of the commercial sites has been analysed independently. Nevertheless as with the residential developments the conclusions are broadly similar. In Figure 73 the cost effectiveness of CO₂ savings for renewable and low carbon measures are shown, based on analysis carried out on the Science Park site. It shows that wind (where feasible and where planning allows) would be one of the most cost effective measures. However, without wind and in common with the residential developments, CHP and district energy networks are the most cost effective means of achieving significant carbon reductions.

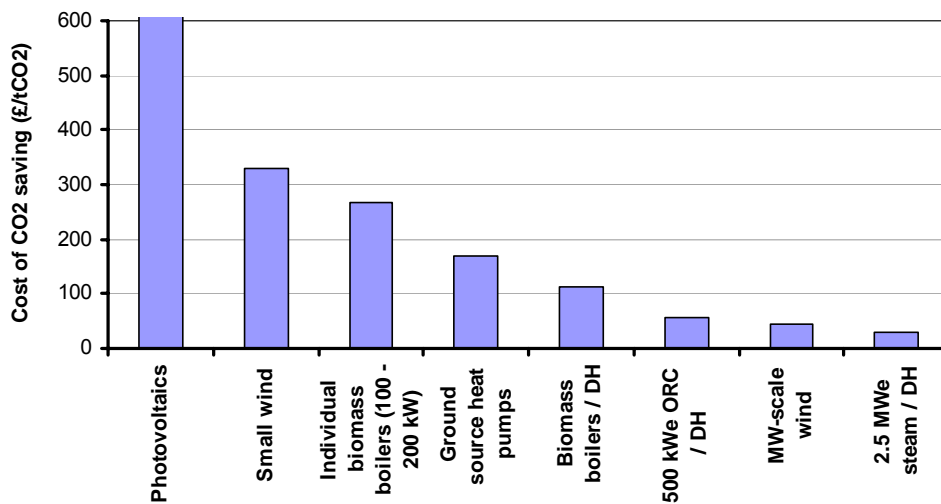


Figure 73, Cost of CO₂ saving (based on a whole-life cost analysis) delivered by potential renewables system options at commercial developments.

The economics of CHP and district heating systems were shown to be closer to commercial viability for the business parks than was the case for the residential developments. This is because the higher heat density on these sites and fewer individual connections limits the capital cost. Discounted cashflow analyses for these systems identified net-present values of - £2 M to - £4M for biomass fuelled systems (biomass-fuelled systems will be required to meet the renewable energy contribution of 20% stipulated by policy set-out in the south west's draft RSS). Although CHP and DH systems are closer to economic viability on the commercial sites, the regulatory framework required to force developers to invest is less well-advanced than in the domestic sector (there is discussion of a Code for Sustainable Non-domestic Buildings, but this is yet to be made public). Therefore, in order to encourage uptake of these systems in the EEDNGP business parks, regional and local planning policy will need to be used.

9.5 Implications of the RSS low carbon policy (Policy G)

The analysis above identifies the most cost effective technologies required to meet the Code for Sustainable Homes legislation. Energy strategies have been recommended in order to meet an accelerated timescale for implementation of the Code for Sustainable Homes Levels (compared to the stated timescale for introduction through the Building Regs) and to achieve high levels of renewable energy supply and energy efficiency in commercial buildings, as proposed in the Draft RSS.

The implication of implementing the Draft RSS policies on the CO₂ emissions impact of the developments in the EEDNGP is shown in *Figure 74*. The net effect across residential and commercial developments is a reduction in CO₂ impact of approximately one-third.

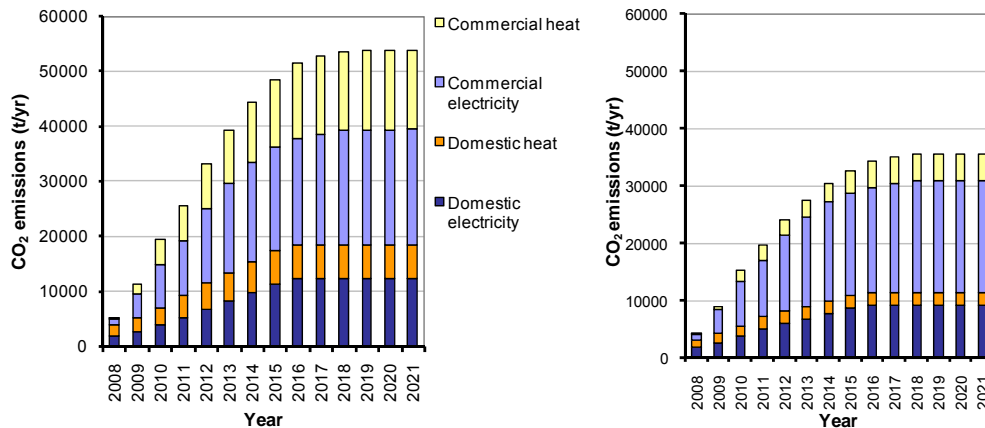


Figure 74, Comparison of CO₂ emissions impact of developments in the EEDNGP under business-as-usual assumptions (in line with anticipated legislation) and under the assumption that Draft RSS policies are implemented.

9.6 Opportunities for Waste to energy

The economics of energy from waste plants using advanced technologies such as pyrolysis and gasification (and also anaerobic digestion) are to be given a significant boost by the proposed banding of the Renewables Obligation. Under the banding regime, planned to come into effect in April 2009, advanced EfW technologies will be eligible to receive a revenue uplift of 2 ROCs/MWh.³⁰

³⁰ Prorated on the basis of the biomass fraction of the waste input. The aspect of "additionality" – whether a system can claim compliance with CHS as well as claiming ROC's, is addressed in the chapter on waste to energy.

An analysis of the economics of advanced EfW technology has shown that a small plant could be economic at a gate fee of around £55/tonne, assuming sale of electricity to the grid and 2 ROCs/MWh (no sale of heat). This is competitive with other alternatives.

The economics of an advanced EfW plant could be improved further by sale of heat via a district heating system. Analysis of a complete CHP system at Cranbrook, i.e. EfW plant and district heating system, has shown economic viability at a gate fee of £115/tonne. Inclusion of electricity sales over a private wire system reduces the economic gate fee to around £90/tonne. This is an economic proposition that could be attractive to a commercial organisation, such as an energy service company (ESCo).

Although the economics of an advanced energy from waste plant are potentially sound, a lack of resource could be a serious obstacle. There is already a 60,000 tonnes/yr waste to energy plant planned for Exeter, to be built at the existing Marsh Barton waste transfer station with reported gate fees in the range £95/tonne to £115/tonne³¹. This plant will be based on conventional incineration technology and, although it may supply some heat to the neighbouring industrial estate, it is not understood to be part of any extensive energy system. This plant is part of Devon County Council's waste planning for the county. It will be one of between 4 to 6 such plants built around the county and will be integral to Devon County Councils plans to divert biodegradable municipal waste from landfill in line with the Landfill Directive. The existence of this plant coupled with the county's targets for high rates of recycling and composting casts doubt on the availability of municipal waste for a further energy from waste plant in the Exeter area. There may be an opportunity for a further energy from waste plant to treat commercial and industrial waste arisings in the area, which may not be part of the planned resource for the Marsh Barton Plant.

On the basis of the economic potential of an EfW plant, which could be linked to a district heating system, it is recommended that a further investigation into the potential commercial waste resource streams is undertaken.

9.7 Private wire electricity and the potential for multi site energy systems

A private wire system can increase the revenue available from the sale of electricity. The analysis suggests that a private wire system can improve the financial viability of site community energy systems in new residential developments such as Cranbrook and the RNSD & ORLN sites (with potential extension to any JAAP sites developed on adjacent land). However the scale of the benefit will not be sufficient to alter earlier conclusions on economic viability as seen from a commercial perspective.

On commercial sites such as Science Park and Sky Park the economics of site-wide energy systems are closer to commercial viability due to the higher heat density. Private wire systems can further improve the economic case. A cashflow analysis for biomass CHP / DH and private wire system at the Sky Park site identified a negative net present value, but of less than £ 1M (at 10% over 15 years). This is approaching an economic proposition that a commercial operator may consider.

The scope for extended private wire systems, interconnecting various sites, is limited to adjacent sites (such as IMFF and Sky Park) and is mostly unnecessary as options exist for trading electricity over the existing distribution network.

The high cost of district heating mains means that physically interconnecting more distant sites is generally not viable. However, opportunities for interconnecting heat infrastructure at adjacent sites such as the IMFF and the Sky Park should be explored when more detail on site energy loads becomes available.

³¹ Exeter Area Energy From Waste Initiative, Devon County Council, 2006

9.8 Importance of site energy systems

The analysis shows that site energy systems will be the least cost means of achieving significant carbon reductions. This applies to all residential and commercial developments, providing the technology is feasible. Site energy is a key strategic issue, as decisions taken in the near future to use alternative technologies, may adversely affect the viability of district energy (which will be the lowest cost) systems in the future.

However, in the near term before the CSH becomes mandatory, implementing site energy systems is a significant challenge. Generally none of these technologies are commercially attractive, and traditional approaches to site development can work against economic viability. For example, packaging up the development of a site into a set of smaller lots reduces the heat load available to a DH/CHP system. Also DH systems represent a significant up front capital expenditure; these assets are effectively stranded until end users take energy and provide revenue. Phased site development increases the commercial risk even further.

All stakeholders need to recognise the significant efforts that will be required to implement site energy systems. For example, in the current legislative climate, simply requiring that a feasibility study be undertaken, is unlikely to be sufficient to encourage the private sector to develop district energy systems.

There are a number of ways in which the development of site energy systems can be achieved. Legislation might be very effective, but is likely to be very difficult to implement. Alternatively, there are a number of commercial structures, such as Energy Services Companies (ESCo's) and other public-private initiatives that recognise the role each stakeholder is best able to play. For example, the public sector may be willing to accept the risk of developing a district heating infrastructure, in return for charging a (commercially attractive) connection tariff, or developing policies to ensure subsequent developments must connect to the system.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The analysis predicts that building fabric performance improvements will result from the application of tighter CO₂ targets. This is because a basic set of fabric performance improvement measures is a relatively cost effective way of reducing energy consumption and CO₂ emissions and would allow houses to get to CSH level 3 without requiring microgeneration. Improving building fabric performance measures now would “futureproof” building designs against all but the highest code level. Legislating for code 3 compliance mainly through fabric measures would pay dividends by putting in place a good construction standard that need not change for some time to come, despite changes in national legislation.

Two distinct approaches to reducing carbon are a) treating each building individually (building by building approach), and b) using “site wide” systems, where energy is generated at a central point on site and distributed to end users via a district energy (heating and/or electricity) system.

Large sites across the Growth Point requiring intermediate carbon reductions (level 4 and above) will be most cost effectively served by site wide district heating; at higher code levels, this would be augmented with biomass CHP.

In the city-centre, district heating systems are ill-suited to the (typically smaller scale) developments. Here, a building-by-building approach to CO₂ reduction represents an upper-bound on cost. The city council will need to ensure that all options for reducing costs are explored, such as connection to shared heating systems.

For the great majority of dwellings, the highest code level (level 6 – carbon free homes) can only be achieved with site energy/heating systems.

The higher heat densities at commercial developments such as the Science Park and Skypark means that site energy systems are predicted to be much more cost effective than microgeneration or renewable technologies in achieving significant CO₂ emission reductions.

The analysis shows that district heating is a key strategic technology for large developments in the Growth Point, enabling significant CO₂ reductions at lowest cost. A district heating system is not currently planned for the first phase of development at Cranbrook. Early investment in a district heating network will benefit the economics of future phases of Cranbrook.

While district energy systems show improved economics (relative to other means of achieving carbon reductions such as microgeneration technologies) their implementation is still a challenge. Capital costs are high (particularly for heat distribution networks); there is a risk of stranded assets if development plans are delayed, coordination over multideveloper sites is complex and there is a requirement for ongoing maintenance and management of energy systems.

Energy from waste, using advanced technologies could be a strategically important renewable resource. If an EfW plant is collocated or adjacent to a significant heat demand, then these systems can be economically viable. A specific opportunity would include an EfW plant at the Intermodal Freight Facility serving the heat demands of adjacent commercial developments.

Initial screening suggests that there is little scope for large (multi MW) wind systems (which can be amongst the most cost effective CO₂ reduction technologies). More detailed analysis is needed to confirm this conclusion.

Private wire systems can help improve the economics of CHP/district energy systems and in some sites this enhancement can make an important difference. However, the improvement is not so significant that it should be viewed as an enabling technology, or one with the strategic importance of district heating systems.

10.2 Recommendations

Recommendation 1:

Adopt policies to ensure that all dwellings are built to achieve code level 3 compliance on CO₂ emissions, to be achieved primarily through fabric improvements.

Evidence Base

- Code level 3 compliance would most cost effectively be achieved through a basic package of fabric improvement measures.
- More substantial improvements to building fabric are not predicted to be required until code level 6.
- Increasing fabric standards now would provide stability for house builders designs, future proofing them against future changes in national legislation.
- This analysis supports an element of Planning Policy G of the Draft RSS, in that all new homes should be built to code level 3 or higher.

Suggested actions

- Adopt regional and local planning policies that require all homes to achieve code level 3 predominantly through fabric improvements.

Recommendation 2:

Ensure that district heating systems are included in all new large-scale developments.

Evidence base

- The analysis shows that district heating systems are (by a large margin) the least costly means of achieving significant carbon reductions (i.e. above Code 4).
- With the exception of the city centre, all developments in the Growth Point will require district heating systems to supply low carbon energy to end users.

Suggested actions

- Apply to the Regional Infrastructure Fund to cash flow the development of a district heating infrastructure for the higher heat density town centre area of Cranbrook.
- Funding should not be recovered from the initial phase of Cranbrook. Connection to a district heating system would provide benefits to first phase developers by, for example, increasing net lettable areas in each building.
- The developers have already committed to a biomass boiler solution for commercial buildings in Cranbrook. Centralising to a single energy centre would reduce costs, and reduce town centre traffic movements associated with biomass deliveries.
- For subsequent phases of Cranbrook, connection to the site energy system could be enforced through local plans and RIF funding recouped through a section 106 agreement or a community infrastructure levy.
- The Growth Point / developers should open discussions with Utilities and ESCo's to understand how they may be able to take a commercial position in the development and maintenance of site energy systems.

Recommendation 3:

Implement a low carbon strategy for “City Centre” and “Rest of City” developments

Evidence Base:

- Site energy systems are unlikely to be feasible for many of these developments
- Renewable electric (predominantly PV) technologies require accelerated uptake to avoid excessive carbon emissions from these developments.

Suggested actions

- Develop planning guidance tailored to technologies relevant to smaller scale and city centre developments. Examples would include developing a Sustainable Planning Guide targeted at city centre developments.
- Ensure city centre developments explore all options for carbon reduction, including connecting to existing supply systems, or using a new development to bring together and supply a number of existing heat users.

Recommendation 4:

Require that large commercial developments such as the Science Park and Sky Park develop district heating networks, and examine the feasibility of supplying these with biomass or waste streams.

Evidence Base:

- Site energy systems are predicted to be the lowest cost way of achieving significant carbon reductions.
- When combined with EFW, these systems can be commercial.

Suggested actions

- Commission a detailed study of the cost of a DH network and CHP system at each site.
- The public sector should explore options for reducing risk to ensure that district energy systems are seen as feasible by the commercial sector.
- RIF funding should be explored. Discussions with utilities and ESCo's (as per recommendation 2) should also extend to cover these developments

Recommendation 5:

Explore potential for an electricity system (private wire) linking the Sky Park and IMFF.

Evidence Base:

- The analysis shows that private wire system linking site energy systems at the Skypark and IMFF could improve the economics of these site energy systems.
- The feasibility of district energy systems at commercial developments should include the beneficial aspects of private wire.

Suggested actions

- Once building uses and energy loads are better defined for the IMFF, revisit the potential for a shared IMFF / Sky park electricity (private wire) system.

Recommendation 6:

An Energy from Waste facility in the Growth Point will be economically viable and an important source of low carbon energy. Further investigation a small energy from waste plant in the area, linked to a community or site energy system is required.

Evidence Base:

- The amendment to the RO and the increasing cost of landfill (high gate fees) combine to make advanced energy from waste plants a commercial proposition.

- At competitive gate fees investment in an EfW plant together with a district heating system could be a commercially attractive proposition.
- There is uncertainty surrounding availability of waste resource in the area and also the commercial readiness of the advanced conversion technologies (pyrolysis/gasification).

Suggested actions

- Commission a detailed study into waste resource availability (focussed on commercial and industrial arisings) and the commercial readiness (bankability) and economics of small advanced treatment technologies.

Recommendation 7:

Large wind (MW scale) energy systems are predicted to be amongst the most economic means of reducing carbon emissions. Therefore large wind is a strategically important low carbon technology.

Evidence Base:

- Comparison of whole life costs for a comprehensive range of low carbon technologies shows that (subject to siting and size of wind farm) large wind can be the most cost effective carbon reduction technology.
- Screening analysis suggests that there are few if any sites in the EEDNGP area.

Suggested actions

- A detailed study to assess the potential for the installation of large scale wind turbines is needed to confirm the screening analysis.

Recommended Action 8:

Develop and implement enabling actions to support growth of biomass supply chains in Devon and in proximity to EEDNGP.

Evidence Base:

- The most cost-effective means of meeting high Code for Sustainable Homes levels and meeting regional policy for renewable contribution to commercial developments is site-wide, biomass fuelled CHP systems. This will require substantial biomass resource.
- The woodfuel resource in the South West is substantial, but the amount of woodland within proximity to the EEDNGP is quite limited.
- Mapping exercises performed by the Renewable Energy 4 Devon (RE4D) and as part of the REvision 2020 exercise has identified significant potential for energy crops (particularly miscanthus).

Suggested Actions

- Work with key stakeholders, including the Regen SW Bioheat programme, RE4D, BiCAL, Forestry Commission, South West Wood fuel and local farmers & landowners, to discuss ways to generate a sustainable biomass supply in the area.
- Focus on establishing a local miscanthus supply chain.

APPENDICEES

Appendix A – CRANBROOK SITE-WIDE ENERGY SYSTEMS: CASHFLOWS

A SITE-WIDE ENERGY SYSTEM CASHFLOWS

A.1 Cranbrook site-wide DH cashflows

2 MWe gas-fired CHP system and site-wide district heating (all parcels)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital costs (£'000s)																
CHP plant costs (including energy centre, boilers etc)	-£2,063	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£61
District heating network costs	-£2,926	-£2,926	-£2,926	-£2,926	-£2,926	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Cost of heat exchangers	-£83	-£300	-£498	-£457	-£468	-£501	-£374	-£22	-£22	-£33	£0	£0	£0	£0	£0	£0
Capital offsets (£'000s)																
Boiler plant	£200	£752	£1,306	£1,206	£1,258	£1,412	£1,006	£103	£103	£155	£0	£0	£0	£0	£0	£0
Gas connections	£44	£154	£242	£220	£220	£220	£176	£0	£0	£0	£0	£0	£0	£0	£0	£0
Operating costs (£'000s)																
CHP fuel cost	£0	-£22	-£104	-£260	-£400	-£572	-£734	-£795	-£800	-£802	-£810	-£810	-£810	-£810	-£810	-£810
Boiler fuel cost	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	-£19.16	-£42.88	-£47.97	-£49.86	-£58.87	-£58.87	-£58.87	-£58.87	-£58.87	-£58.87
O&M cost	£0	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75	-£75
Revenues (£'000s)																
Revenue from electricity sales	£0	£15	£71	£178	£274	£392	£502	£545	£548	£549	£555	£555	£555	£555	£555	£555
Revenue from sale of ROCs	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Revenue from sale of heat	£0	£21	£97	£228	£346	£476	£618	£714	£720	£722	£733	£733	£733	£733	£733	£733
Total cost in year (£'000s)	-£4,827	-£2,381	-£1,886	-£1,886	-£1,771	£1,352	£1,101	£426	£426	£466	£344	£344	£344	£344	£344	£404
Cumulative cost (£'000s)	-£4,827	-£7,208	-£9,094	-£10,980	-£12,751	-£11,399	-£10,298	-£9,872	-£9,447	-£8,981	-£8,637	-£8,294	-£7,950	-£7,607	-£7,263	-£6,859
Net present value (£'000s)	-£4,827	-£6,992	-£8,550	-£9,967	-£11,177	-£10,337	-£9,716	-£9,497	-£9,299	-£9,101	-£8,969	-£8,848	-£8,739	-£8,639	-£8,549	-£8,452

500 kWe Organic Rankine Cycle, biomass-fuelled CHP and site-wide district heating

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital costs (£'000s)																
CHP plant costs (including energy centre, boilers etc)	-£3,224	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£61
District heating network costs	-£2,926	-£2,926	-£2,926	-£2,926	-£2,926	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Cost of heat exchangers	-£83	-£300	-£498	-£457	-£468	-£501	-£374	-£22	-£22	-£33	£0	£0	£0	£0	£0	£0
Capital offsets (£'000s)																
Boiler plant	£200	£752	£1,306	£1,206	£1,258	£1,412	£1,006	£103	£103	£155	£0	£0	£0	£0	£0	£0
Gas connections	£44	£154	£242	£220	£220	£220	£176	£0	£0	£0	£0	£0	£0	£0	£0	£0
Operating costs (£'000s)																
CHP fuel cost	£0	-£10	-£45	-£113	-£174	-£247	-£309	-£332	-£334	-£335	-£339	-£339	-£339	-£339	-£339	-£339
Boiler fuel cost	£0.00	£0.00	£0.00	£0.00	£0.00	-£1.32	-£28.34	-£56.32	-£61.49	-£63.32	-£71.92	-£71.92	-£71.92	-£71.92	-£71.92	-£71.92
O&M cost	£0	-£31	-£53	-£89	-£122	-£157	-£190	-£213	-£213	-£213	-£213	-£213	-£213	-£213	-£213	-£213
Revenues (£'000s)																
Revenue from electricity sales	£0	£4	£20	£49	£76	£108	£135	£145	£146	£146	£148	£148	£148	£148	£148	£148
Revenue from sale of ROCs	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Revenue from sale of heat	£0	£21	£97	£228	£346	£476	£618	£714	£720	£722	£733	£733	£733	£733	£733	£733
Total cost in year (£'000s)	-£5,989	-£2,336	-£1,857	-£1,882	-£1,790	£1,310	£1,034	£339	£338	£379	£257	£257	£257	£257	£257	£317
Cumulative cost (£'000s)	-£5,989	-£8,324	-£10,181	-£12,063	-£13,853	-£12,543	-£11,509	-£11,170	-£10,832	-£10,453	-£10,197	-£9,940	-£9,683	-£9,427	-£9,170	-£8,853
Net present value (£'000s)	-£5,989	-£8,112	-£9,647	-£11,060	-£12,283	-£11,469	-£10,886	-£10,712	-£10,554	-£10,394	-£10,295	-£10,205	-£10,123	-£10,049	-£9,981	-£9,905

2.5 MWe steam-cycle, biomass fuelled CHP system and site-wide district heating (all parcels)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital costs (£'000s)																
CHP plant costs (including energy centre, boilers etc)	-£6,093	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£61
District heating network costs	-£2,660	-£2,660	-£2,660	-£2,660	-£2,660	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Cost of heat exchangers	-£75	-£273	-£453	-£415	-£425	-£455	-£340	-£20	-£20	-£30	£0	£0	£0	£0	£0	£0
Capital offsets (£'000s)																
Boiler plant	£200	£752	£1,306	£1,206	£1,258	£1,412	£1,006	£103	£103	£155	£0	£0	£0	£0	£0	£0
Gas connections	£44	£154	£242	£220	£220	£220	£176	£0	£0	£0	£0	£0	£0	£0	£0	£0
Operating costs (£'000s)																
CHP fuel cost	£0	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270	-£1,270
Boiler fuel cost	£0.00	£0.00	£0.00	-£0.01	-£0.01	-£0.02	-£0.02	-£0.03	-£0.03	-£0.03	-£0.03	-£0.03	-£0.03	-£0.03	-£0.03	-£0.03
O&M cost	£0	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294	-£294
Revenues (£'000s)																
Revenue from electricity sales	£0	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786	£786
Revenue from sale of ROCs	£0	£1,490	£1,380	£1,198	£1,031	£787	£613	£478	£474	£472	£463	£463	£463	£463	£463	£463
Revenue from sale of heat	£0	£21	£97	£228	£346	£476	£618	£714	£720	£722	£733	£733	£733	£733	£733	£733
Total cost in year (£'000s)	-£8,584	-£1,294	-£866	-£1,001	-£1,009	£1,661	£1,295	£496	£499	£540	£417	£417	£417	£417	£417	£478
Cumulative cost (£'000s)	-£8,584	-£9,878	-£10,743	-£11,745	-£12,754	-£11,093	-£9,798	-£9,302	-£8,803	-£8,264	-£7,846	-£7,429	-£7,012	-£6,594	-£6,177	-£5,699
Net present value (£'000s)	-£8,584	-£9,760	-£10,476	-£11,228	-£11,917	-£10,886	-£10,155	-£9,900	-£9,668	-£9,439	-£9,278	-£9,132	-£8,999	-£8,878	-£8,768	-£8,653

A.2 Cranbrook town centre DH cashflows

500 kW_e Organic Rankine Cycle, biomass-fuelled CHP and district heating in the town centre (Parcel B)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital costs (£'000s)																
CHP plant costs (including energy centre, boilers etc)	-£3,040	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£23
District heating network costs	-£564	-£564	-£564	-£564	-£564	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Cost of heat exchangers	£0	£0	-£116	-£198	-£168	-£66	-£33	-£11	-£11	-£22	£0	£0	£0	£0	£0	£0
Capital offsets (£'000s)																
Boiler plant	£0	£0	£295	£495	£426	£189	£95	£32	£32	£63	£0	£0	£0	£0	£0	£0
Gas connections	£0	£0	£44	£82	£65	£12	£6	£2	£2	£4	£0	£0	£0	£0	£0	£0
Operating costs (£'000s)																
CHP fuel cost	£0	£0	£0	-£21	-£51	-£88	-£129	-£136	-£140	-£140	-£152	-£152	-£152	-£152	-£152	-£152
Boiler fuel cost	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
O&M cost	£0	-£33	-£33	-£36	-£40	-£45	-£50	-£51	-£51	-£51	-£53	-£53	-£53	-£53	-£53	-£53
Revenues (£'000s)																
Revenue from electricity sales	£0	£0	£0	£9	£22	£38	£56	£59	£61	£61	£66	£66	£66	£66	£66	£66
Revenue from sale of ROCs	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Revenue from sale of heat	£0	£0	£0	£39	£99	£169	£248	£261	£269	£270	£293	£293	£293	£293	£293	£293
Total cost in year (£'000s)	-£3,604	-£597	-£374	-£194	-£211	£210	£193	£156	£162	£184	£154	£154	£154	£154	£154	£177
Cumulative cost (£'000s)	-£3,604	-£4,202	-£4,576	-£4,770	-£4,981	-£4,771	-£4,579	-£4,422	-£4,261	-£4,076	-£3,922	-£3,768	-£3,614	-£3,460	-£3,306	-£3,129
Net present value (£'000s)	-£3,604	-£4,147	-£4,457	-£4,602	-£4,747	-£4,616	-£4,508	-£4,427	-£4,352	-£4,274	-£4,214	-£4,160	-£4,111	-£4,067	-£4,026	-£3,984

5 MW biomass boiler plant and district heating in the town centre (Parcel B)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital costs (£'000s)																
CHP plant costs (including energy centre, boilers etc)	-£1,265	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£163
District heating network costs	-£564	-£564	-£564	-£564	-£564	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Cost of heat exchangers	£0	£0	-£116	-£198	-£168	-£66	-£33	-£11	-£11	-£22	£0	£0	£0	£0	£0	£0
Capital offsets (£'000s)																
Boiler plant	£0	£0	£295	£495	£426	£189	£95	£32	£32	£63	£0	£0	£0	£0	£0	£0
Gas connections	£0	£0	£44	£82	£65	£12	£6	£2	£2	£4	£0	£0	£0	£0	£0	£0
Operating costs (£'000s)																
Wood fuel cost	£0.00	£0.00	£0.00	-£14.64	-£36.90	-£63.17	-£92.87	-£97.94	-£101.05	-£101.16	-£109.81	-£109.81	-£109.81	-£109.81	-£109.81	-£109.81
O&M cost	£0	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50	-£50
Revenues (£'000s)																
Revenue from sale of heat	£0	£0	£0	£39	£98	£168	£247	£261	£269	£269	£292	£292	£292	£292	£292	£292
Total cost in year (£'000s)	-£1,829	-£614	-£391	-£211	-£230	£190	£172	£135	£140	£163	£132	£132	£132	£132	£132	£295
Cumulative cost (£'000s)	-£1,829	-£2,444	-£2,835	-£3,046	-£3,276	-£3,086	-£2,914	-£2,779	-£2,638	-£2,475	-£2,343	-£2,210	-£2,078	-£1,945	-£1,813	-£1,518
Net present value (£'000s)	-£1,829	-£2,388	-£2,711	-£2,870	-£3,027	-£2,909	-£2,812	-£2,742	-£2,677	-£2,608	-£2,556	-£2,510	-£2,468	-£2,430	-£2,395	-£2,324

B COST IMPLICATIONS OF MEETING CODE FOR SUSTAINABLE HOMES LEVELS AT CRANBROOK

Combinations of fabric efficiency measures and micro-generation technologies were considered to achieve the minimum CO₂ reduction standards stipulated by each level of the Code for Sustainable Homes (CSH). The choices of measures used were guided by the cost effectiveness graphs presented in Section 4.2.2. The most cost effective carbon saving measures were applied (where combinations and sequential application were appropriate) to produce appropriate low carbon strategies which achieve the CSH levels at the lowest possible capital costs.

The cost per dwelling of implementing a site-wide system (e.g. gas/biomass CHP) was also considered and compared to the relevant dwelling-by-dwelling strategies for the various code levels.

There are few suitable strategies to achieve each Code Level.

It was also observed that the suitable low CO₂ strategies vary little between different dwelling types, although minor variations occurred between the strategies for flats and houses.

The key differences between houses and flats are summarised below:

1. Fabric efficiency measures alone can achieve CSH level 3 for houses, but not for flats. A solar water heater is required for flats.
2. Micro-biomass boilers are inappropriate for flats (due to space constraints) and therefore extra PV (with respect to the strategy used for a house) is used to achieve CSH level 4.

B.1 Strategies for achieving each code level and costing

The appropriate strategies to achieve the CSH level CO₂ emissions targets and their capital cost implications are discussed below. The discussion focuses on the case of a typical house (the appropriate strategies differ slightly for flats, as discussed in Appendix B.2).

It is assumed that basic energy efficiency measures are applied at all Code Levels. These basic energy efficiency measures are referred to as Fabric Package A and are tabulated in *Figure 75*.

Fabric package A- initial, highly cost effective fabric efficiency measures (typical house)
4:1 S:N glazing ratio
Delayed start thermostat
Thermostat in hot water cylinder
Zone and time controlled heating
Air permeability to $5\text{m}^3/\text{m}^2/\text{hr}$
High efficiency condensing boiler (omitted for site wide or micro-biomass strategies)
Windows to $1.3\text{W}/\text{m}^2\text{K}$

Figure 75, Basic fabric efficiency measures applied at all Code Levels (note that high efficiency condensing boilers are omitted from the package of energy efficiency measures applied when site-wide heating is implemented)

The highest level of the Code (Level 6) stipulates a minimum fabric performance in addition to net zero CO₂ emissions. In order to achieve this very high levels of insulation and low infiltration are required. This is achieved by application of Fabric Package B.

Fabric package B- low cost effectiveness fabric efficiency measures (typical house)
Walls to $0.21\text{ W}/\text{m}^2\text{K}$
Reduce air permeability to $3\text{m}^3/\text{m}^2/\text{hr}$ + add balanced whole house ventilation and heat recovery

Figure 76, Additional increase in insulation and infiltration standards required to meet the fabric efficiency standards stipulated by Code Level 6.

B.1.1 CSH level 3

CSH level 3 requires a 25% reduction in dwelling CO₂ emissions, (appliance emissions excluded) and was the least strict CSH level considered. Fabric efficiency measures alone can achieve this level, but combining fabric efficiency with a solar water heater is more cost effective.

CSH level 3 can be achieved by applying fabric package A and then either:

- 1) A solar water heater
- 2) Fabric package B

Both routes provide a robust method of achieving CSH level 3 and are entirely dwelling independent.

The cumulative carbon reductions associated with each strategy are presented below:

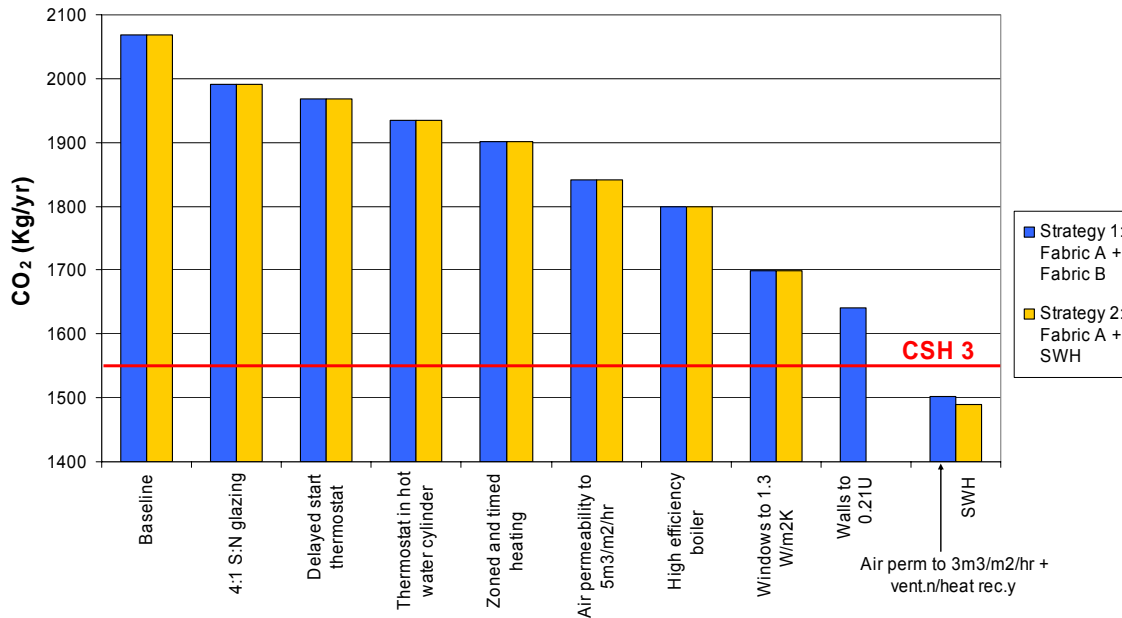


Figure 77, Cumulative reduction in CO₂ emissions as low carbon measures are sequentially applied. The reduction of CO₂ accumulates from left to right (starting from base case emissions) as additional measures are added. Red lines indicate the target emissions levels to achieve CSH levels. Note the divergence of the strategies after the installation of highly efficient windows.

The capital costs of the strategies can be broken down as follows:

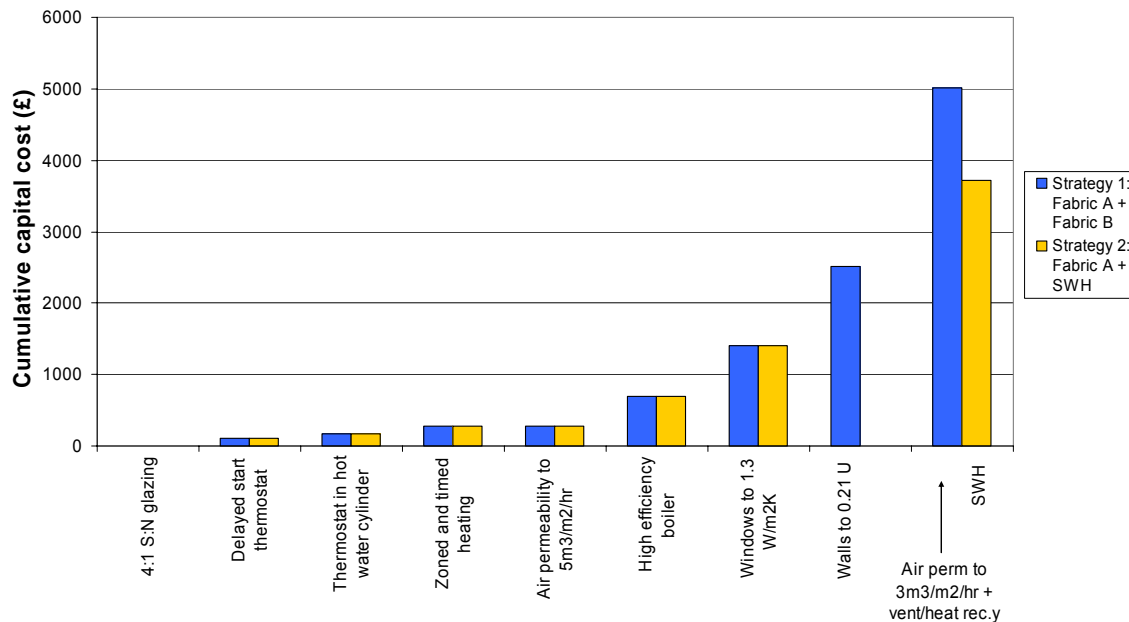


Figure 78, Cumulative capital cost of methods designed to achieve CSH level 3.

The costs incurred for each strategy are as follows:

- 1) Fabric A + SWH Capital cost = £3,700
- 2) Fabric A + B Capital cost = £5,000

Using basic fabric efficiency measures and a SWH provides a robust method of reaching CSH Level 3 at the lowest capital cost.

B.1.2 CSH level 4:

CSH level 4 demands a 44% reduction in CO₂ base case emissions (appliance emissions neglected). Very close to this level of CO₂ reduction could be achieved by provision of the whole heat demand from renewable sources, i.e. with a biomass boiler, however a lower cost means of reaching Code Level 4 is combination of fabric efficiency measures and renewable electricity generation (photovoltaics).

To achieve CSH Level 4, site-wide energy systems (CHP and district heating) become more cost-effective than microgeneration measures applied in individual buildings.

CSH level 4 can be achieved by applying fabric package A and then:

- 1) A photovoltaic array
- 2) Gas-fired site-wide CHP

The cumulative CO₂ reductions for the 2 strategies are as follows:

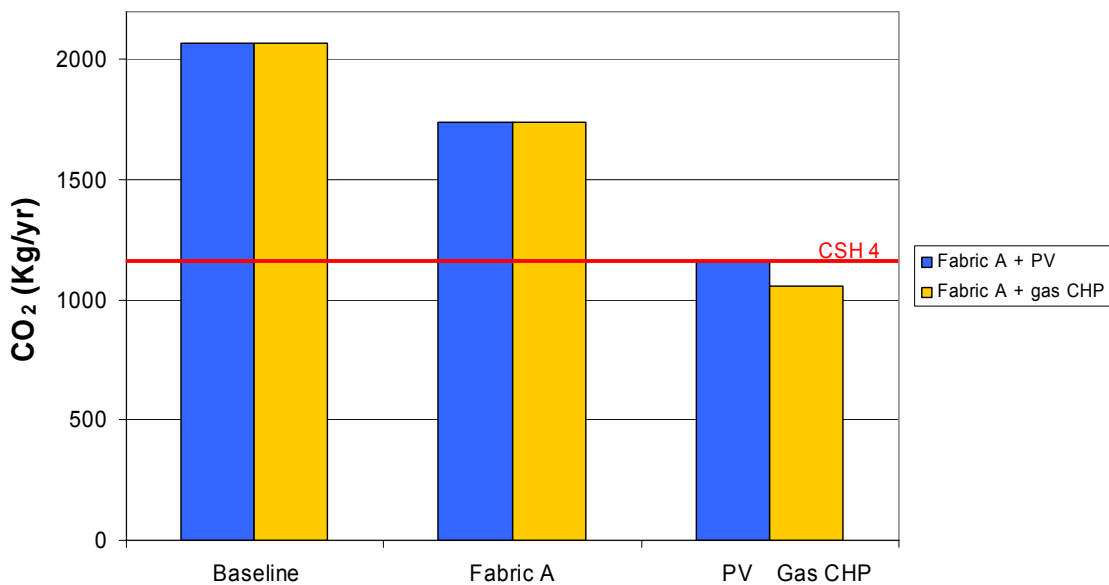


Figure 79, cumulative CO₂ reductions for strategies designed to achieve CSH level 4.

The associated capital costs are presented below:

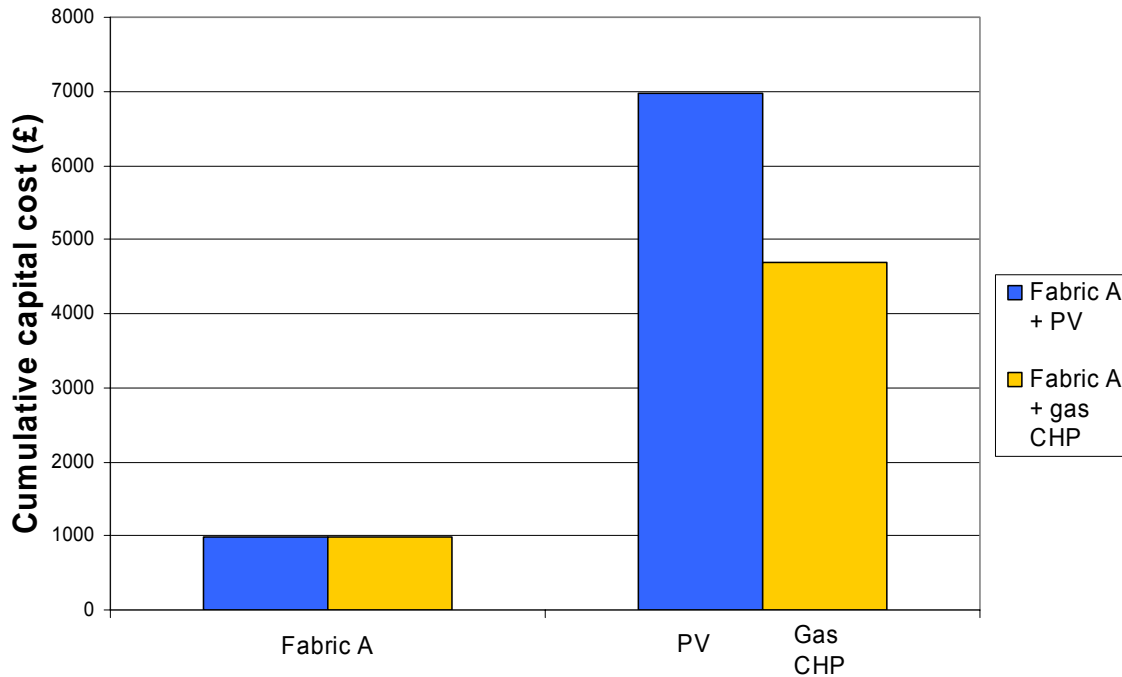


Figure 80, Cumulative capital cost of strategies designed to achieve CSH level 4.

The costs incurred for each strategy are as follows:

- 1) Add PV (1.1kWp array required) Capital cost = £7000
- 2) Implement gas-fired CHP Capital cost = £4,700
per dwelling

The site-wide gas CHP option is the lower cost route to achieving Code Level 4. This analysis is based on the Cranbrook site, which is planned to be built at an average density of 35 – 40 dwellings per hectare, i.e. relatively low density. Site-wide systems will become increasing cost-effective on higher density sites.

This analysis has demonstrated that site-wide systems become the more cost-effective than microgeneration measures once Code Level 4 is enforced. For a site such as Cranbrook, which will be developed in packages and for which differing Levels of the Code are likely to be enforced on the later packages, implementation of the lower cost microgeneration approach to achieving CSH Level 3 in the first phase could increase the cost of achieving Code Level 4 and above on subsequent packages. In order for developers to invest in measures that may deliver CO₂ reductions in excess of currently enforced levels so as to ensure the whole package is developed in the most cost-effective way, certainty is required that the higher Levels of the Code will be enforced on a definite timetable.

B.1.3 CSH level 5:

Attainment of CSH level 5 requires a large, abrupt step in CO₂ reduction. CO₂ emissions relating to all heating and dwelling electricity demand (appliance electricity neglected) must be offset. Technology combinations must allow a large fraction (if not all) of the dwelling heat demand to be met and also provide for at least the entire dwelling based electricity demand (over producing

electricity for grid export is possible to offset the dwelling heating emissions – a net zero carbon solution neglecting appliances).

CSH level 5 can be achieved by applying fabric package A and:

- 1) Installing a 15kW micro-Biomass boiler + supplementary PV array.
- 2) Implementing Biomass site CHP using an Organic Rankine Cycle (ORC) plant and adding supplementary PV.
- 3) Implementing Biomass site CHP using an oversized system (compared to heat loads) and operating it to maximise electricity generation.

The cumulative CO₂ reductions for the 3 strategies are presented below:

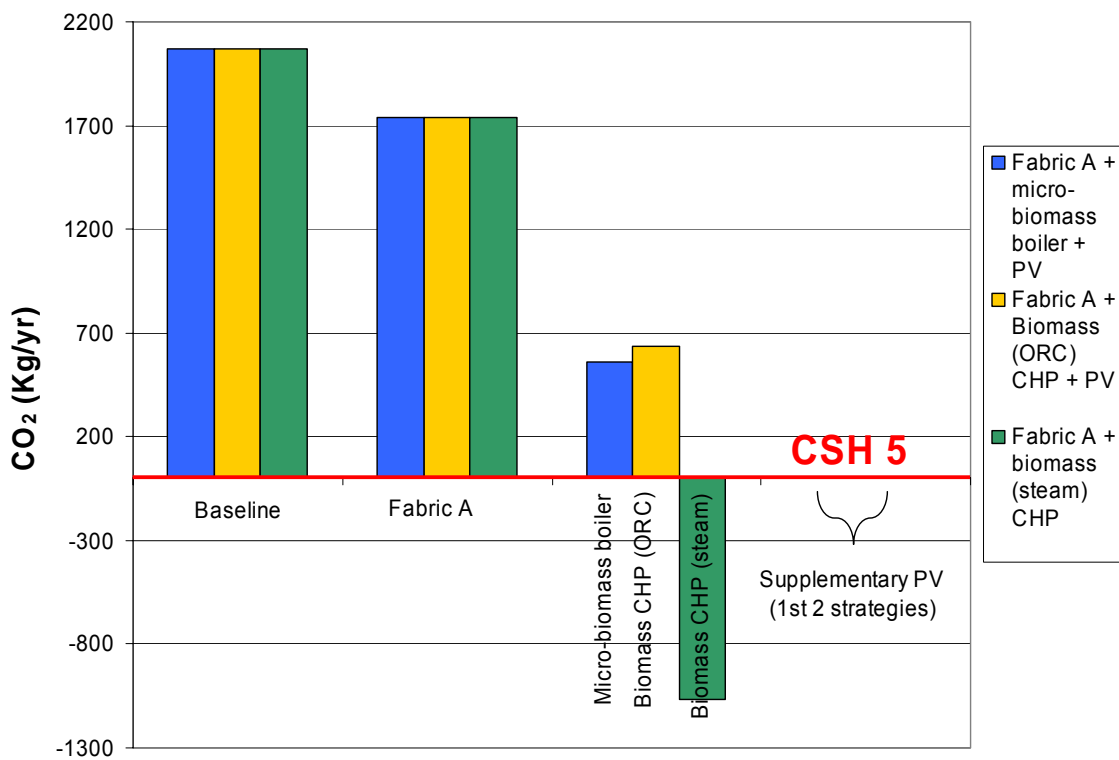


Figure 81, cumulative CO₂ reductions for strategies designed to achieve CSH level 5.

The associated capital costs are as follows:

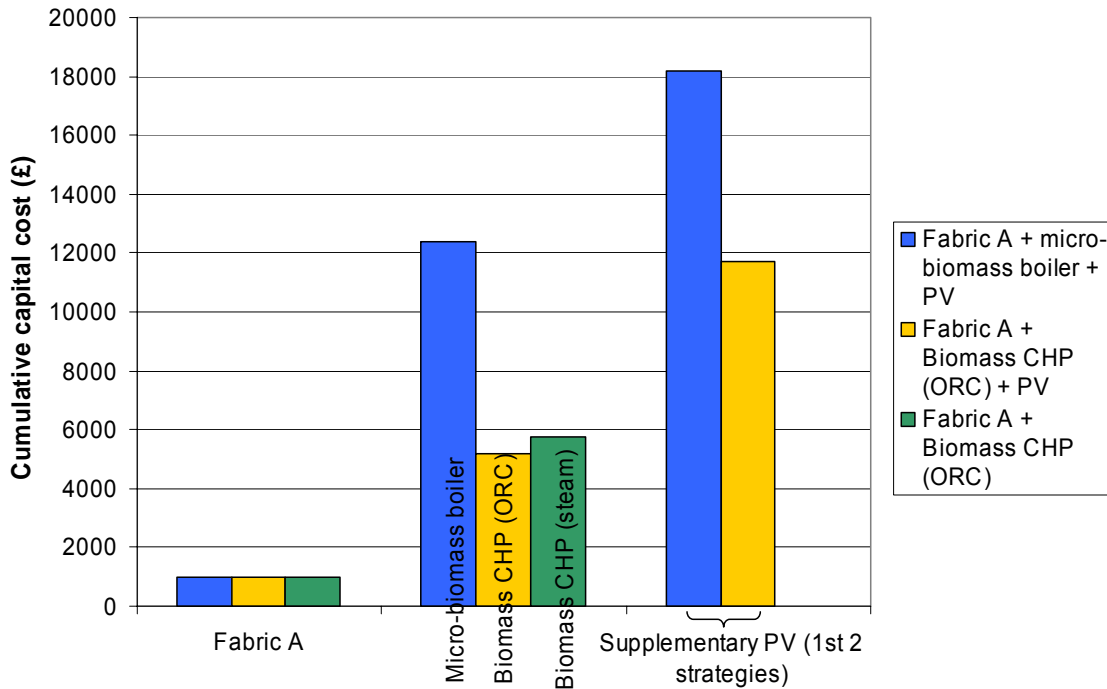


Figure 82, Cumulative capital cost of strategies designed to achieve CSH level 5.

The capital costs incurred for each strategy are as follows:

- 1) Micro-biomass boiler + PV Capital cost = £17,200
- 2) Biomass CHP ORC + PV (1.3kWp required) Capital cost = £11,700
- 3) Biomass CHP (steam) Capital cost = £5,700

The micro-biomass and PV strategy is expensive in capital terms due to the high on-costs of the boiler and PV array.

Biomass site-wide CHP becomes financially optimal for CSH code levels 5 and 6 and costs only c£2,000 more than the strategies designed to achieve CSH code level 3. Using gas CHP initially to achieve CSH level 4 and re-fitting later with a biomass plant is possible, however the gas engine has a 15 year life before becoming due for replacement and substantial modifications would be required to adapt the energy centre for a biomass-fuelled system (biomass storage, fuel delivery system etc).

B.1.4 CSH level 6

Code for Sustainable Homes Level 6 demands that a dwelling is net zero carbon. Emissions relating to a dwellings heat demands and all electricity demands (including appliances) must be offset.

The strategy designed to achieve CSH level 6 provides for the entire domestic heating and electricity demands using a biomass CHP system. The system needs to be oversized and operated at high load factor in order to maximise the generation of renewable electricity (heat will be rejected when there is insufficient heat load on the district heating system).

CSH level 6 can only be achieved by applying fabric efficiency package A and B and then implementing biomass CHP using an oversized steam-turbine plant.

The cumulative CO₂ reductions resulting from this strategy are presented below:

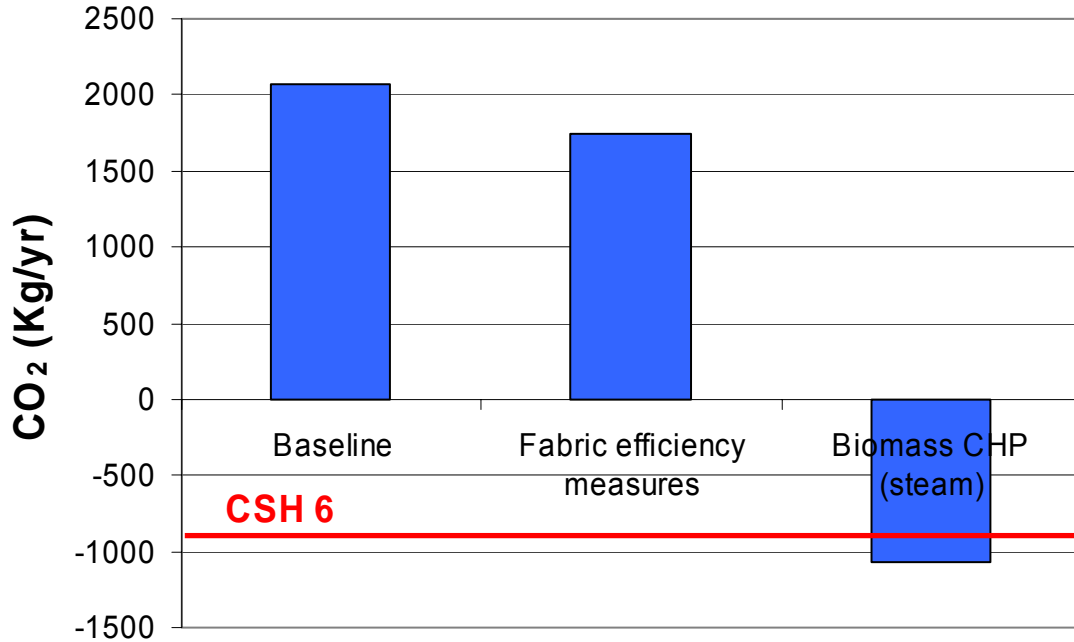


Figure 83, Cumulative CO₂ reductions for the strategy designed to achieve CSH level 6.

The associated capital costs of the strategy are as follows:

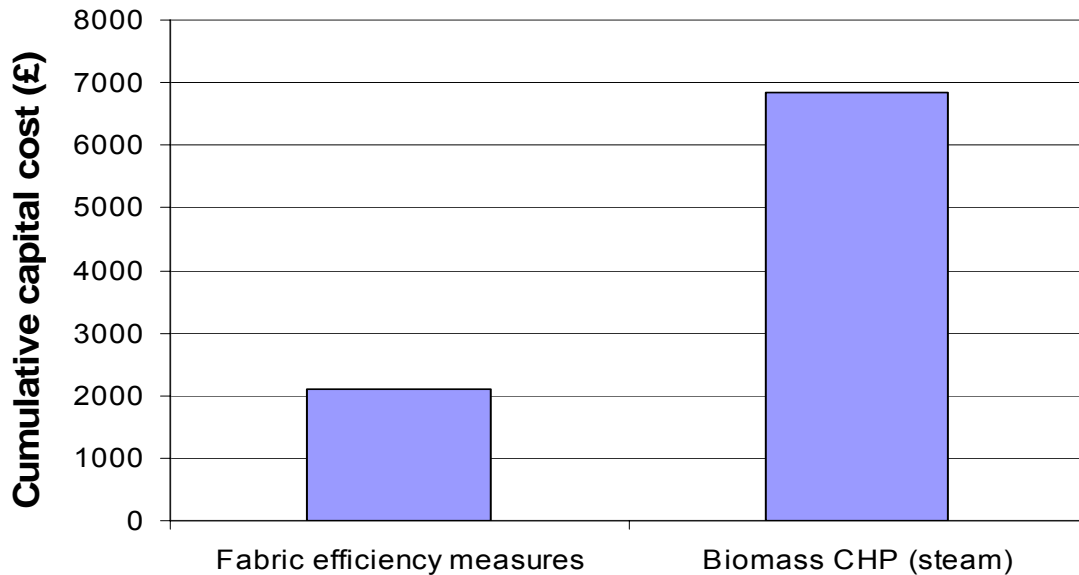


Figure 84, cumulative capital cost of strategy designed to achieve CSH level 6.

This strategy has a capital cost of £6,800

No other appropriate strategies can provide the carbon savings required to achieve CSH level 6. Dwelling-by-dwelling strategies fall a long way short of being able to achieve CSH level 6, due to the restrictions inherent to applying renewable technologies to an individual dwelling e.g. areas required for PV arrays become larger than available roof spaces.

A site-wide biomass CHP system is essential for achieving CSH level 6 (the only other potential means would be installation of sufficient wind turbine capacity to offset the whole site’s CO₂ emissions. This has not been considered in detail as it is assumed that planning constraints will effectively preclude this option).

B.1.4 Summary of lowest cost measures to achieve CSH Levels in Houses

The financially optimal methods of achieving the various CSH code levels (for a typical house) are presented in the following table as an overview:

CSH code level	Most cost effective low carbon strategy	Capital cost
3	Fabric A + SWH	£3,700
4	Fabric A + site-wide gas CHP	£4,700
5	Fabric A + site-wide biomass CHP (steam)	£5,700
6	Fabric A & B + site-wide biomass CHP (steam)	£6,800

Figure 85, the most cost effective strategies of achieving CSH compliance (typical house).

The following flow chart denotes the cumulative step-wise nature of the low carbon strategies proposed:

Typical house:

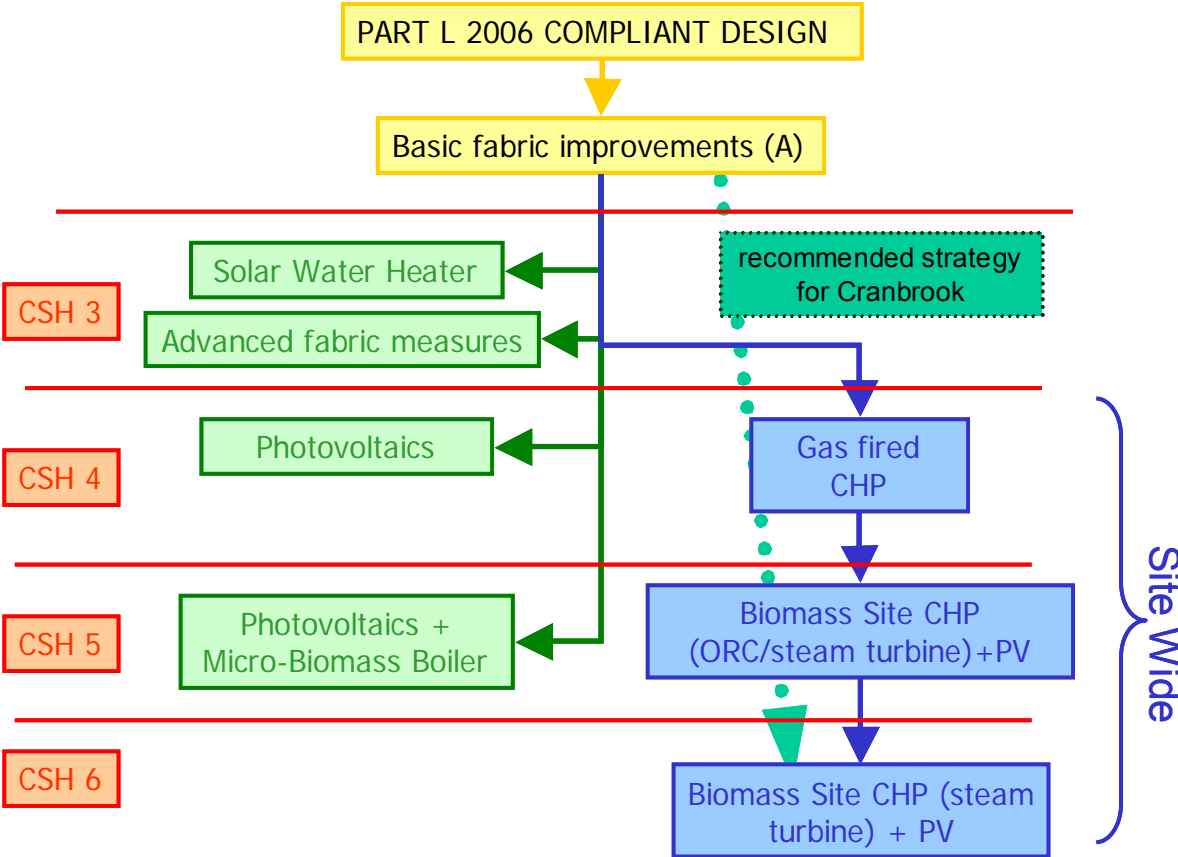


Figure 86, Flow chart detailing the most appropriate least cost strategies for achieving each of the CSH code levels. Measures are added cumulatively as they are passed through. Part L compliance is taken as the base case starting point. The dashed green line represents the recommended strategy.

B.2 Strategies for achieving each code level and costing- flat variations

As mentioned, the low carbon strategies required for a typical flat vary little from the strategies required for a typical house. The relevant low carbon strategies for a typical flat will now be presented and assigned costs for each code level. Any variations from the strategies suggested for the typical house will be clearly noted.

Basic fabric efficiency measures were again seen as essential for all low carbon strategies considered. A fabric A package contains highly cost effective fabric efficiency measures (no fabric B package as fabric efficiency measures alone are insufficient to achieve CSH level 3). These measures vary from those used in the typical house analysis and may be summarised as follows:

Fabric package A – initial, highly cost effective fabric measures (typical flat)
4:1 N:S glazing ratio
Delayed start thermostat
Zone and time controlled heating
Air permeability of external walls reduced to 5m ³ /m ² /hr

Wall (to 0.21 W/m²K) and window improvements (to 1.3W/m²K) were again including for CSH level 6 minimum fabric performance compliance.

B.2.1 CSH level 3

CSH level 3 can only be achieved reasonably by adding fabric package A and a SWH. There is no way to achieve CSH level 3 using only fabric efficiency measures as for a typical house.

Capital cost = £2,200

Achieving CSH level 3 is cheaper for a flat than a house due to the comparatively low heat demand of the flat. A smaller SWH is required for the flat.

As for the typical house, dwelling-by-dwelling low carbon strategies are financially optimal for CSH levels 3 and below.

B.2.2 CSH level 4

For CSH levels 4 and above site-wide systems again become financially optimal.

CSH level 4 can be achieved by adding fabric package A and then:

- 1) A photovoltaic (PV) array Capital cost = £4,700
- 2) Gas site-wide CHP Capital cost = £4,000

Site-wide strategy capital costs are even cheaper for flats than for houses, strengthening the argument that site-wide systems should be considered from an early stage at Cranbrook.

The following flow chart denotes the cumulative step-wise nature of the low carbon strategies proposed:

Flat:

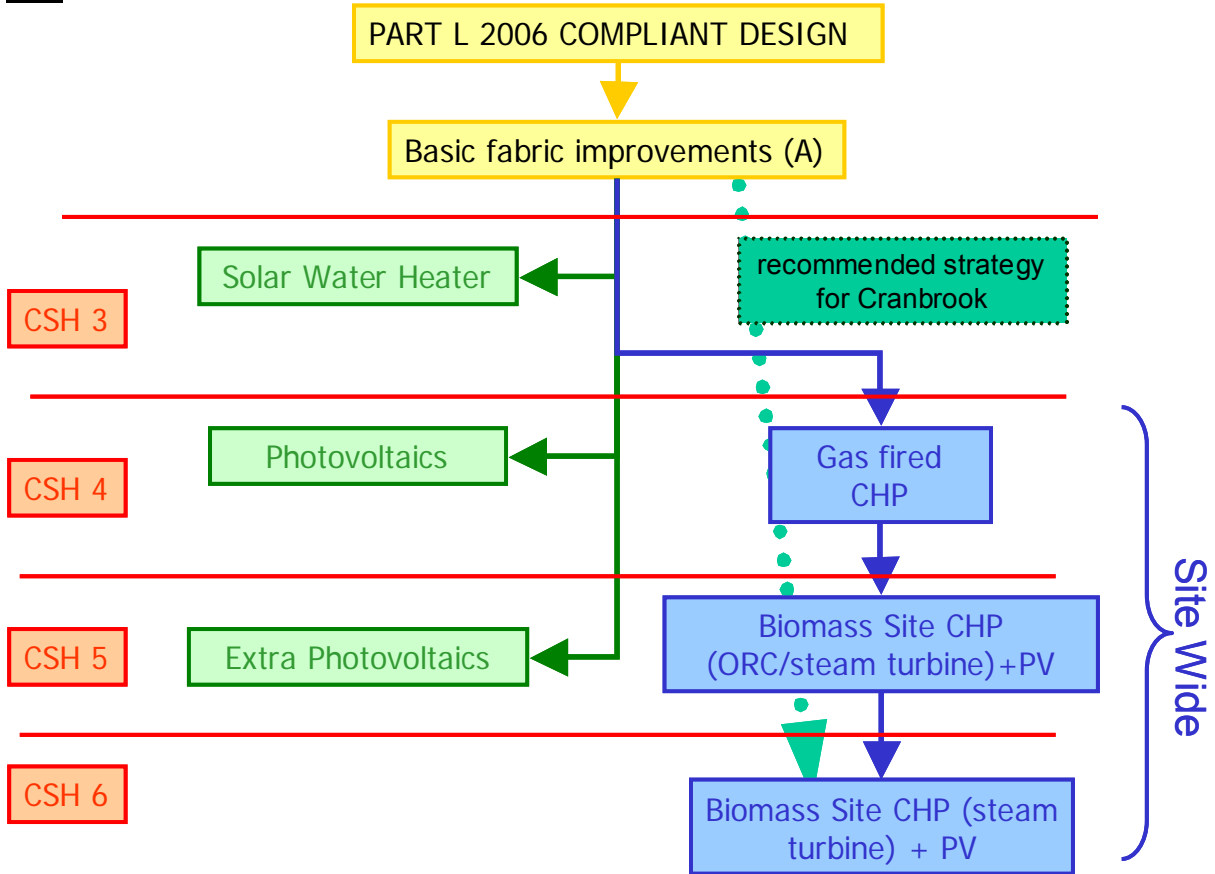


Figure 88, The flow chart for the flats is very similar to that for the houses.

B.3 Low CO₂ strategy summary and conclusions

The developers at Cranbrook are committed to achieving Code for Sustainable Homes Level 3 in the residential development. The analysis above has shown that the lowest capital cost approach to achieving this, and therefore the route likely to be favoured by the developers, is implementation of a package of fabric improvement measures with solar thermal heating.

However, the preceding analysis has also highlighted that to achieve higher levels of the Code for Sustainable Homes, site-wide energy systems are more cost-effective. Indeed to achieve Code Level 6, a biomass CHP system (operated at high load factor) with district heating is the only practical route. If the developers could be incentivised to adopt a site-wide system at the outset, a number of longer-term benefits could be captured.

1. Capital cost

The steam biomass CHP strategy is the cheapest in capital terms at CSH code levels 5 and 6, and only marginally more expensive at level 4. Capital outlay to achieve higher code level compliance will be far less in the future if a site-wide DH network is installed in the first instance.

2. The Cranbrook site is a Greenfield site

Construction of the DH system at an early stage will be far more cost effective and simple, than removing infrastructure installed to meet lower code levels in the short term.

3. House by house strategies present severe complications:

- Micro-Biomass boilers (in each home) require fuel to be delivered regularly to individual dwellings. This is far more complicated than having a centralised system.
- Micro-Biomass boilers (15kW studied) are bulky and are inappropriate for flats and many houses.
- Strategies involving extensive PV usage require extensive areas of suitably inclined roof space, which may not always be available (particularly relevant to flats where roof space is shared).

4. Initial house-by-house treatment does not facilitate later measures to retrospectively increase the Code level standard:

Several house-by-house strategies (e.g. SWH for CSH 3) become rapidly obsolete for higher code levels. These short-term strategies can even hinder long term CSH 6 compliance e.g. by occupying essential roof space for PV. However, retrospective improvement to achieve higher code levels is not expected to be mandatory.

To achieve CSH level 6 at Cranbrook, a steam biomass CHP system and district heating scheme must be installed (at significant capital cost). House-by-house strategies cannot provide the necessary CO₂ savings to meet the onerous requirements of the highest code level and are less cost effective for levels 4 and above than site-wide low carbon strategies. Site-wide systems are the only way to achieve the highest code level.

C KEY RESOURCE ASSESSMENT

C.1 Biomass

Potential sources of biomass in the near Exeter area includes forestry residues, primary processing co-products (i.e. from sawmills), recycled wood waste, packaging and pellets as well as energy crops (short rotation coppice, miscanthus). The latter are not extensively grown at present, however, the potential areas suitable for growth of these crops are shown in *Figure 91*. According to the Regional Zero Carbon Study, such crops may in future fill the gap between wood fuel supply and demand.

According to Devon County Council in the South West region there is a total of 200,000 odt/yr of biomass material easily obtainable.

The potential resources presently available in the Southwest region, compiled from data from a range of sources, are described in the table below.

Resource	Odt/yr	Source
Woodland (brashings only)	46,500 *	Revision 2020
Woodland (brashings and stemwood from thinning and felling)	100,000-135,000 potentially available for wood fuels ** (491,000 total)	Renewable Heat and Power Ltd report for Forestry Commission (2004) (Forestry Commission)
Arboricultural residues	34,000	Revision 2020 (BRL report)
Arboricultural residues	51,300	Forestry commission
Sawmill	27,200	Revision 2020 (BRL report)
Primary processing co-products	27,200	Forestry commission
Packaging and pellets	100,000	Revision 2020 (BRL report)
Clean recycled wood waste (Devon and Somerset area only)	50,000	Renewable Heat and Power Ltd (Revision 2020 annex)
Short Rotation Coppice	964	Forestry commission
Total	c. 258,700 - 364,500 odt/yr	

Figure 89, Estimate of the woodfuel resource in the South West (data taken from a variety of prior studies and Forestry Commission figures)

* Assumes a yield of 2 odt/ha, and only 25% of this is recoverable & available for use, it does not include the 'backlog' of wood available from overgrown woodlands being renovated

** Technical and environmental constraints are considered in calculating this figure but not economic/market constraints

C.1.1 Woodland and forest residues

Estimates of woodland area in the southwest range from 8.7% to 9.8%, this is equivalent to an area of c. 212,000 ha. The Revision 2020 report claims c. 93,100 ha of this is managed. Exmoor and Dartmoor have slightly higher levels of woodland at 12% and 11% respectively. Exmoor National Park has recently been working with Southwest Woodfuels to utilise woodfuel heating within the park. The resources are only expected to cover 13% of Exmoor’s heating requirements.

Forest residues that are potentially available for wood fuel include stemwood (of small diameter) and branches from early thinnings and ‘lop and top’. The following chart from the Forestry Commission shows c.50,000t of stemwood and c.75,000t of branches, a total of 125,000t of available biomass from Forestry Commission and private land.

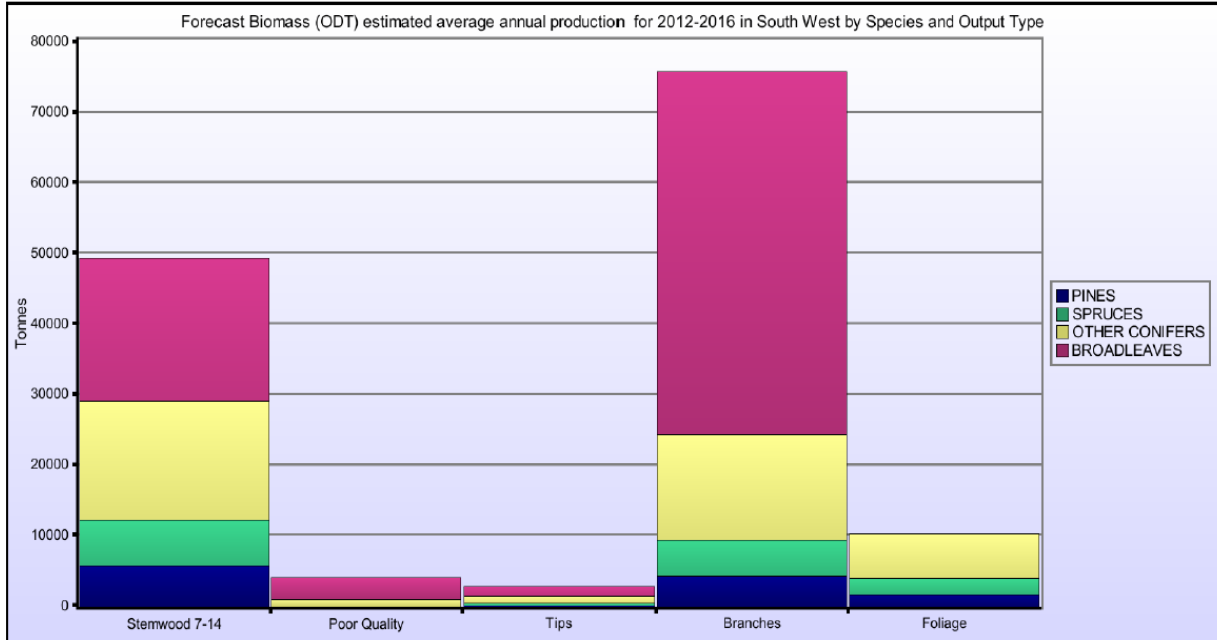


Figure 90, Forestry Commission estimation of the sustainable wood fuel resource in the South West from Forestry Commission land and private forestry. The analysis includes short round wood and brashings from all woodland varieties and includes forestry residue and resource arising from felling.

C.1.2 Sawmills and pellet manufacturers

The nearest sawmill is Culver Sawmill c.4miles West of Exeter and the next nearest sawmill is Rattery Sawmill, South Brent, 27 miles to the Southwest.

There is one major pellet producer in the southwest listed by the Revision 2020 report, Western Wood Pellets Ltd in Shepton Mallet, producing c.2000t/yr.

There are other pellet producers closer to Exeter (e.g. Ecowood Fuels, Hemyock, Devon, manufactures and imports pellets). Matford TRECO based next to the Marsh Barton waste transfer site in Exeter, supplies wood pellets and grain.

C.1.3 Energy crops

The following map has been extracted from South West REvision 2020 report. It highlights the land considered to be of good potential for growth of energy crops – miscanthus and short rotation coppice.

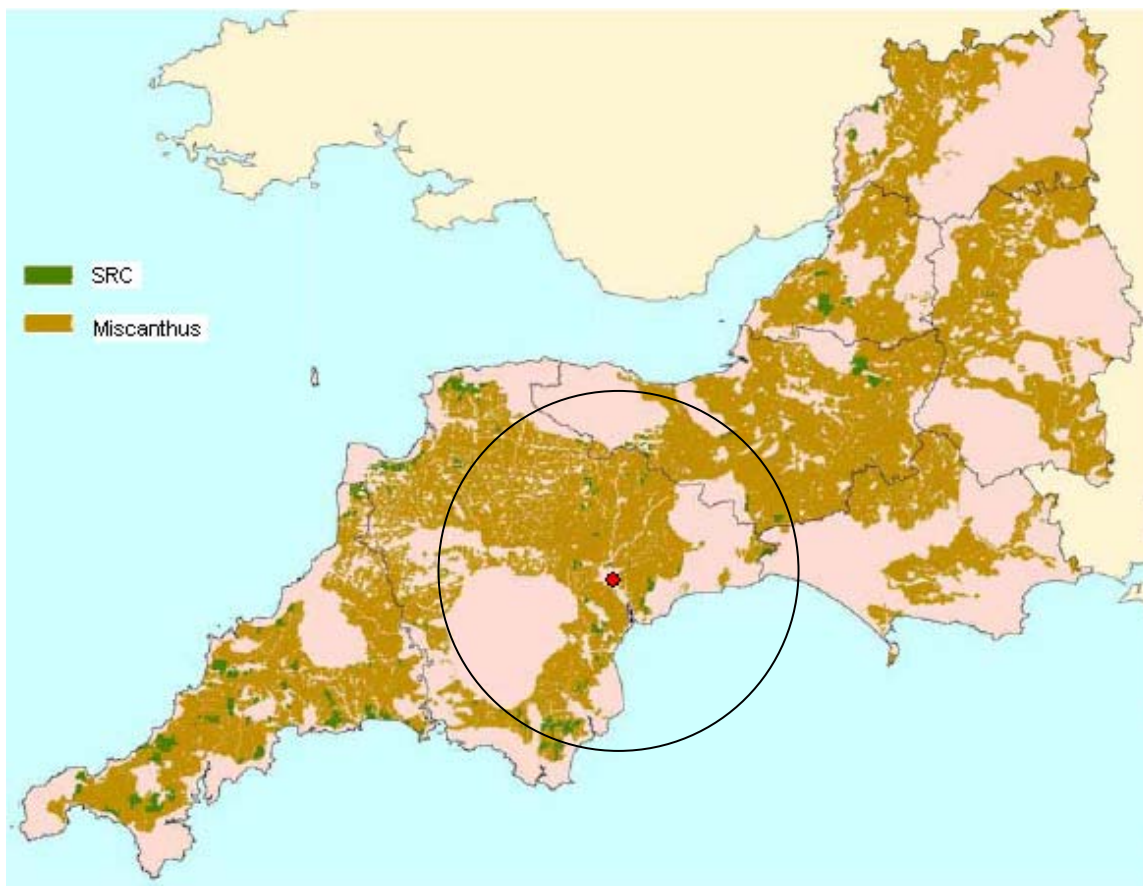


Figure 91, Potential area for growing energy crops (on land grade 1,2, or 3). Circle of 30 mile radius surrounds Exeter.

The total shaded area of potential Miscanthus plantation in the Southwest is 942,258 ha and for short rotation coppice (SRC) 45,284ha (Figure 91). The Revision 2020 report assumes 5% uptake of this by 2010 and 10% by 2020. On this basis, the capacity of biomass-fuelled plant that could be supported by the energy crop resource in the South West was estimated to be 96 MWe in 2010 and 187 MWe by 2020 (based on an assumption that 1MWe plant requires 8000odt/yr of fuel).

In the Southwest, the county of Devon has the largest area of rural land outside designated areas (Appendix C.3) and an arguably greater potential for the growth of energy crops.

Within a 30 mile radius of Exeter, as estimated from Figure 91, there are c.220,000ha which could potentially be planted with Miscanthus. Assuming a 5% uptake of this area (11,000ha) and the mature yield of 15 odt/ha, there is a potential supply of 165,000 odt/yr³². This is approximately equivalent to an energy resource of 740 GWh/yr, adequate to fuel around 30 MW of CHP plant.

³² The first harvest of miscanthus is 2 years after planting, however, can only be expected to have a 50% yield compared with the mature crop. Maturity is achieved 4 years after planting.

C.1.4 Other demand for biomass

The Regen SW project survey (April 2007) lists 10MW of total capacity of biomass projects in the southwest of which 2.2MW can be found in Devon. Planned projects that are part of the South West Bioheat Programme are expected to add 30MW to the total, consuming 40,000 odt/yr. A map displaying woodfuel installations (until 2005) across the Southwest has been compiled by the Forestry Commission (Appendix C.4).

Summary

- Information from Devon County Council, the REvision 2020 study and various other local sources suggests a potential woodfuel resource (including short rotation coppice) of around 250,000 odt/yr.
- The South West Bioheat Programme plans to add 30 MW of biomass plant capacity to the 10 MW of plant currently in operation across the region. This additional capacity is expected to consume around 40,000 odt/yr of biomass resource.
- In addition to the woodfuel resource, the REvision 2020 study identifies the opportunity for cultivation of a significant miscanthus resource in the South West region, although there is little existing miscanthus resource.
- It has been estimated that the area within a 30 mile radius of Exeter could potentially yield miscanthus crops equivalent to an annual energy resource of 740 GWh/yr, capable of supporting 30 MWe of efficient CHP capacity.
- The developments in the EEDNGP have a projected energy requirement of around 175 GWh/yr by 2020. There is adequate potential biomass resource in the region to make a significant contribution to this demand.

C.2 Waste to Energy

Waste can be converted to energy via various processes, heat from incineration can be used to raise steam to drive a steam turbine, anaerobic digestion produces a methane-rich biogas and advanced thermal treatments such as pyrolysis and gasification produce a combustible syngas, comprising H₂ and CO.

Mass-burn incineration facilities range in capacity from about 25,000 to over 500,000 tonnes/year throughput and are beyond the scope of this project. The technologies most appropriate for a small-scale energy recovery plant are anaerobic digestion and advanced thermal treatments and are described below.

C.2.1 Anaerobic Digestion (AD)

Anaerobic digestion is the biological degradation of organic material in the absence of oxygen. It generates a residue or digestate that is suitable for use as a fertilizer and produces a biogas, which is approximately 60% methane. It has long been a standard method for the treatment of sewage sludge and the biogas produced is often used for generation of on-site heat and power. Anaerobic digestion has also been used for the treatment of the organic fraction of municipal wastes, although there are issues surrounding the degree of segregation of the waste feedstock that is required.

The largest AD plant in the UK is based in Holsworthy, Devon and treats animal manure and organic food waste with a capacity of 146,000t.p.a. The plant size and operational capacity of AD systems are, however, typically smaller than those for energy from waste incineration. Systems treating c.5000t.p.a are described below.

- Greenfinch Ltd – 5000t.p.a. Biogas Plant
This plant has a capital cost of £1.2m (extracted from the Environment Agency's Waste Technology Data Centre) and requires source-separated household and green waste.
- Bioplex Ltd – Portagester system
This is a mobile and modular pre-composter and anaerobic fermenter system designed for local farm or community scale waste treatment. The separated liquid from this system can then be treated in an anaerobic digester. This system is suitable for upwards of 2000t.p.a.

Greenfinch Limited's Ludlow project received an average amount of kitchen waste of 4.2kg per household per week. On this basis Cranbrook, with 7,500 homes is therefore likely to generate 1638t.p.a, significantly below the capacity of their system.

C.2.2 Advanced Thermal Treatment (ATT) – Pyrolysis and gasification

These are novel, promising technologies that have not yet been tested widely in the U.K – the first UK plant treating MSW and clinical waste streams was built in Avonmouth, Bristol by Compact Power. Numerous other technologies are being developed and it is likely that small scale ATT will be commercially proven in the next 5 years.

Pyrolysis – Involves heating waste in the *absence* of oxygen at temperatures of 400 to 800 °C. The heat breaks down the molecules in the feedstock to produce a mixture of gaseous and liquid fuels which can subsequently be combusted.

Gasification – Involves heating waste in a *low oxygen* environment to produce a syngas (mixture of CO and H₂). The syngas is suitable for combustion in a gas engine. Gasification is not a new technology, it was used as far back as the 19th century to produce town gas from coal.

So far such systems have primarily been used to treat single, unmixed waste streams or pre-prepared fuel such as RDF. A example of a small scale system using the latter is being developed by ITI Energy Ltd. They have an advanced gasification modular system that is claimed to convert 1t of RDF to 1MWe and 1.5 MWth per hour. One module processes c.12-13,000t.p.a. and has a capital cost of £5m. The company builds, owns and operates the system and could provide a service to convert MSW to RDF but at additional cost.

The Stein Gassifier being developed by the First London Group is another potentially important technology (see <http://firstlondonpower.com/home>).

C.2.3 Available waste resources

Devon County Waste Local Plan, which covers the period until 31st March 2016, proposes a decentralized approach to waste management in the County, including the establishment of 4 to 6 waste to energy sites near the County’s urban centres, each of up to 75,000t.p.a capacity. One of these plants (c. 50-60,000t.p.a.) will be in close proximity to Exeter at Marsh Barton Industrial Estate. This facility is due to take residual municipal waste from Exmouth, Teignbridge and Exeter to convert to energy by thermal treatment. A waste transfer station dealing with c.100,000t.p.a already exists on the site and the WtE plant is due to be operational by Spring 2010.

Devon local authorities also have a target of achieving a recycling and composting rate of 50% by 2010 and 60% by 2020, for comparison the rate in the county was 40% in 2005/6. Levels of waste in actual terms are increasing at c.1% each year.

Marsh Barton and the recycling goals will have significant impacts on available resources for any potential new facilities in the area are not part of this Waste Local Plan. Calculations were carried out assuming 40% of the residual municipal waste from East Devon is taken by Marsh Barton and 7500 new homes in Cranbrook produce the same quantity of waste on average as existing households in Devon.

Source	Recycling rate	Total Waste (tpa)	Residue (tpa)	Available residual after Marsh Barton (tpa)
East Devon	40%	42792	25675	15405
	50%		21396	12838
	60%		17117	10270
Cranbrook	40%	5153	3089	3089
	50%		2575	2575
	60%		2061	2061
Total	40%	47945		18495
	50%			15412
	60%			12331

Figure 92, Estimate of the MSW arisings that could be available for a further waste to energy plant in Exeter (assuming that the Marsh Barton plant takes 40% of the residual waste).

Assuming that Marsh Barton takes 40% of the residual waste from East Devon, there will be an annual waste resource of 12,000 – 18,500 t.p.a. This is the minimum that would be required for a further EfW plant, in addition to that at Marsh Barton. However, the Marsh Barton plant is part of

a Devon wide plan to provide sufficient waste diversion options to meet the Council's landfill diversion targets and has adequate capacity to treat significantly more than this level of the areas residual waste. The implication is that there may not be sufficient, dependable MSW resource to justify investment in an additional energy from waste plant in the area. Commercial and Industrial waste arisings may provide an alternative source, as treatment of commercial and industrial waste arisings has not been factored into sizing of the Marsh Barton plant. The disposal of commercial & industrial waste arisings is less well documented than MSW. A detailed study into the size of this resource is required to understand the opportunity for a further EFW plant.

C.3 Map of opportunity areas and areas of particular constraint for renewable energy development

Map 2: Opportunities & Constraints on Renewable Energy Development

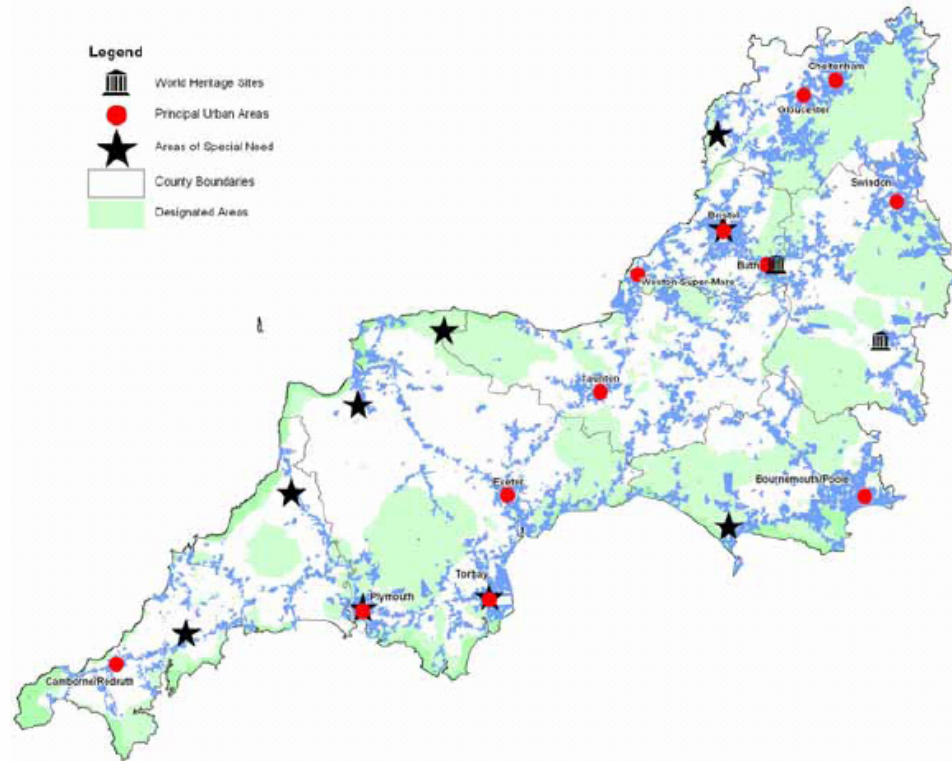


Figure 93, Designated areas are defined as National Parks, nature reserves, SSIs and similar areas

C.4 Existing wood fuel installations in the South West

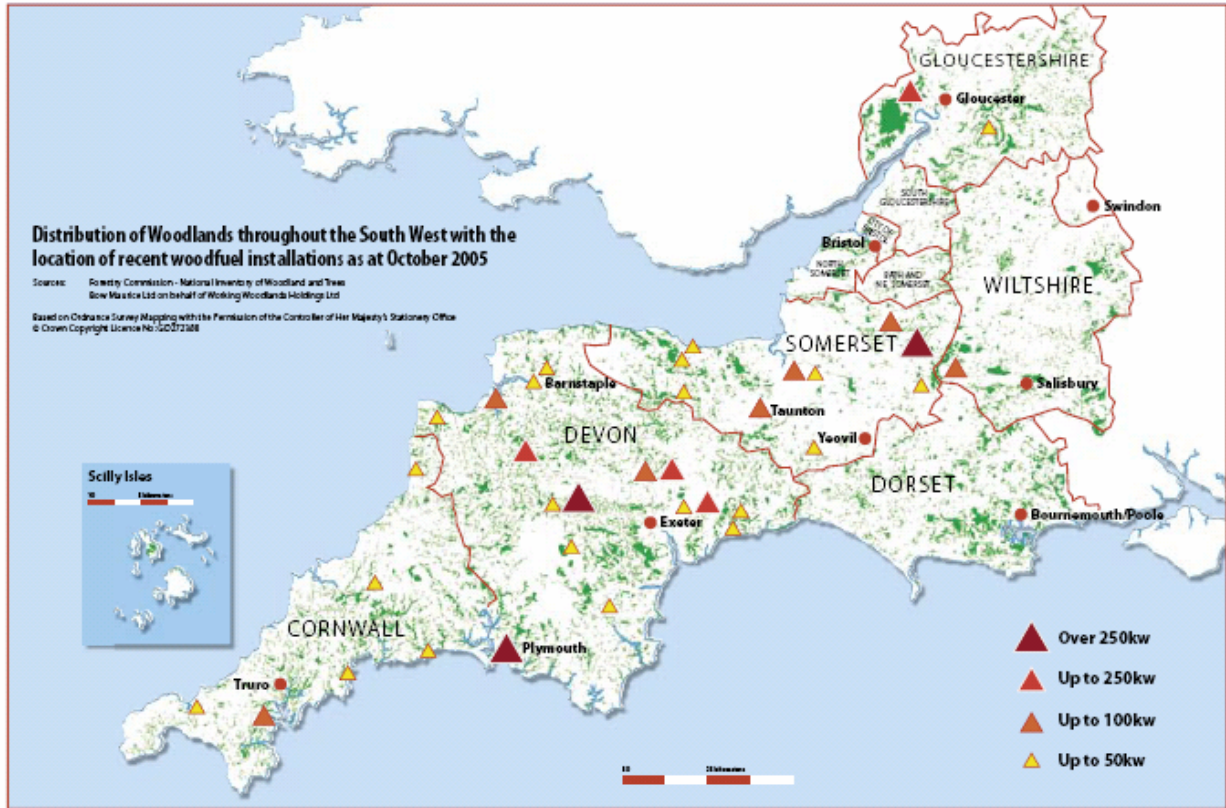


Figure 94, Woodfuel installations as of 2005, Forestry Commission