# Delivery and Site Allocations DPD – Evidence to Support Sustainable Construction

**Volume 2: Technical and Financial Assessment of Opportunities for Decentralised Energy**

# Report to Wycombe District Council

# FINAL REPORT

# April 2010

Contents

# Executive Summary

This report provides an economic assessment of district energy, considering three sites proposed for redevelopment within High Wycombe district. The sites are Handy Cross, RAF Daws Hill and Abbey Barn South. These sites have been selected so that the results of the assessment may provide a generic model for understanding the financial barriers and opportunities associated with the delivery of district energy in High Wycombe district, and with particular reference to the higher standards in future for carbon emissions reductions associated with Part L of Building Regulations and the energy categories included within the Code for Sustainable Homes.

District energy in this case includes a central energy building with gas fired CHP plant, woodchip heat-only boilers and gas-fired boilers, along with district heating pipework, electricity networks and individual metered connections at each property as major elements. A district energy scheme for each site would be expected to be provided by a specialist Energy Services Company, or ESCo, in place of conventional energy infrastructure and systems (mains gas networks, individual boilers and electrical heating plant) historically provided by the developer as part of the buildings themselves.

The three sites each offer a mix of residential and non-residential development, existing and new build, brownfield and greenfield sites, significant base-load heat demand and phased development.

The proposed redevelopment of Handy Cross includes retention of the existing sports centre, along with new buildings comprising a coach station, 27,800m² of office space and a hotel. The redevelopment of RAF Daws Hill comprises 483 new dwellings along with 4,500m² of office and retail space. Abbey Barn South is a greenfield site earmarked to receive up to 550 new dwellings, 7,000m² of office space, a small amount of retail space and a community centre.

The analysis has considered three options for the implementation of district energy at these sites:

1. Handy Cross as a standalone scheme
2. Handy Cross and RAF Daws Hill as a combined scheme
3. Abbey Barn South as an extension to the Handy Cross and RAF Daws Hill scheme

The timescale for development of these sites is likely to result in Handy Cross and Daws Hill being developed within the next 10 years, with Abbey Barn South following.

An estimate of the baseline cost which would normally be borne by the site developer of providing conventional energy supplies and systems for each site to comply with current Building Regulations standards has been provided. This is based on individual gas boilers providing space heating and hot water to all buildings (with the exception of the coach station at Handy Cross and all retail development which are assumed to be served by electrical systems) and including no renewable energy micro-generation technologies installed as individual systems integrated into each building or dwelling. These costs are taken to represent the minimum capital contribution from the developer to an Energy Services Company (ESCo) in order to support what would be the additional capital cost of providing district energy to serve the new developments, with the ESCo funding the remaining cost (the net capital cost) and recovering

that cost through the sale of energy services (heat and electricity in this case) over a long term contract.

It is recognised that as future evolutions of Building Regulations require more stringent carbon emissions standards, the cost of providing 'conventional' energy systems will increase significantly as these will need to include individual renewable energy technologies supplying each building or dwelling as micro-generators such as solar thermal panels, solar PV panels and/ or ground source heat pumps, as well as perhaps small scale wind turbines where appropriate. This situation will as a consequence improve the attractiveness of district energy in financial terms, requiring increasing contributions from the developer to an ESCo. As the requirement for delivery of zero carbon dwellings (2016) and non-domestic buildings (2019) becomes a reality, the complexity and cost to a developer of compliance with these energy standards will increase further, leading to a situation where the capital cost of a range of individual building integrated energy systems and additional zero carbon electricity generation may be greater than that of providing district energy.

A financial analysis has been carried out for each site development option, and measures each project by IRR (Internal Rate of Return) and NPV (Net Present Value). IRR is the measure by which competing projects can be compared on a financial basis, and can be thought of as a rate of growth a project is expected to generate. NPV is the present value of an investment's future net cash flows minus the initial investment – the higher the NPV for a given discount rate (cost of money) the better is the financial return of the project; individual projects can be compared on a like for like basis using a fixed discount rate.

Sensitivity analysis using a range of internal rates of return, including higher IRRs which might be typical for private sector investment demonstrates the increased amounts of capital contribution over the cost of conventional energy systems as defined above which would be required by the ESCo in order to present a financially competitive investment. This additional capital contribution resulting in higher IRRs could be realized through the increased cost of otherwise providing conventional energy systems, which would include building integrated micro-generation technologies to comply with future Building Regulations standards. These additional capital contributions are shown in the financial analysis summary below, and range from £126,408 or 36% of the total capital cost of the district energy scheme to serve Handy Cross to provide an IRR of 10%, to £3,268,710 or 66% of the total capital cost of the district energy scheme to serve Handy Cross and Daws Hill combined to provide an IRR of 25%.

The developer contribution to the capital cost of providing a new district energy scheme borne by an ESCo in the case of the stand alone projects (Handy Cross and Handy Cross plus Daws Hill) is around 30% of the total cost of district energy based on this amount being equal to the cost of providing conventional energy plant and infrastructure, as defined above. It is noted that providing accurate estimates of the cost of conventional and district energy plant infrastructure in particular is difficult and how much a developer would in practice expect to contribute to a district energy scheme is uncertain – in particular for mains gas networks where once connected to new loads the gas supplier will receive long term revenues from the sale of gas.

Nevertheless there would be an offset cost and this would be a contribution towards the capital cost, to an ESCo, of the district energy scheme. The results of the financial analysis show increasing project viability as greater capital contribution is provided by the developer to the ESCo, as would be expected.

The larger the connected load the greater is the financial viability of the district energy project, demonstrated by the comparison between Handy Cross and Handy Cross and Daws Hill combined, showing increasingly higher internal rate of return figures when considering the baseline conventional energy cost. A discount rate of 3.5% has been chosen to represent the public sector finance rate in determining the project net present value (NPV) and enabling comparisons to be made between each project.

Assuming project capital contribution from offset costs of conventional energy supplies, the resulting project IRRs for the two stand alone schemes are what might be considered to be a lower limit for financial viability in the private sector of between 8.6 and 11.9%. The addition of heat and electricity loads to an existing scheme as modelled by the inclusion of Abbey Barn South to the Handy Cross/ Daws Hill scheme provides an improvement in financial performance.

For the two projects Handy Cross and Handy Cross plus Daws Hill, a 15% IRR as might be expected to offer a financially attractive investment in a competitive arena within the private sector would demand that each project received around 50% of the total capital cost from the developer, equating to approximately £1m and £2.5m for each project respectively. This could feasibly equate to the higher cost of providing conventional energy solutions which include micro-generation technologies in order to comply with increasing standards required by future evolutions of Building Regulations.

Issues which would affect the delivery of district energy schemes include the location, required building footprint and access requirements for the central energy plant and biomass fuel store, access routes for district energy infrastructure (pipework and electrical cables) within areas of existing development and specifically connecting one site to another, and environmental issues relating to local emissions from energy plant, specifically biomass boilers. Also of importance to project implementation are long term biomass fuel supplies, visual impact of the central energy facility and associated planning issues.

The following provides a summary of the financial results.

**Handy Cross**

| | |
|---|---|
| Capital cost of district energy scheme | £1,957,250 |
| Capital cost of conventional energy (from developer) | £570,998 |
| Developer contribution as a % of total capital cost | 29% |
| IRR to provide an NPV of £0 | 8.6% |
| NPV with a discount rate of 3.5% | £709,293 |

<u>To provide a district energy project IRR of 10%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £126,408 |

| | |
|---|---|
| Developer contribution as a % of total capital cost | 36% |

<u>To provide a district energy project IRR of 15%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £463,959 |
| Developer contribution as a % of total capital cost | 53% |

<u>To provide a district energy project IRR of 20%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £673,944 |
| Developer contribution as a % of total capital cost | 64% |

<u>To provide a district energy project IRR of 25%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £812,661 |
| Developer contribution as a % of total capital cost | 71% |

**Handy Cross & RAF Daws Hill**

| | |
|---|---|
| Capital cost of district energy scheme | £4,932,300 |
| Capital cost of conventional energy (from developer) | £1,634,173 |
| Developer contribution as a % of total capital cost | 33% |
| IRR to provide an NPV of £0 | 11.9% |
| NPV with a discount rate of 3.5% | £3,130,546 |

<u>To provide a district energy project IRR of 15%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £2,221,588 |
| Developer contribution as a % of total capital cost | 45% |

<u>To provide a district energy project IRR of 20%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £2,856,328 |
| Developer contribution as a % of total capital cost | 58% |

<u>To provide a district energy project IRR of 25%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £3,268,710 |

| | |
|---|---|
| Developer contribution as a % of total capital cost | 66% |

**Abbey Barn South as an extension**

| | |
|---|---|
| Capital cost of district energy scheme | £2,127,500 |
| Capital cost of conventional energy (from developer) | £1,258,675 |
| Developer contribution as a % of total capital cost | 59% |
| IRR to provide an NPV of £0 | 21.5% |
| NPV with a discount rate of 3.5% | £3,142,165 |

<u>To provide a district energy project IRR of 25%:</u>

| | |
|---|---|
| Additional capital contribution to ESCo | £1,383,788 |
| Developer contribution as a % of total capital cost | 65% |

When considering district energy and CHP systems with reference to the Code for Sustainable Homes (CSH), CHP is already playing a role in delivering the requirements associated with the Ene1 (energy) sub-category of the CSH. This is nearly always in the form of gas-fired units feeding a communal system for a block of flats. However, this is still not a typical solution for developers. It has to borne in mind that within the CSH, energy and in particular carbon reduction measures form only 2 out of a total of 34 sub-categories taken into account when assessing a residential development against the CSH. Based on typical modern build standards the inclusion of central gas CHP and gas boilers combined with district heating would be expected to provide CO2 emissions reductions sufficient to attain the number of energy credits equivalent to achieving CSH level 3. The sites examined have all included biomass heat along with gas CHP and this would be expected to provide improved results, potentially achieving CSH level 4. It should be noted that CSH levels are aligned with Part L1 of current Building Regulations standards and future changes to the latter would be expected to affect the relative CSH energy standards and the requirements in terms of energy supplies to achieve the carbon emissions reductions of Building Regulations required. The detail on this however is far from clear and is not yet defined by the CSH administering authority (Building Research Establishment, or BRE).

Moving forward and considering the changes to Part L1 of Building Regulations, which will come into play in the next few years, in line with the CSH Ene1 requirements, for CHP systems to be of assistance with CSH ratings they will need to be operating in conjunction with biomass heat supply from boilers if CHP is gas-fired, or as biomass CHP to provide improved carbon emissions reductions. Within the timescale of planning for the three sites, some parts of the development will require compliance with significantly tighter Building Regulations standards (expected 44% carbon reduction from current 2006 levels by 2013) and CSH levels which are close to, or reach ‘zero carbon’ standards (CSH level 6) by 2016, with the equivalent standards for non-domestic buildings expected to be in place by 2019. This will demand that 100% of supplied energy is zero carbon, requiring additional amounts of renewable electricity to be generated in particular in order to comply. This additional renewable electricity might be made up from a combination of biomass CHP as part of district energy supplies, along with perhaps one or a number of medium wind turbines, or a single, large scale wind turbine and/ or extensive building integrated solar PV, depending on the detailed layout and characteristics of the buildings for each site in question. Currently biomass CHP technology is still in its infancy and is not considered commercially robust, however developments are known to be making steady progress at the scale suitable for development sites of this size. In any case the electricity generated by biomass-fired CHP would be insufficient on its own to provide the quantity required to provide compliance with CSH level 6 or equivalent zero carbon buildings standards, and would require additional technologies.

Biomass systems come with a range of other issues which currently make them un-attractive to developers, such as space requirements, high up front capital costs (especially if tied to a district heating/power scheme) and the need to engage with operator/management organisations. These issues may or may not be realistic impediments, but there is still a fundamental change in mindset that will need to be addressed and which must occur for future developments to emerge as zero carbon, or close to zero carbon sites.

Currently it is difficult for district heating schemes, let alone those including biomass and private wire arrangements, to be made to look financially attractive for smaller and/or lower density developments. Unless wider schemes are already in place within a locale, feeding existing demand, it is extremely unlikely that a developer will engage with the business of developing a new scheme from scratch specifically for their development. However as we move closer to tighter energy and carbon standards and ultimately ‘zero carbon’ development, this will need to change.

In short, CHP does already and will continue to have a role to play in assisting with the delivery of CSH ratings. However if the development of CHP schemes on a district-wide level is to be a policy objective, relying on the CSH as the prime route to deliver this will fail. To deliver an objective such as this other policies, specifically structured towards the desired result will be required.

# 1 Introduction

1.1 The purpose of this report is to provide a summary of the technical and economic aspects associated with the development of district or decentralised energy schemes through examining the characteristics of three M40 Gateway sites within High Wycombe district and proposed for redevelopment. Wycombe District Council wishes to understand the issues of costs and financial viability and therefore be better placed to encourage engagement of developers, ESCos and the Council itself in bringing these types of scheme forward.

1.2 Wycombe District Council is also looking to assess the overall viability of using CHP networks to meet the requirements of the Code for Sustainable Homes to the various levels that are proposed in the coming years; from Level 3 later in 2010 to the eventual adoption of zero-carbon homes in 2016, which will equate to Level 6. This will be covered after the sections reviewing the technical and economic aspects outlined above.

1.3 A report examining six sites as potential locations for CHP district/decentralised energy schemes was provided by SEA Renue/Ramboll/Brodies to Wycombe District Council in March 2008. This report considered each site and a combination of sites for the inclusion of district energy and the results provided financial and carbon emissions assessments of each case. Central to the financial assessment was the assumption that the additional costs over conventional energy supply plant and infrastructure were between 20 and 25% of the total capital cost of the district energy schemes examined in the study.

1.4 Three of these sites, Handy Cross, RAF Daws Hill and Abbey Barn South are further examined in this report as examples intended to provide a generic model and which include a number of important characteristics often part of district energy; a mix of residential and non-residential development, existing and new build, brownfield and greenfield sites, significant base-load heat demand and phased development. The assessment of the three sites has paid particular attention to the following:

1. New buildings, both non-residential and dwellings, are characterised by improved thermal insulation, air tightness and increased electrical efficiency reflecting future Building Regulations standards, and a drive towards energy efficiency in the commercial sector;
2. Existing buildings undergoing thermal and electrical efficiency improvements to reduce energy demand;
3. The efficient use of gas fired CHP to provide base-load hot water demand and electricity supply with reduced carbon emissions over conventional systems, with supplies of each sold directly to end users;
4. The use of biomass boilers to generate low carbon heat for space heating, taking advantage of the availability of local fuel sources as well as incentives aimed at increasing the uptake of renewable heat in future;
5. Estimates of scheme capital cost offsets of conventional energy plant and infrastructure;

6. Sensitivity analysis considering different levels of discount rate for capital finance applicable to private and public sector owned ESCos.

1.5 Decentralised energy enables the provision of low carbon and renewable energy supplies as heat, electricity and cooling to end users through the use of CHP, low carbon fuels such as biomass, and absorption chillers as central plant, and which can sometimes include distributed micro-generation technologies such as solar energy systems, wind power and heat pumps. A programme of development of district energy in Wycombe would provide energy services with reduced $CO_2$ emissions to end users compared to the existing situation of heat provision via individual boilers fuelled by mains gas, and national grid-supplied electricity for lighting, small power, and cooling.

1.6 This study is intended to support site requirements proposed in the Delivery and Site Allocations DPD and as an aid to developing district energy projects with a view to ultimate delivery of schemes in future. One possible delivery mechanism is through the establishment of a partnership agreement between Wycombe District Council and a private sector specialist to form an Energy Services Company (ESCo). Alternatively a private sector ESCo may take full responsibility for a scheme. Depending on its terms of reference the ESCo might be responsible for a complete service including finance, design, procurement, installation and operation of the district energy scheme, including the establishment of energy supply contracts with end users and billing. These issues were discussed in some detail within the previous SEA Renue/Ramboll/Brodies report.

## Development Sites

1.7 The following sites are considered in this report:

Handy Cross

1.8 An existing sports centre is located at the site which is able to take advantage of a range of energy efficiency improvements including the installation of CHP plant to replace plant already in place. Proposed site development as new build includes a new coach station, five office buildings and a hotel. This site is expected to be developed in the near future, and fully within the next ten years.

RAF Daws Hill

1.9 An existing RAF site proposed to be redeveloped to include 483 new dwellings as well as a limited amount of office, retail and A1, A5 uses. Daws Hill is approximately 1km distant from Handy Cross and is expected to be developed immediately following, and before 2019.

Abbey Barn South

1.10 A greenfield site able to accept around 550 new dwellings along with office, retail and community buildings. Abbey Barn is immediately adjacent to Daws Hill and is anticipated to be developed sometime following Daws Hill.

The analysis has considered three options for the implementation of district energy at these sites:

4. Handy Cross as a stand-alone scheme
5. Handy Cross and RAF Daws Hill combined
6. Abbey Barn South as an extension to Handy Cross and RAF Daws Hill

# 2 Energy Demand Assessment

2.1 The following table provides a summary of energy demand estimates associated with the three sites for space heating, hot water and electricity. In the case of the sports centre the figures have been estimated on information contained within a previous report by NIFES examining the options for reductions in energy consumption. Benchmark figures are used for new build commercial and residential development taking into account anticipated reductions in space heating demand in future.

2.2 It is understood that the Coachway building is proposed to be a low energy design using a combination of all electric heating and micro-generation renewable energy technologies and is therefore not included within the district energy scheme. Other buildings with predicted low heat demand have also been discounted from the scheme, as shown below.

| | | | | Rambol report<br>CIBSE Guide F fossil fuel | | NIFES report<br>Gas demand | | BBP figures<br>Heat<br>Demand | | | | Electricity<br>demand | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | sq.m | HWS<br>kWh/sq.m/yr | Space heat<br>kWh/sq.m/yr | HWS<br>kWh/yr | Space heat<br>kWh/yr | HWS<br>kWh/sq.m/yr | Space heat<br>kWh/sq.m/yr | HWS<br>kWh/yr | Space heat<br>kWh/yr | 8pm - midnight minimum<br>kW | 10am - 3pm minimum<br>kW |
| Handy Cross | | | | | | | | | | | | | |
| **New Build** | Offices | A | 5,630 | 12 | 67 | | | 8 | 40 | 45,040 | 225,200 | 60 | 120 |
| | | B | 5,630 | 12 | 67 | | | 8 | 40 | 45,040 | 225,200 | 60 | 120 |
| | | C | 3,417 | 12 | 67 | | | 8 | 40 | 27,336 | 136,680 | 50 | 100 |
| | | D | 2,083 | 12 | 67 | | | 8 | 40 | 16,664 | 83,320 | 40 | 80 |
| | | E | 11,008 | 12 | 67 | | | 8 | 40 | 88,064 | 440,320 | 80 | 160 |
| | | | | | | | | | | 222,144 | 1,110,720 | | |
| | Hotel | | 3,884 | 299 | 61 | | | 60 | 80 | 233,040 | 310,720 | 50 | 40 |
| | Coachway | | 1,075 | N/A | N/A | | | N/A | N/A | N/A | N/A | | |
| **Existing** | Sports Centre | | 9,271 | | | 4,200,000 | 1,512,649 | | | | | | |
| savings | pool cover | | | | | 916,000 | 229,000 | | | | | | |
| | BMS | | | | | 70,000 | 280,000 | | | | | | |
| | calorifier insul | | | | | 30,000 | | | | | | | |
| | | | | | | 3,184,000 | 1,003,649 | | | 2,419,840 | 762,773 | 100 | 140 |
| **TOTAL** | | | | | | | | | | **2,875,024** | **2,184,213** | **440** | **760** |
| Daws Hill | Residential | | 38,640 | | | | | 35 | 25 | 1,352,400 | 966,000 | 145 | 48 |
| | Non resi | office | 3,000 | | | | | 8 | 40 | 24,000 | 120,000 | 40 | 80 |
| | | retail | 800 | | | | | N/A | N/A | N/A | N/A | | |
| | | A1 - A5 | 700 | | | | | N/A | N/A | N/A | N/A | | |
| **TOTAL** | | | | | | | | | | **4,251,424** | **3,270,213** | **625** | **888** |
| Abbey Barn | Residential | | 44,000 | | | | | 35 | 25 | 1,540,000 | 1,100,000 | 165 | 55 |
| | Non resi | office | 7,000 | | | | | 8 | 40 | 56,000 | 280,000 | 60 | 120 |
| | | comm. centre | *1000* | | | | | N/A | N/A | N/A | 150,000 | | |
| | | retail | | | | | | N/A | N/A | N/A | N/A | | |
| **TOTAL** | | | | | | | | | | **5,847,424** | **4,800,213** | **850** | **1,063** |

## 3 Assumptions

### Technical

3.1 Central to district energy systems, CHP is typically employed to provide the main source of revenue into a scheme through the generation and sale of electricity along with heat. A CHP plant in this case will be heat demand lead and not dump heat and therefore the magnitude and daily/seasonal pattern of the combined heat demand for all connected loads will determine the capacity of the CHP plant such that it is able to operate for a minimum number of hours per year at equivalent full load (usually considered to be 5000 hours). This is the most efficient mode of operation for CHP plant.

3.2 CHP plant capacity has been selected to enable year-round operation such that the maximum running hours for the machine can be realised, thereby fully utilising the capital invested. Gas-fired CHP plant is set to operate and generate heat and power during daytime electricity tariff periods only, thereby maximizing revenue with respect to plant operating costs. Consideration is also given to the minimum electricity demand likely for the development to be supplied in sizing the CHP unit so as to enable close to 100% of the energy generated to be sold directly to end users through a private wire network thereby realising the full retail value of generated electricity into the ESCo.

3.3 Biomass boiler plant is sized to provide the majority of space heat demand during the heating season with consideration given to the capital cost per kWh output.

3.4 Gas boilers are sized to supply minimum loads during summer periods not provided for by CHP plant, peak loads not supplied by biomass boilers as well as the total peak demand of the entire connected network and therefore provide full backup capability. A percentage of network heat capacity provided by existing boilers within the sports centre could be used to provide a portion of the peak and standby requirements.

3.5 The thermal store is sized to even out the generation of heat and electricity from CHP and biomass plant to enable operation at the most economically advantageous times and at maximum efficiency.

3.6 District heating network losses are assumed to be 4% of the total annual heat demand supplied by central plant.

3.7 The expected cooling demand associated with offices and the hotel is likely to be significant, and spread over the six buildings at Handy Cross. The combined cooling load as modelled is peaky as a demand profile however and is therefore not straightforward to deliver efficiently and economically in terms of capital investment. Bearing in mind the high capital cost of absorption chiller plant and associated heat rejection equipment and the requirement for additional dedicated district pipe network to deliver chilled water assuming that absorption chiller plant cannot be located at individual cooling users, its inclusion as additional heat load for the CHP unit during the summer months is not included within the analysis.

3.8 The layout and therefore density of the proposed residential build is unknown however a mix of higher density apartments arranged in small blocks, plus townhouse type, semi-detached and detached properties is assumed.

## Financial

3.9 It is important to note that when considering the development of district energy schemes the extent and type of energy supply, selection and scale of energy generation technologies and the mix of conventional and alternative fuels, in the absence of other drivers such as planning requirements and local policies, is driven primarily by economic considerations in order that a scheme can demonstrate commercial viability from the point of view of investment, risk and return. The sites examined in this study are assessed from this viewpoint and include central plant and infrastructure which are most likely to provide maximum returns for the capital costs incurred.

3.10 Recent government announcements relating to the Feed In Tariff (FIT) and proposed Renewable Heat Incentive (RHI) due to commence in April 2010 and April 2011 respectively describe the level of support anticipated to be given to small scale distributed renewable and low carbon electricity generators and renewable heat. The proposed support levels at various scales of technology deployment have been taken into account in considering the capacity of renewable energy technology included.

3.11 The RHI levels proposed for biomass generated heat are 6.5p/kWh for plant output capacity between 45 and 500kW, and between 1.6 and 2.5p/kWh for plant capacity above 500kW. Although currently less than clear as the RHI scheme is out for public consultation, the position regarding a number of smaller capacity units being employed to take advantage of higher levels of support is assumed to be that full benefit from additional boiler plant can be realized if additional units are added separately in phases.

3.12 It is noted that Renewables Obligation Certificates (ROCs) will continue to be applicable for the electricity generated by biomass CHP below $5MW_e$ capacity, based on 1.5ROCs per MWh of electricity generated, and assumed to have a value of 6.75p/kWh (based 1 ROC being equivalent to £45/MWh).

3.13 Within the financial analysis it is assumed that electricity generated by CHP plant will directly offset electricity otherwise purchased from the grid to supply one or more buildings, therefore a notional retail value and hence maximum revenue into the ESCo for CHP generated electricity can be realised. The alternative would be export of electricity to the wholesale market with much reduced value by comparison.

3.14 The retail value figure is set at 10.0p/kWh for non-domestic customers, inclusive of all other related charges, and 11.0p/kWh for an approximate equal mix in terms of annual electricity delivered to non-domestic and domestic customers, assuming that domestic customers would be charged 12.0p/kWh.

3.15 The per unit revenue from heat supply is set at a rate estimated to be equivalent to the total cost of providing heat associated with conventional supply from individual boilers to include fuel and other elements of operating costs such as maintenance and insurance. This is set at a flat rate 3.0p/kWh for non-domestic customers, and 4.0p/kWh plus £150 per property as a notional standing charge for domestic customers to take account of the equivalent cost of an annual maintenance agreement for an individual gas boiler.

3.16 Central plant fuel costs reflect those appropriate to commercial rates for conventional fuels and estimated values in the case of wood-fuel based on the boiler plant annual requirements along with the capacity of fuel delivery vehicle likely to be used to serve a facility of this scale. The purchased rates for natural gas and biomass fuel as woodchip @30%MC are 2.5p/kWh and £70/tonne respectively.

3.17 The annual costs of operation and maintenance (O&M) of plant and equipment are based on rates typical for each item. CHP plant O&M is set at a rate based on the amount of electricity generated to reflect the wear on moving parts; 1.5p/kWhe for gas CHP for the smaller capacity unit supplying the Handy Cross site and 1.3p/kWh for the larger capacity unit supplying Handy Cross, Daws Hill and Abbey Barn.

3.18 Other operating costs include fixed and variable charges for electricity supplied to the central facility, ESCo management, supervision and billing. A separate annual cost is also included to cover plant replacement over the lifetime of the operation of the district energy scheme. This is set at £50,000 p.a. for Handy Cross, £100,000 p.a. for Handy Cross and RAF Daws Hill and an additional £25,000 p.a. for the connection of Abbey Barn South.

3.19 Engineering and project management costs are set at 15% of the total capital cost of each project and ESCo set up costs are included for each project at a figure of £100,000.

3.20 Future trends in the costs of energy supplies year on year are set according to increases expected under carbon-driven policies.

3.21 An estimate of the overall project capital cost of the central plant, energy centre building, heat and electricity distribution network and connections to individual buildings and dwellings for each scheme is included within the analysis.

3.22 A connection charge for each connected heat load would normally be included within the analysis equivalent to the cost of capital to provide individual heating plant for each connected customer. This would be relevant to the sports centre only in this case and has been estimated at £20,000.

3.23 An estimate of the capital cost offset to account for the developer otherwise having to provide for conventional energy plant and systems is included for each scheme, to provide the net capital cost to the ESCo.

3.24 A financial appraisal over 20 years is considered as the means of assessing each project. Alternative discount rates considering private and public sector financing arrangements are presented in order to compare both types of potential scheme ownership models. These range from a public sector rate of return of 3.5% to 25% for a wholly private sector owned scheme competing for finance against other projects with varying degrees of risk and return.

3.25 It is recognised that estimating capital costs, in particular the costs of energy distribution infrastructure associated with mains gas/ electricity grids and district heating networks is not straightforward and a reasonable degree of accuracy demands that considerable time must be spent in assessing the route and connections of each site. In any case the offset costs would be the subject of negotiation between the developer and the ESCo and the net capital costs resulting from the calculated cost figures should be seen as a starting point for determining the financial viability of each individual project. Benchmark figures based on typical specific costs of various elements of energy plant and distribution infrastructure are used in the analysis.

3.26 It is considered unlikely that capital grant funding will be available for district heating schemes which include standard technologies such as gas CHP. Certainly no such funding scheme currently exists in the UK to support community heating and gas CHP, although previously the EST Community Energy Programme supported the development of this type of scheme. The longer term future of UK sourced capital funding to support the uptake of renewable energy technologies is uncertain, with the introduction of the FIT and RHI intended to replace project capital support with a revenue-based system. State Aids rules limit the total amount of financial support which can be given to commercial projects and it is unlikely that significant amounts of grant capital will be able to be combined with revenue support. In the case of advanced low carbon technologies such as small scale biomass CHP linked with district heating aimed at providing distributed energy services at the local level which involve the public sector, European funding streams are known to have provided targeted support in the past and continue to do so through specific programmes.

# 4 Analysis

## General

4.1 The following sections present the results of the technical and financial analysis, using output graphs from 'Energypro' district energy development software and spreadsheet models.

4.2 The graphs of seven day energy demand and delivery profiles show the operation of the energy plant selected at the appropriate capacities to deliver the combined heat load for each scheme. Gas CHP plant is sized to provide for the year-round base-load *hot water* heat demand, operating during the daytime electricity tariff period only, for reasons of economics. The combined electricity demand profile is not shown in the graphs, the table shown in section 2 gives the estimated kW base-load for each connection and end use type, the electricity output from the CHP plant for each scheme is set so as not to exceed the electrical base-load figures and therefore model the entire electrical output receiving a retail value based on each type of end user.

4.3 Biomass boiler plant provides the majority of the *space* heating load and is sized based on capital cost and associated output. It is assumed that the biomass boiler would be turned off outside of the heating season, during the summer months, due to the low heat demand. Gas boiler plant provides for 100% standby capacity for the entire connected heat load, as well as heating season demand peaks and during the summer when the CHP unit combined with the thermal store is unable to supply entire heat load outside of the daytime electricity tariff period.

4.4 Overall, it is noted that the peak heat loads are relatively low for the building types and total floor area as a result of new development expecting to show significant improvement over existing build standards with regard to thermal efficiency and heat loss associated with space heating. As a consequence, and particularly in the case of residential build, the demand for hot water is of greater importance in shaping energy supply technology choice and in the case of CHP will allow a greater percentage of the overall annual heat load to be delivered by this technology. The inclusion of the existing sports centre to the district heat network as a significant year round heat load is a benefit in the economic viability of the projects considered.

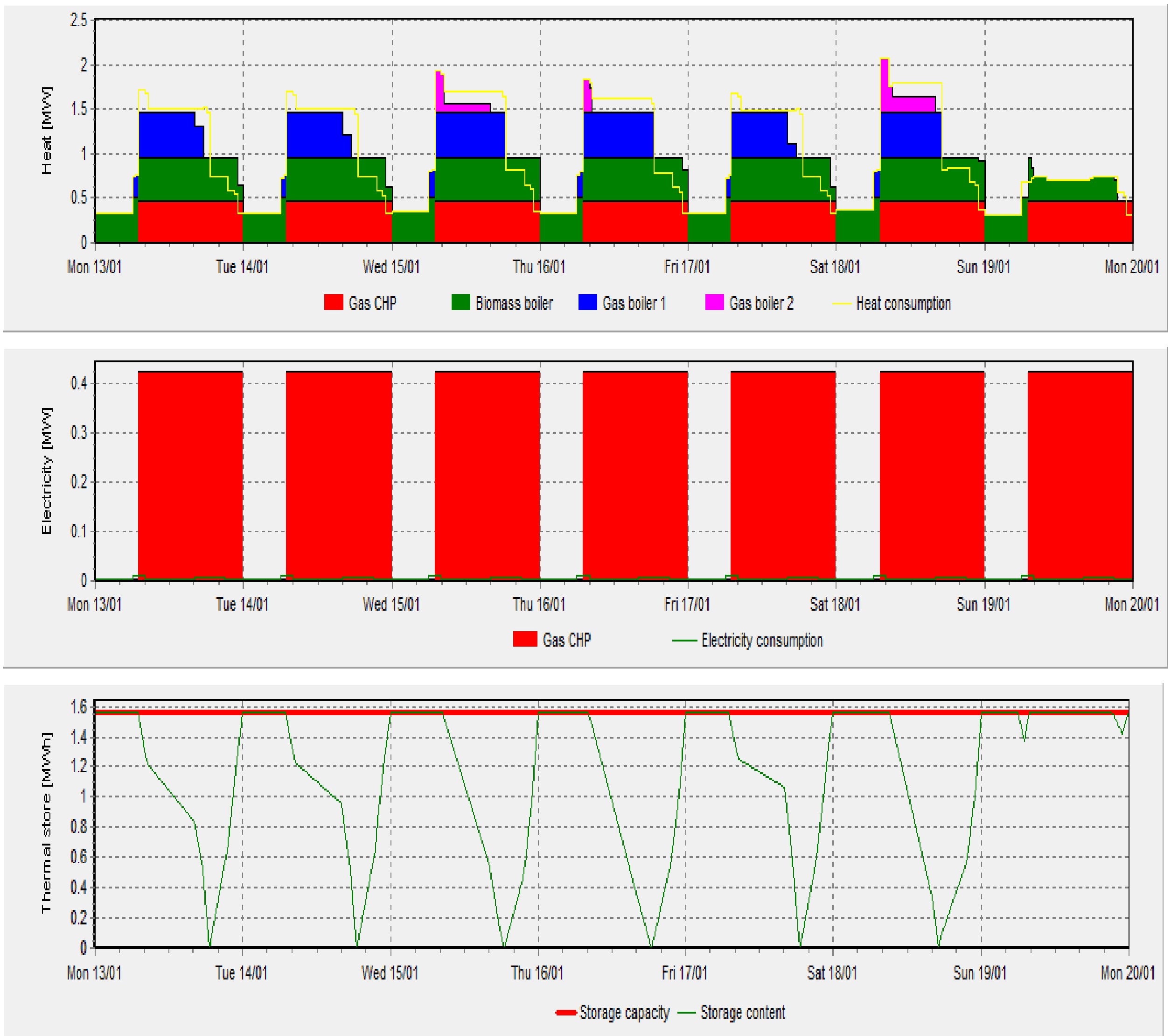
4.5 The technical issues involved in delivering the energy schemes are likely to include:

- The location, required building footprint and access requirements for the central energy plant and biomass fuel store;
- Access routes for district energy infrastructure (pipework and electrical cables) within areas of existing development and specifically connecting one site to another;
- Environmental issues relating to local emissions from energy plant, specifically biomass boilers
- Biomass fuel supply
- Visual impact of the central energy facility and associated planning issues

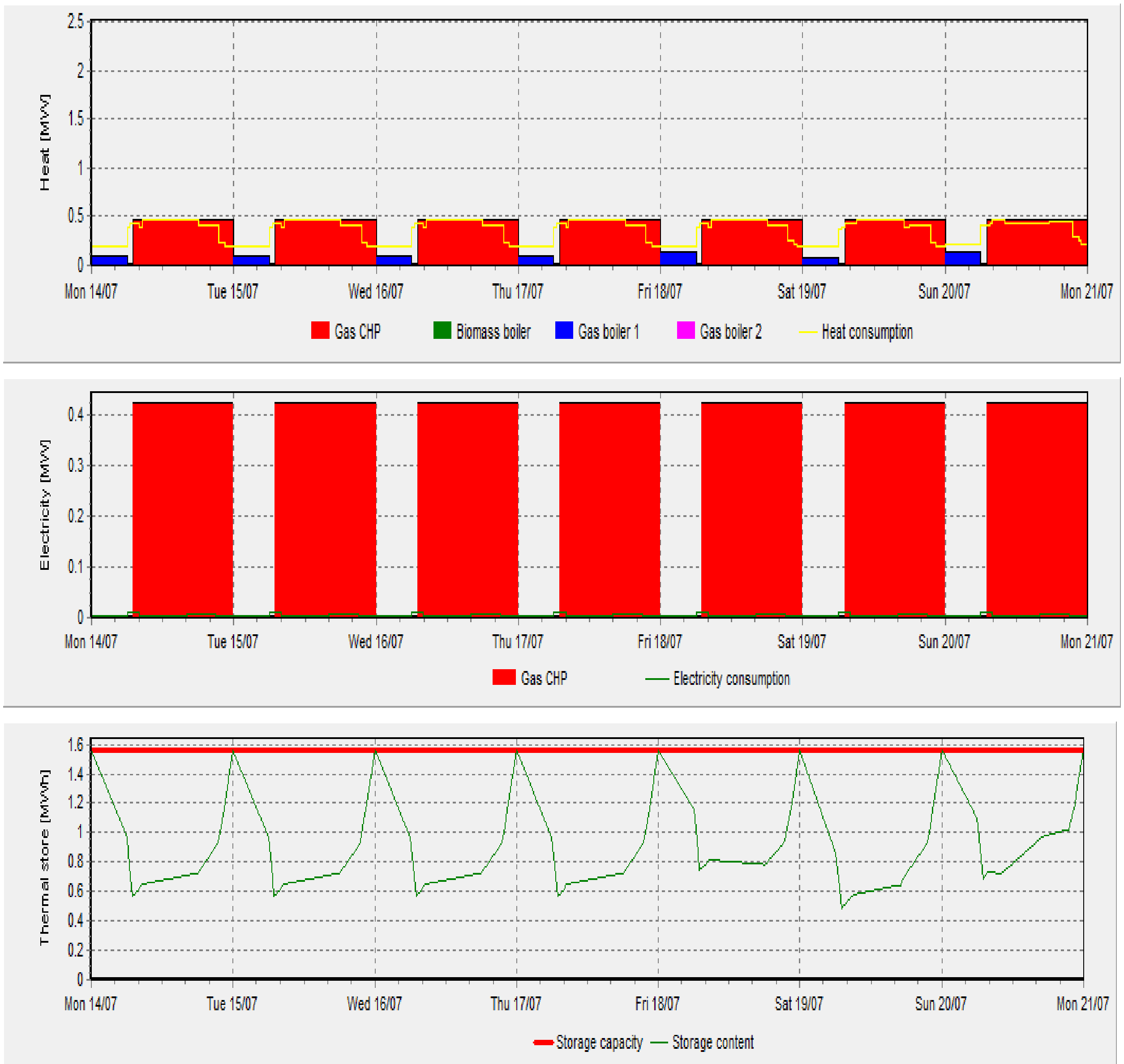
# Handy Cross

4.6 The following graphs show the seasonal variation in operation of the energy plant selected to serve the combined heat demand profile of all connected loads.

<u>Winter – Typical 7 day profile</u>



Summer – Typical 7 day profile




4.7 The following table outlines the major elements of the district energy scheme and conventional alternative along with estimated capital costs for each element. The total figure for capital cost shown under 'Conventional Energy' is the cost of providing conventional energy supplies and systems to the buildings and is therefore assumed to represent the capital contribution from the developer to an ESCo in order to provide a district energy scheme to serve the new development.

Capital Costs – Handy Cross

| | energy plant | energy plant | pipework | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | | pipework | | | |
| | | | trench | installed (incl | End user | End user | |
| | o/p capacity | installed | length | civils) | connections | connections | |
| DISTRICT ENERGY | kW | £/kW | m | £/m | quantity | £/connection | £ |
| gas CHP | 425 | £800 | | | | | £340,000 |
| biomass boiler | 500 | £180 | | | | | £90,000 |
| gas boilers | 500 | £60 | | | | | £30,000 |
| | 1500 | £50 | | | | | £75,000 |
| M & E (energy centre) | | | | | | | £100,000 |
| energy centre building, utility conns | | | | | | | £300,000 |
| electricity network (additional) | | | | | | | £100,000 |
| DH network flow & return | | | 1,000 | £500 | | | £500,000 |
| DH end user conns (new building) | | | | | 6 | £10,000 | £60,000 |
| DH end user conns (existing building) | | | | | 1 | £20,000 | £20,000 |
| Subtotal | | | | | | | **£1,615,000** |
| Engineering & Project Management | | | | | | | £242,250 |
| ESCo set up | | | | | | | £100,000 |
| **TOTAL** | | | | | | | **£1,957,250** |
| CONVENTIONAL ENERGY | | | | | | | |
| Individual gas boiler/ CHP systems: | | | | | | | |
| Offices (each) | 139 | £150 | | | 10 | | £208,260 |
| Hotel | 194 | £150 | | | 2 | | £58,260 |
| Sports Centre | 125 | | | | 1 | | £150,000 |
| Gas network | | | 800 | £100 | | | £80,000 |
| Subtotal | | | | | | | **£496,520** |
| Engineering & Project Management | | | | | | | £74,478 |
| **TOTAL** | | | | | | | **£570,998** |
| **NET CAPITAL COST** | | | | | | | **£1,386,252** |
| District energy cost net/gross % | | | | | | | **71%** |
| Conventional/district energy cost % | | | | | | | **29%** |

4.8 The headline figures which emerge from the financial analysis assuming the project net capital cost shown in the table above are presented below.

IRR = Internal Rate of Return

NPV = Net Present Value

| | |
|---|---|
| Capital cost of district energy scheme | £1,957,250 |
| Capital cost of conventional energy supplies | £570,998 |
| Developer contribution as % of total capital cost | 29% |
| IRR to provide an NPV of £0 | 8.6% |
| NPV with a discount rate of 3.5% | £709,293 |

4.9 The following considers a range of higher IRRs typical of the private sector and shows the increased amounts of capital contribution required by the ESCo from the developer in order to present a financially competitive investment.

<u>To provide an IRR of 10%:</u>

| | |
|---|---|
| Capital cost of conventional energy supplies | £570,998 |
| Additional capital over cost of conventional energy | £126,408 |
| Capital contribution to the ESCo | £697,406 |
| Developer contribution as a % of total capital cost | 36% |

<u>To provide an IRR of 15%:</u>

| | |
|---|---|
| Capital cost of conventional energy supplies | £570,998 |
| Capital contribution to the ESCo | £1,034,957 |
| Additional capital over cost of conventional energy | £463,959 |
| Developer contribution as a % of total capital cost | 53% |

<u>To provide an IRR of 20%:</u>

| | |
|---|---|
| Capital cost of conventional energy supplies | £570,998 |
| Capital contribution to the ESCo | £1,244,942 |
| Additional capital over cost of conventional energy | £673,944 |
| Developer contribution as a % of total capital cost | 64% |

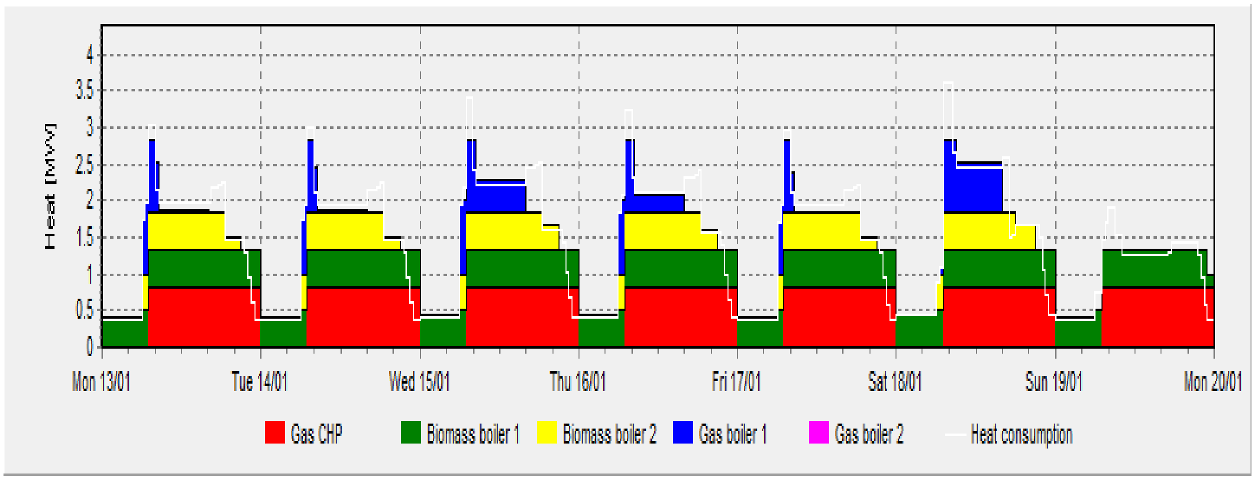
<u>To provide an IRR of 25%:</u>

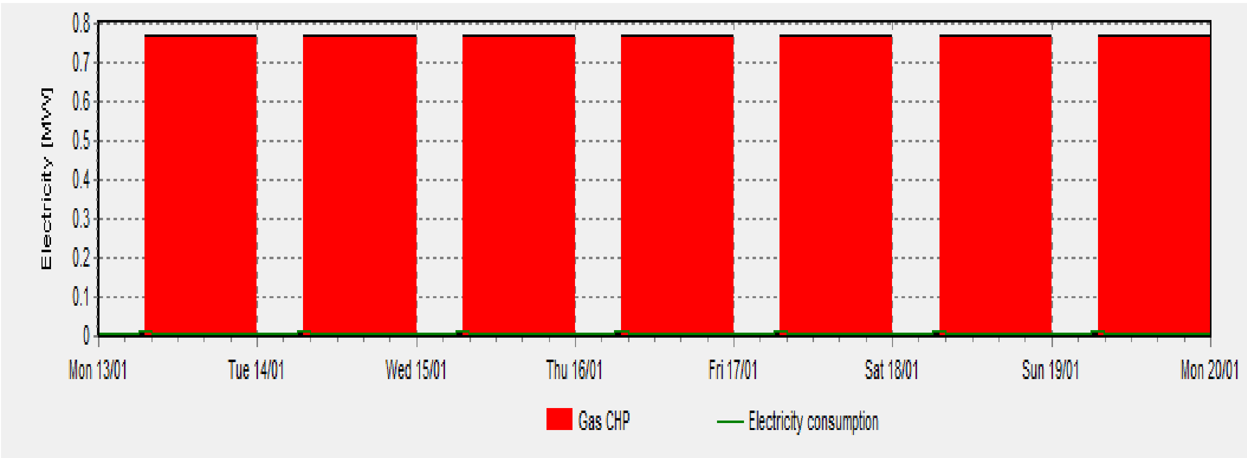
| | |
|---|---|
| Capital cost of conventional energy supplies | £570,998 |
| Capital contribution to the ESCo | £1,383,659 |
| Additional capital over cost of conventional energy | £812,661 |
| Developer contribution as a % of total capital cost | 71% |

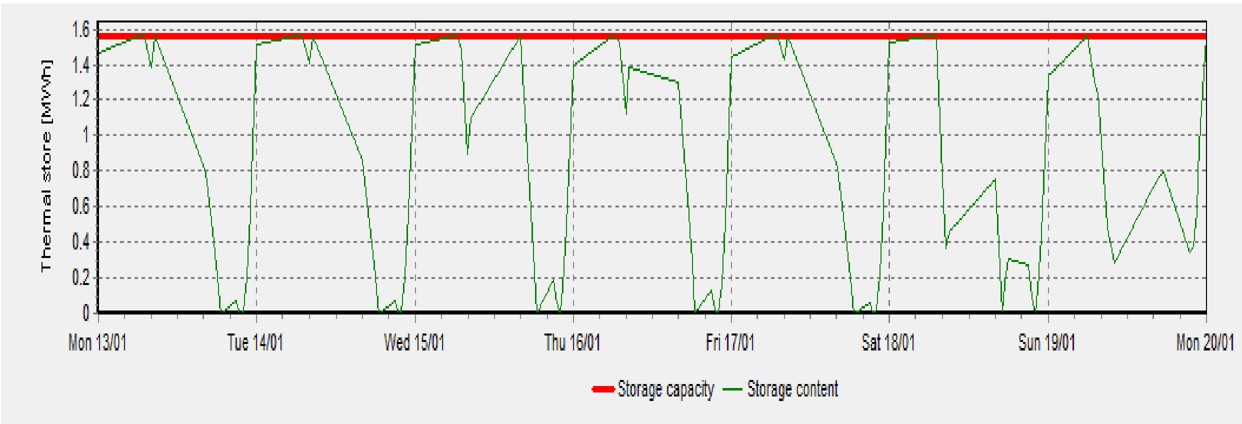
## Handy Cross & RAF Daws Hill

4.10 The following graphs show the seasonal variation in operation of the energy plant selected to serve the combined heat demand profile of all connected loads.

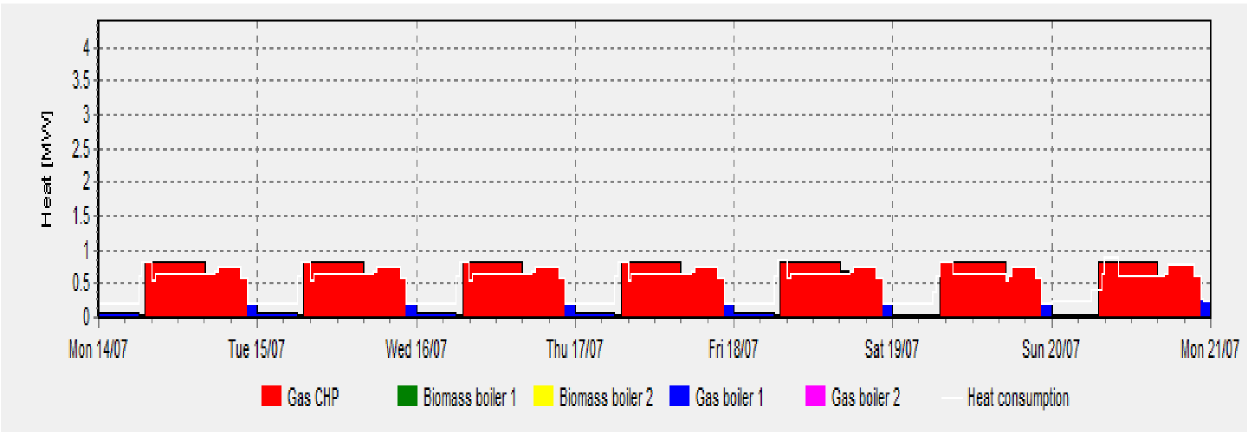
Winter – Typical 7 day profile

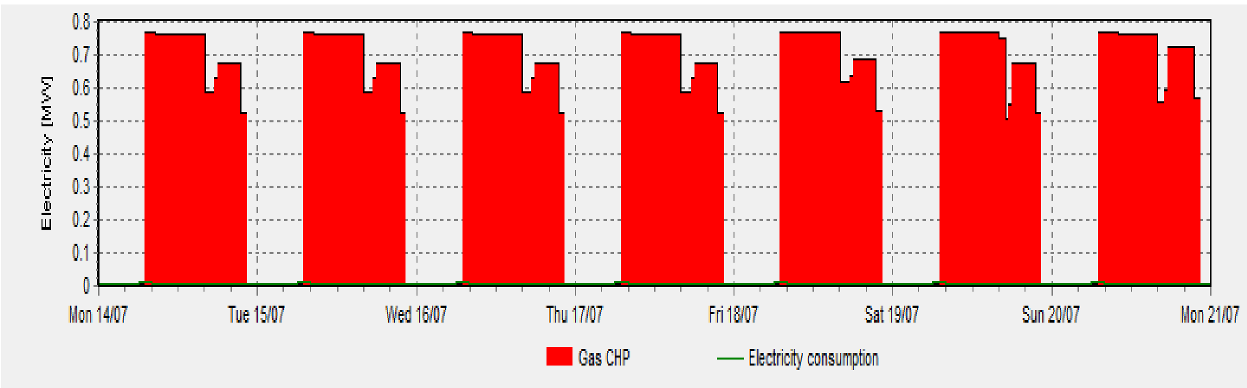


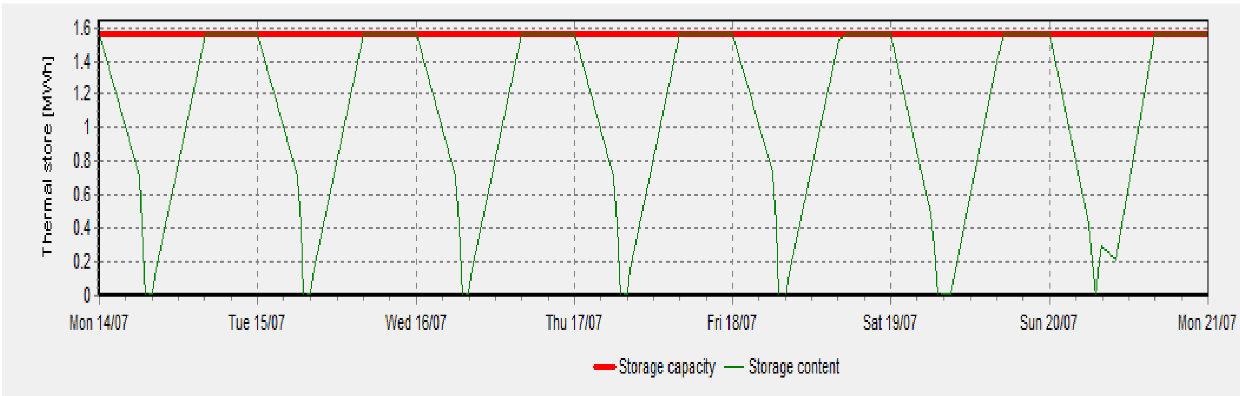






## Summer – Typical 7 day profile






4.11 The following table outlines the major elements of the district energy scheme and conventional alternative along with estimated capital costs for each element. The total figure for capital cost shown under 'Conventional Energy' is the cost of providing conventional energy supplies and systems to the buildings and is therefore assumed to represent the capital contribution from the developer to an ESCo in order to provide a district energy scheme to serve the new development.

## Capital Costs – Handy Cross & RAF Daws Hill

| | energy plant | energy plant | pipework | | | | Total |
|---|---|---|---|---|---|---|---|
| | o/p capacity | installed | trench length | pipework installed (incl civils) | End user connections | End user connections | |
| DISTRICT ENERGY | kW | £/kW | m | £/m | quantity | £/connection | £ |
| gas CHP | 770 | £700 | | | | | £539,000 |
| biomass boiler | 500 | £180 | | | | | £90,000 |
| | 500 | £180 | | | | | £90,000 |
| gas boilers | 1000 | £60 | | | | | £60,000 |
| | 2500 | £40 | | | | | £100,000 |
| M & E (energy centre) | | | | | | | £150,000 |
| energy centre building, utility conns | | | | | | | £500,000 |
| electricity network (additional) | | | | | | | £100,000 |
| DH network flow & return | | | 4,000 | £500 | | | £2,000,000 |
| DH end user conns (new building) | | | | | 7 | £10,000 | £70,000 |
| DH end user conns (new dwelling) | | | | | 483 | £1,000 | £483,000 |
| DH end user conns (existing building) | | | | | 1 | £20,000 | £20,000 |
| Subtotal | | | | | | | **£4,202,000** |
| Engineering & Project Management | | | | | | | £630,300 |
| ESCo set up | | | | | | | £100,000 |
| **TOTAL** | | | | | | | **£4,932,300** |
| CONVENTIONAL ENERGY | | | | | | | |
| Individual gas boiler/ CHP systems: | | | | | | | |
| Offices (each) | 116 | £150 | | | 12 | | £208,260 |
| Hotel | 194 | £150 | | | 2 | | £58,260 |
| Sports Centre | 125 | | | | 1 | | £150,000 |
| Residential | 10 | £150 | | | 483 | | £724,500 |
| Gas network | | | 2800 | £100 | | | £280,000 |
| Subtotal | | | | | | | **£1,421,020** |
| Engineering & Project Management | | | | | | | £213,153 |
| **TOTAL** | | | | | | | **£1,634,173** |
| **NET CAPITAL COST** | | | | | | | **£3,298,127** |
| District energy cost net/gross % | | | | | | | **67%** |
| Conventional/district energy cost % | | | | | | | **33%** |

4.12 The headline figures which emerge from the financial analysis assuming the project net capital cost shown in the table above are presented below.

IRR = Internal Rate of Return

NPV = Net Present Value

| | |
|---|---|
| Capital cost of district energy scheme | £4,932,300 |
| Capital cost of conventional energy supplies | £1,634,173 |
| Developer contribution as % of total capital cost | 33% |
| IRR to provide an NPV of £0 | 11.9% |
| NPV with a discount rate of 3.5% | £3,130,546 |

4.13 The following considers a range of higher IRRs typical of the private sector and shows the increased amounts of capital contribution required by the ESCo from the developer in order to present a financially competitive investment.

To provide an IRR of 15%:

| | |
|---|---|
| Capital cost of conventional energy supplies | £1,634,173 |
| Additional capital over cost of conventional energy | £587,415 |
| Capital contribution to the ESCo | £2,221,588 |
| Developer contribution as a % of total capital cost | 45% |

To provide an IRR of 20%:

| | |
|---|---|
| Capital cost of conventional energy supplies | £1,634,173 |
| Additional capital over cost of conventional energy | £1,222,155 |
| Capital contribution to the ESCo | £2,856,328 |
| Developer contribution as a % of total capital cost | 58% |

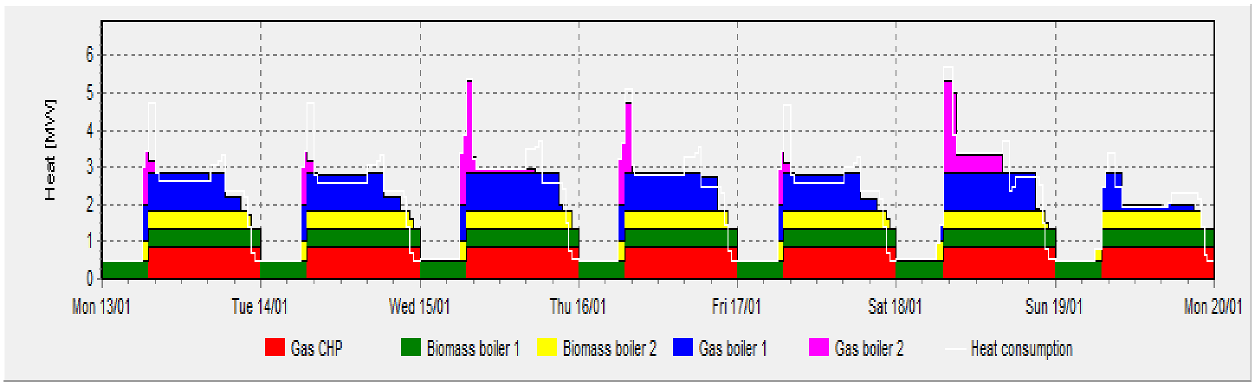
To provide an IRR of 25%:

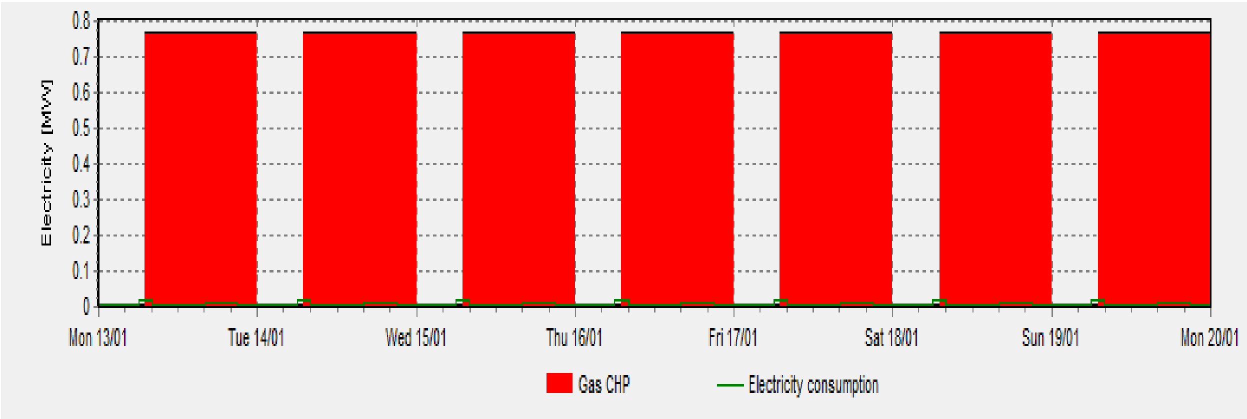
| | |
|---|---|
| Capital cost of conventional energy supplies | £1,634,173 |
| Additional capital over cost of conventional energy | £1,634,537 |
| Capital contribution to the ESCo | £3,268,710 |
| Developer contribution as a % of total capital cost | 66% |

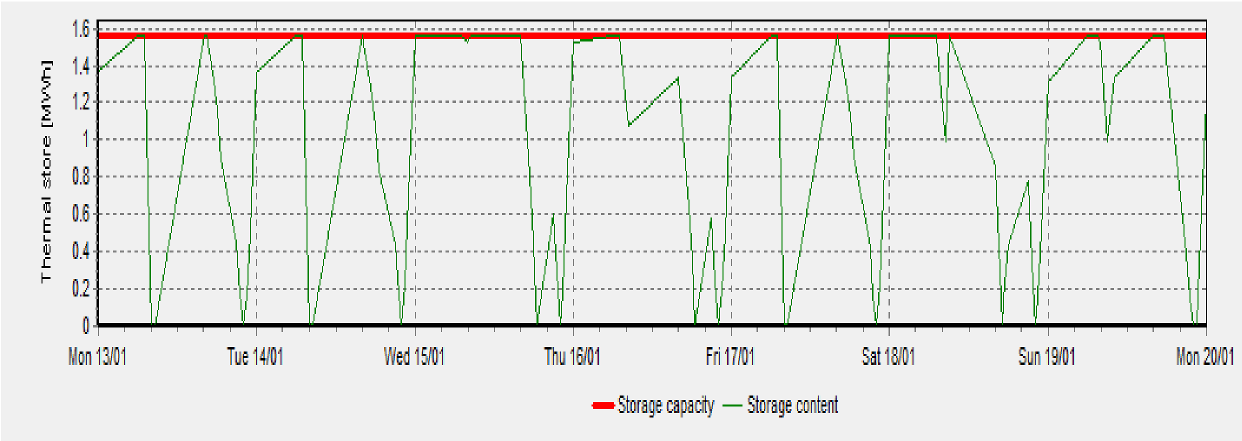
## Addition of Abbey Barn South

4.14 The following graphs show the seasonal variation in operation of the energy plant selected to serve the combined heat demand profile of all connected loads for all three sites.

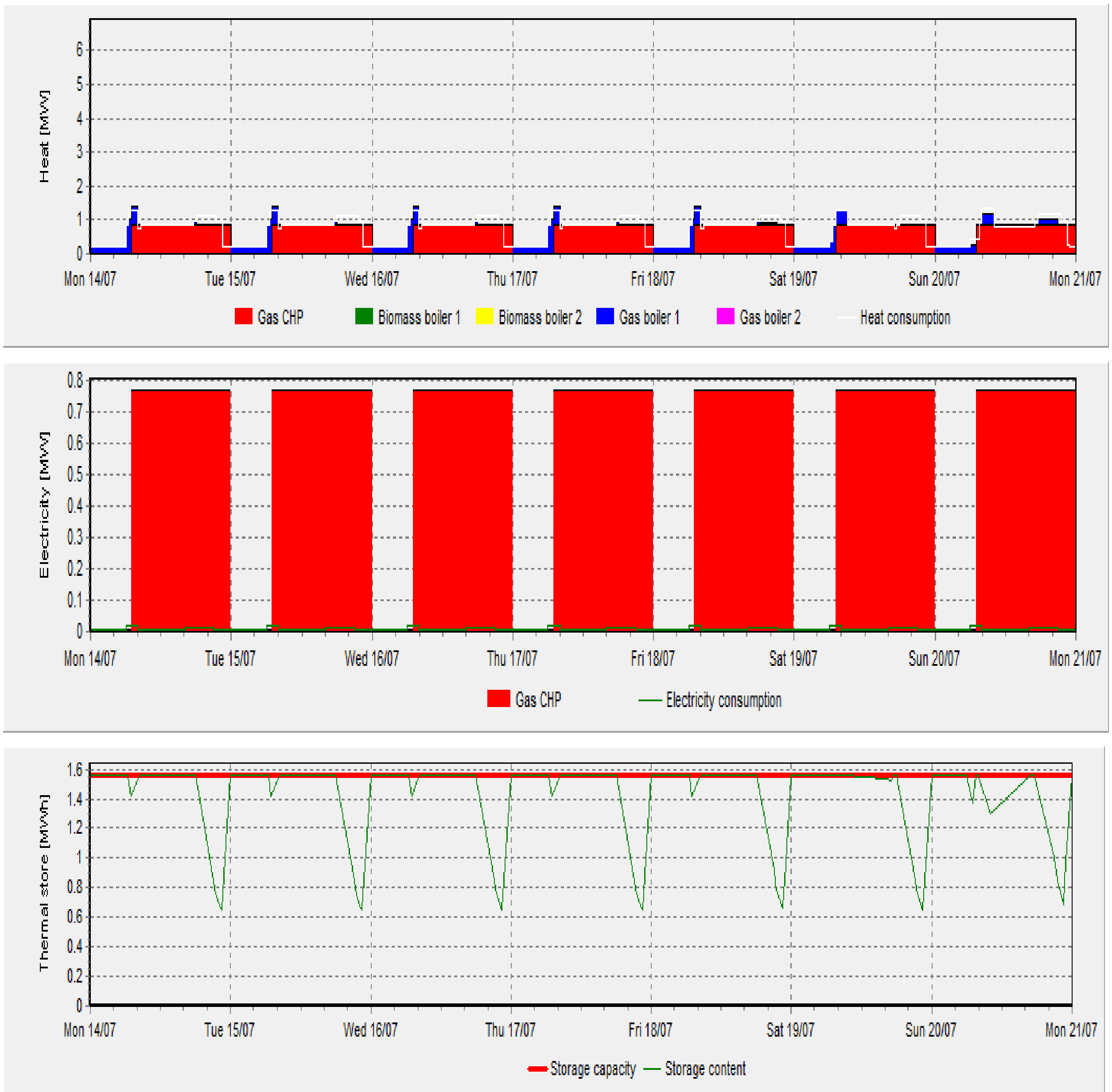
## Winter – Typical 7 day profile



Summer – Typical 7 day profile




4.15 The following table outlines the major additional elements of the district energy scheme and conventional alternative to include Abbey Barn South, along with estimated capital costs for each element. The total figure for capital cost shown under 'Conventional Energy' is the cost of providing conventional energy supplies and systems to the buildings and is therefore assumed to represent the capital contribution from the developer to an ESCo in order to provide a district energy scheme to serve the new development.

Capital Costs – Abbey Barn as an extension to Handy Cross & Daws Hill

| | energy plant o/p capacity kW | energy plant installed £/kW | pipework trench length m | pipework installed (incl civils) £/m | End user connections quantity | End user connections £/connection | Total £ |
|---|---|---|---|---|---|---|---|
| DISTRICT ENERGY | | | | | | | |
| gas boiler | 2500 | £40 | | | | | £100,000 |
| M & E (energy centre) | | | | | | | £10,000 |
| energy centre building, utility conns | | | | | | | £20,000 |
| electricity network (additional) | | | | | | | £150,000 |
| DH network flow & return | | | 2,000 | £500 | | | £1,000,000 |
| DH end user conns (new building) | | | | | 2 | £10,000 | £20,000 |
| DH end user conns (new dwelling) | | | | | 550 | £1,000 | £550,000 |
| Subtotal | | | | | | | **£1,850,000** |
| Engineering & Project Management | | | | | | | £277,500 |
| **TOTAL** | | | | | | | **£2,127,500** |
| CONVENTIONAL ENERGY | | | | | | | |
| Individual gas boiler/ CHP systems: | | | | | | | |
| Offices (each) | 66 | £150 | | | 5 | | £49,500 |
| Residential | 10 | £150 | | | 550 | | £825,000 |
| Gas network | | | 2200 | £100 | | | £220,000 |
| Subtotal | | | | | | | **£1,094,500** |
| Engineering & Project Management | | | | | | | £164,175 |
| **TOTAL** | | | | | | | **£1,258,675** |
| **NET CAPITAL COST** | | | | | | | **£868,825** |
| District energy cost net/gross % | | | | | | | **41%** |
| Conventional/district energy cost % | | | | | | | **59%** |

4.16 The headline figures which emerge from the financial analysis assuming the project net capital cost shown in the table above are presented below.

IRR = Internal Rate of Return

NPV = Net Present Value

| | |
|---|---|
| Capital cost of district energy scheme | £2,127,500 |
| Capital cost of conventional energy supplies | £1,258,675 |
| Developer contribution as % of total capital cost | 59% |
| IRR to provide an NPV of £0 | 21.5% |
| NPV with a discount rate of 3.5% | £3,142,165 |

4.17 The following considers a range of higher IRRs typical of the private sector and shows the increased amounts of capital contribution required by the ESCo from the developer in order to present a financially competitive investment.

To provide an IRR of 25%:

| | |
|---|---|
| Capital cost of conventional energy supplies | £1,258,675 |
| Additional capital over cost of conventional energy | £125,113 |
| Capital contribution to the ESCo | £1,383,788 |
| Developer contribution as a % of total capital cost | 65% |

# 5 Case Study Conclusions

5.1 The results show that a developer contribution to the capital cost of providing a new district energy scheme in the case of the stand alone projects (Handy Cross and Handy Cross plus Daws Hill) is around 30% of the total project cost based on this amount being equal to the cost of providing conventional energy plant and infrastructure. It is noted that providing accurate estimates of the cost of conventional and district energy plant infrastructure in particular is difficult and the amount that a developer would in practice expect to pay is uncertain – in particular for mains gas networks where once connected to new loads the gas supplier will receive long term revenues from the sale of gas.

5.2 Nevertheless there would be an offset cost and this would go towards the capital cost of the district energy scheme, the results of the financial analysis show increasing project viability as greater capital contribution is provided from outside the ESCo, as would be expected. The larger the connected load the greater is the financial viability of the project, with increasingly higher internal rate of return figures.

5.3 Assuming project capital contribution from offset costs of conventional energy supplies the resulting project IRRs for the two stand alone schemes are what might be considered to be a lower limit for financial viability in the private sector of between 8.6 and 11.9%. The addition of heat and electricity loads to an existing scheme as modelled by the inclusion of Abbey Barn South provides an improvement in financial performance.

5.4 For the two projects Handy Cross and Handy Cross plus Daws Hill, a 15% IRR as might be expected to offer a financially attractive investment to an ESCo in a competitive arena within the private sector, would demand that each project received around 50% of the total capital cost external to the ESCo, equating to approximately £1m and £2.5m for each project respectively.

# 6 The Code for Sustainable Homes

6.1 The Code for Sustainable Homes (CSH) is an environmental assessment method for rating and certifying the performance of new dwellings. It is a national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home building. It was launched in December 2006 with the publication of *Code for Sustainable Homes: A step-change in sustainable home building practice* (Communities and Local Government, 2006). The Code became operational in April 2007 in England and having a CSH rating for new build homes mandatory, from 1st May 2008.

6.2 The CSH covers nine categories of sustainable design listed below:

- Energy and $CO_2$ Emissions
- Water
- Materials
- Surface Water Run-off
- Waste
- Pollution
- Health and Wellbeing
- Management
- Ecology.

6.3 Each category includes a number of environmental issues (giving a total of 34 sub-categories). Each issue is a source of impact on the environment which can be assessed against a performance target and awarded one or more credits. Performance targets are more demanding than the minimum standard needed to satisfy Building Regulations or other legislation. They represent good or best practice, are deemed technically feasible, and can be delivered by the building industry.

6.4 Mandatory standards are set in the following sub-categories; Ene1 – Dwelling emission rate, Wat1 – Internal water use, Mat1 – Environmental impact of materials, Sur1 – Management of surface water runoff, Was1 – Storage of non-recyclable and recyclable household waste & Was2 – Construction site waste management. The first two of these have graded standards that must be achieved to attain certain Levels of the CSH, the others are minimum standards for CSH compliance.

6.5 In addition to a number of mandatory standards, each design category scores a number of percentage points and these are open to the developer to chose for compliance with the aim being to score enough to attain the Level required. This total number of percentage points establishes the Level or Rating for the dwelling.

## The Role of Energy within the CSH

6.6 Issues relating to energy are currently covered under the nine sub-categories under the first category, Energy and $CO_2$ Emissions. Of these nine sub-categories, only the first, Ene1 – Dwelling Emission Rate and the seventh, Ene7 – Low or Zero Carbon (LZC) will be effectively influenced by the uptake or otherwise of district/decentralised CHP schemes. This is a total of two out of thirty-four categories that can be considered by developers seeking CSH compliance. However, the first sub-category, Ene1, does have mandatory levels to achieve and it is worth looking at this in a bit more detail.

6.7 Ene1 – Dwelling Emission Rate, has an aim of limiting emissions of $CO_2$ to the atmosphere arising from the operation of a dwelling and its services. Credits are awarded based on the percentage improvement in the Dwelling Emission Rate (DER) over the Target Emission Rate (TER) as calculated under Part L1A (2006) of the Building Regulations. There are 0-15 credits available, with mandatory levels set as outlined in the table below.

| *% Improvement of DER over TER* | *Credits* | *Mandatory Levels* |
|---|---|---|
| **Equal or above 10%** | **1** | **Level 1** |
| Equal or above 14% | 2 | |
| **Equal or above 18%** | **3** | **Level 2** |
| Equal or above 22% | 4 | |
| **Equal or above 25%** | **5** | **Level 3** |
| Equal or above 31% | 6 | |
| Equal or above 37% | 7 | |
| **Equal or above 44%** | **8** | **Level 4** |
| Equal or above 52% | 9 | |
| Equal or above 60% | 10 | |
| Equal or above 69% | 11 | |
| Equal or above 79% | 12 | |
| Equal or above 89% | 13 | |
| **Equal or above 100%** | **14** | **Level 5** |
| **Zero Carbon Home*** | **15** | **Level 6** |

- Exact definition still to be confirmed by Government

6.8 Clearly developers are rewarded under this scale relating to the ambition of their design and specification within this area. The Building Research Establishment (BRE) who administer the CSH state that it is technically possible to achieve Level 3 compliance without the need to include low and zero carbon (LZC or renewable energy) technologies and whilst this is *technically* true, in reality it is rarely the case.

6.9 This point is important as the upcoming (2010) revision to Part L of the Building Regulations proposes to make a 25% improvement on the current regime, which will make the Level 3 position outlined above, the minimum position for Building Regulations compliance, until the next revision in 2013, when the Level 4 position has been signposted as the ambition, with zero carbon the aim for 2016.

6.10 It is with this tightening of the Building Regulations that the issue of the role of CHP as a working solution becomes of interest. However, it is the Building Regulations and not the CSH that is the driver for this.

6.11 The category Ene7 – Low or zero carbon technologies is not mandatory, so need not be scored if credits can be accrued elsewhere. It aims to reduce carbon emissions and atmospheric pollution by encouraging local energy generation from renewable sources to supply a significant proportion of the energy demand. There are two credits available and to guarantee scoring the two credits, biomass would need to make up a significant proportion of the fuel utilised by the CHP system, although in some cases, gas CHP may also yield one and two credits, but this would be on a case-by-case basis and cannot be automatically relied upon.

6.12 It is also worth mentioning under this section, that whilst not under the Energy category, Pol2 – NOx emissions in the Pollution category has three credits available dependent on the NOx emissions of heating plant and the use of CHP could have an affect here in the overall attempts of a developer to comply to a specific CSH level.

## Projected evolution of domestic energy demand

6.13 The result of tightened Building Regulations under Part L should see a dramatic reduction in heating requirements amongst new build homes. This will lead to hot water provision and power requirements forming a larger percentage of overall reduced domestic energy requirements.

6.14 Indeed, the focus on the reducing heating requirements has recently seen the proposed introduction of tightened building fabric standards, known as the 'Energy Efficiency Standard for Zero Carbon Homes', to ensure compliance with the Part L changes are not simply met by bolt on LZC technology with a lifespan significantly shorter than the building to which they are attached, but by fundamental alterations to design and construction that will last for the lifetime of the dwelling.

6.15 On the negative side, recent studies show that power requirements in standard UK homes from non-controlled equipment (items that cannot be covered under the Building Regulations, such as televisions, computers etc.) has risen. This may continue to be the case in the coming years, although work, mainly as a result of European legislation, continues to tackle the issue of appliance energy use and attempt to drive this down. In the long run it could be anticipated that this will be successful, in much the same way as it has been with lighting technology, which continues to make great strides in increased energy efficiency.

6.16 All of the above has to be considered within the context of how CHP can be utilised with regard to assisting the attainment of CSH ratings.

## Renewable energy CHP

6.17 Traditionally CHP systems have used gas, however new and emerging technologies also allow for the use of woody biomass-fuelled CHP. CHP can then be referred to as biomass CHP and it can constitute a renewable/LZC solution if the biomass is sustainably sourced. There are a number of alternative processes involved in taking the energy in the solid biomass fuel and transforming it into a form such that it can be used to generate electrical power and provide useful heat as in CHP.

6.18 A low energy value gas, sometimes termed syngas, is produced though the gasification of woody biomass as short-rotation coppice or forestry residues. The syngas can be used to fuel an internal combustion engine and thereby generate power at relatively high efficiency, as well as heat as a by-product, although significant cleaning and treatment of the gas is required beforehand and this traditionally has affected the reliability of these systems.

6.19 Alternatively the syngas can be combusted in a furnace without prior cleaning and the resulting hot products of combustion routed to a heat exchanger connected to a Stirling engine to generate electrical power. Systems developed in Denmark are now reaching technical maturity at 35kW electrical output, 140kW corresponding heat output, and would be suitable for medium sized residential developments of around 400 dwellings to provide the majority of the base-load heat demand as domestic hot water.

6.20 The use of wood gasification applied to schemes in the 100s of kW scale electrical capacity would be applicable to larger developments. Under current building regulations, this would involve a development of at least 1,000 homes. Published figures in 2007 indicate that only 9% of new build stock occurs in developments over 1,000 homes. So the technology needs to be developed further to be viable in smaller developments. However, the issues associated with smaller CHP installations are not just technical, there are also organisational and managerial issues associated with operating smaller schemes.

6.21 Biomass CHP systems can also use solid wood directly within a traditional combustion process within a steam boiler, the steam then driving a turbine to generate electricity. A portion of the energy in the steam can be taken from the turbine at low pressure and used for heating, with much improved overall efficiency. This process is only economical at higher capacities above 5MWe and is therefore suited to district heating schemes supplying large mixed use developments of many thousands of homes and other non-domestic buildings with complimentary heat loads.

6.22 There is one manufacturer within the UK that offers a variant of this technology, but it is still in its early stages. It claims that it can use wood chips, coppiced willow and miscanthus in a combustion process to drive a closed-loop turbine at high speed by the hot combustion gases. The plant under development generates from 50kW to 200kW electrical capacity, which would allow its implementation in smaller developments.

6.23 Biodiesel CHP uses diesel-based reciprocating engines running on fuel that can be obtained from vegetable oil and from the processing of waste oil for instance. Technology is mature in that it is based on the internal combustion engine, biomass-derived liquid fuels requiring modification to fuel feed and delivery components. Internal combustion engines also offer flexible operation, able to modulate to suit the intended load. CHP engine technology has however tended to focus on gas fired spark ignition types due to the availability of mains gas.

6.24 It should be noted that SAP2005 includes a cap that limits the contribution of CHP in achieving carbon reductions in new dwellings. The original purpose of the cap was to curb the carbon savings achieved by over-reliance on those natural gas-fired CHP systems that have high electrical efficiencies. It appears that the same cap may result in the carbon savings from biomass CHP being severely underestimated, as the electricity from biomass CHP is assumed to have the same carbon content as the grid (and the full carbon savings are not allowed to be carried through on the heating side).

6.25 This issue has been brought to the attention of those responsible for SAP and, it is understood and will be reviewed as part of the wider review of SAP following the launch of the revised Part L of the Building regulations in 2010. It is essential that this issue is resolved, otherwise one of the possible routes to helping to achieve Code levels 5 and 6 will be unnecessarily restricted.

## The role of CHP in delivering CSH ratings

6.26 The first point to make under this section is that CHP only has a role to play in up to three of the thirty-four sub-categories of the CSH. The CSH is a many layered scheme and many of these thirty-four sub-categories will need to be scored to attain, for example, a Level 3 rating.

6.27 From a theoretical technical perspective, a CHP scheme, be it gas or biomass powered, considered in isolation as a LZC, will help to score the required mandatory credits under Ene1 for a Level 3 rating and may well deliver a Level 4 rating too. For a Level 5 and Level 6 rating almost all, if not all the fuel used will need to be biomass to get over the negative carbon impact of gas (biomass being viewed as carbon neutral) which will not allow for the higher improvements over minimum Part L standards to be scored.

6.28 The use of biomass will also bring the two credits available under Ene7 into play, but may mean that the three credits under Pol2 are less attainable (currently at least two of the three tend to be secured for gas based systems), although improvements in boiler technology may make this less of an issue moving forward.

6.29 The reality is more confused. There are already examples of CSH compliant projects at Level 3 and above where gas CHP schemes are operating. Larger blocks of flats, for example, find it difficult to comply with the exacting conditions of Ene1 under the CSH as the SAP methodology makes things difficult for this type of design. Given that, in these situations, there is some tradition in the UK of installing communal heating schemes, the leap to installing a gas fired CHP scheme has not been too difficult for some developers to take and this has helped attain the CSH levels required by planning bodies/funding agencies.

6.30 District heating schemes involving houses, tied to the need to attain a CSH rating are far fewer on the ground and this may be due to a number of reasons. Currently, the CSH Level most frequently required by planning authorities and/or funding bodies has been Level 3. As mentioned earlier, theoretically, this can be achieved with no recourse to LZC technologies. The reality is that whilst some attention is paid to house design, construction and services, the extra improvements needed to reach a 25% improvement (mandatory at Level 3) over Part L1A of the Building Regulations is normally met by solar thermal, heat pump, or, occasionally, solar photovoltaic technology (PV). These technologies, individually, are easier and cheaper to install than a district based CHP scheme.

6.31 It is likely that this will continue to be the case into the medium term at the very least, due to the immature market that exists within the UK with regards district-wide, decentralised energy supply, be it conventional, heat only or CHP focused.

6.32 A pinch point may occur as we near the requirement for 'Zero Carbon Homes', as all the technologies outlined above have their limitations. Solar thermal cannot deliver all the annual domestic hot water requirements of a dwelling, heat pumps still require the use of 'carbon-heavy' electricity and PV is limited by the amount of space available on a roof and its efficiency at turning daylight into electricity. This space issue will be a problem for smaller houses and flats, unless efficiency levels improve significantly. At this point, biomass fired CHP district networks may start to look attractive, but they still have their limitations.

6.33 Limitations include the degree to which a sustainable biomass fuel market will be in place; the need for owner/operating companies to come forward to manage the networks and for the finance to be available to build them; the problem of consumer choice, whereby it is currently not legal for a single energy provider to have a geographic monopoly on supply; and the fact that not all developments are suitable for a CHP network due to size scale and energy profiles.

6.34 Indeed, as heating requirements in dwellings will increasingly be driven by domestic hot water requirements as opposed to space heating needs, this means that the heat density on many developments will be smaller and that the life cycle costs of the heat delivered per dwelling will increase. This phenomenon will be more significant in those areas where the housing density is lower e.g. groups of detached houses, and where other heat sinks do not exist.

## CHP & the CSH: Conclusions

6.35 CHP is already playing a role in delivering the requirements associated with the Ene1 sub-category of the CSH. This is nearly always in the form of gas-fired units feeding a communal system for a block of flats. However, this is still not a typical solution for developers of even this type of development, let alone for developments at the other end of the scale, those of low-density detached houses.

6.36 Moving forward and considering the changes to Part L1 of the Building Regulations which will come into play in the next few years, in line with the CSH Ene1 requirements, for CHP systems to be of assistance with CSH ratings, they will need to be operated using biomass. This technology is still in its infancy and biomass systems come with a range of other issues which currently make them un-attractive to developers, such as space requirements, high up front capital costs (especially if tied to a district heating/power scheme) and the need to engage with operating and management organisations. These issues may or may not be realistic impediments, but there is still a fundamental change in mindset that will need to be addressed.

6.37 It is also unlikely that district heating schemes, let alone those including CHP and private wire arrangements, can be made to look financially attractive for smaller and/or lower density developments. Unless wider schemes are already in place within a locale, feeding existing demand, it is extremely unlikely that a developer will engage with the business of developing a new scheme from scratch specifically for their development. As mentioned earlier, a district biomass-fuelled CHP scheme, as an example, would need at least 400 dwellings and these would be built to current, not future, improved Building Regulations standards, although the impact on domestic hot water use is not thought to be affected to a significant degree.

6.38 In summary, CHP does already and will continue to have a role to play in assisting with the delivery of CSH ratings. However, if the development of CHP schemes on a district-wide level is to be a policy objective, relying on the CSH as the prime route is unlikely to succeed in the short to medium term. To deliver an objective such as this other policies, specifically structured policies will be required.