Assessment Report
District Energy

Significant Future Redevelopment Sites within Reading Borough

Project Reference: TVR157

Report to Reading Borough Council, July 2010

TV Energy

This report has been prepared by TV Energy Ltd for Reading Borough Council. Report reference TVR157.

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Executive Summary

This report presents the results of a feasibility study carried out on behalf of Reading Borough Council as part of the Climate Berkshire initiative, and provides an economic assessment of district energy for significant proposed redevelopment sites within Reading borough.

The sites are Worton Grange, the Berkshire Brewery site and land to the north of Manor Farm Road, all located within south Reading, and the area to the north of Reading station.

District energy in this case includes a central energy building with gas CHP plant and biomass CHP as an alternative, 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. In the case of Worton Grange and the Berkshire Brewery, these sites have been combined within the analysis due to their proximity and include central and district cooling. 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 proposed redevelopment of each site includes a mixture of significant number of new dwellings, and office space in the case of Worton Grange and North of Reading Station, along with supporting retail and leisure development.

The timescale for development of these sites is likely to be within the next 10 years.

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 within the analysis. This is based on individual gas boilers providing space heating and hot water to all buildings in the case where district cooling is included, and excepting retail development assumed to be served by electrical systems where only district heating is included. Renewable energy micro-generation technologies installed as individual systems integrated into each building or dwelling are not considered specifically as part of district energy provision. These baseline 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. In any case, Reading Borough Council currently demands a 20% reduction in Building Regulations-assessed carbon emissions for new developments, from a mix of building energy efficiency measures (to reduce energy demand) and Low and Zero Carbon (LZC) energy generation technologies (to supply low carbon energy). 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 has been provided, 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.

The developer contribution to the capital cost of providing a new district energy scheme borne by an ESCo, for each site is around one third 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. 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.

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 a district energy project capital contribution from the offset costs of conventional energy supplies, the resulting project IRRs for all sites at around 7% are not considered especially attractive to an ESCo, and therefore at a lower limit for financial viability within the private sector. A 15% IRR might be expected to offer a financially attractive investment to an ESCo in a competitive arena within the private sector, and would demand that each project received over 60% of the total capital cost external to the ESCo. In the case of the Worton Grange and the Berkshire Brewery sites this equates to approximately £1.76m and £1.92m, for the North of Manor Farm Road site equals around £1.57m and £1.52m, and for the North of

Reading Station site equals around £2.62.m and £3.33.m, for the gas CHP and biomass CHP projects respectively. An IRR of 25% would require each project to receive roughly 75% of the capital cost of the district energy project from outside the ESCo.

Examination of individual elements within the financial assessment points to the fact that an attractive scheme relies heavily on revenues from the Renewable Heat Incentive, and ROCs in the case of biomass CHP. In the absence of capital grants these revenue based support measures become crucial in providing financial viability.

In the case of the North of Manor Farm Road site the financial performance figures are slightly worse than the Worton Grange and the Berkshire Brewery sites due to the smaller scheme in terms of the total connected load, due to many of the operating costs being fixed costs. The North of Reading Station site again features slightly lower performance, due to the site being relatively spread out based on the building layout.

The financial performance of the larger schemes Worton Grange & Berkshire Brewery and the North of Reading Station is thought to be hampered in this instance through the inclusion of central cooling and the use of absorption chilling. The additional cost of central cooling plant and distribution infrastructure is high at around £1.4m by comparison to the revenues which would be realised by the ESCo through the sale of chilled water to provide cooling services. The cooling demand as modelled is relatively peaky and does not allow the absorption chiller to be utilised in an economically efficient way, and in any case with a significant summer time heat load on the CHP plant from the domestic hot water requirement there is no benefit to be gained through increased CHP running hours as it is already operating at its peak capacity, given the hot water and electricity demand profiles.

Comparing the overall financial performance of gas CHP and biomass CHP options, there is little to choose between the two, although the biomass CHP capital cost is around double that of gas CHP with similar heat output capacity. This additional cost is recovered mainly through ROC revenues, additional RHI revenues in the case of the North of Manor Farm Road site where the biomass boiler is sized below 500kW, and the use of less costly biomass fuel compared to gas, and which also allows greater benefit to be gained from the RHI payment given that the CHP heat output capacity is around 500kW. The total electricity generated is reduced however, compared to gas CHP, due to the higher heat to power ratio of biomass CHP plant. This highlights the limitations of biomass CHP on its own as a means to facilitate zero, or close to zero carbon development at this scale, in this case only 22% of the total annual electricity demand can be delivered from the central CHP plant, whereas by comparison the total heat demand, and for that matter cooling demand given sufficient biomass fuelled and absorption chiller plant capacity, can be delivered through renewable energy sources relatively straightforwardly. This shortfall in local renewable electricity generation required to serve the entire development is typical, and additional quantities would need to be supplied by a combination of other technologies, for example one or more wind turbines and extensive use of roof mounted solar PV, considerably adding to the overall capital cost of the district energy scheme.

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.

Worton Grange & Berkshire Brewery (gas CHP)

Total capital cost of district energy scheme	£6,584,800
Capital cost of conventional energy (from developer)	£2,363,535
Developer contribution to ESCo as % of total capital cost	36%
IRR to provide an NPV of £0	7.0%
NPV with a discount rate of 3.5%	£1,443,934

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

Additional capital contribution to ESCo	£844,122
Total capital contribution to ESCo	£3,207,657
Developer contribution as a % of total capital cost	49%

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

Additional capital contribution to ESCo	£1,761,459
Total capital contribution to ESCo	£4,124,994
Developer contribution as a % of total capital cost	63%

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

Additional capital contribution to ESCo	£2,330,189
Total capital contribution to ESCo	£4,693,724
Developer contribution as a % of total capital cost	71%

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

Additional capital contribution to ESCo	£2,705,419
Total capital contribution to ESCo	£5,068,954
Developer contribution as a % of total capital cost	77%

Worton Grange & Berkshire Brewery (biomass CHP)

Total capital cost of district energy scheme	£7,133,600
Capital cost of conventional energy (from developer)	£2,363,535
Developer contribution to ESCo as % of total capital cost	33%
IRR to provide an NPV of £0	6.9%
NPV with a discount rate of 3.5%	£1,507,599

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

Additional capital contribution to ESCo	£923,033
Total capital contribution to ESCo	£3,286,568
Developer contribution as a % of total capital cost	46%

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

Additional capital contribution to ESCo	£1,919,533
Total capital contribution to ESCo	£4,283,068
Developer contribution as a % of total capital cost	60%

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

Additional capital contribution to ESCo	£2,546,721
Total capital contribution to ESCo	£4,910,256
Developer contribution as a % of total capital cost	69%

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

Additional capital contribution to ESCo	£2,965,453
Total capital contribution to ESCo	£5,328,988
Developer contribution as a % of total capital cost	75%

North of Manor Farm Road (gas CHP)

Total capital cost of district energy scheme	£2,387,040
Capital cost of conventional energy (from developer)	£914,780
Developer contribution to ESCo as % of total capital cost	38%
IRR to provide an NPV of £0	6.3%
NPV with a discount rate of 3.5%	£392,433

<u>To provide a district energy project IRR of 10%:</u>	
Additional capital contribution to ESCo	£360,194
Total capital contribution to ESCo	£1,274,974
Developer contribution as a % of total capital cost	53%

<u>To provide a district energy project IRR of 15%:</u>	
Additional capital contribution to ESCo	£659,880
Total capital contribution to ESCo	£1,574,660
Developer contribution as a % of total capital cost	66%

<u>To provide a district energy project IRR of 20%:</u>	
Additional capital contribution to ESCo	£844,836
Total capital contribution to ESCo	£1,759,616
Developer contribution as a % of total capital cost	74%

<u>To provide a district energy project IRR of 25%:</u>	
Additional capital contribution to ESCo	£966,442
Total capital contribution to ESCo	£1,881,222
Developer contribution as a % of total capital cost	79%

North of Manor Farm Road (biomass CHP)

Total capital cost of district energy scheme	£2,518,640
Capital cost of conventional energy (from developer)	£914,780
Developer contribution to ESCo as % of total capital cost	36%
IRR to provide an NPV of £0	7.1%
NPV with a discount rate of 3.5%	£492,158

<u>To provide a district energy project IRR of 10%:</u>	
Additional capital contribution to ESCo	£279,101
Total capital contribution to ESCo	£1,193,881
Developer contribution as a % of total capital cost	47%

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

Additional capital contribution to ESCo	£607,113
Total capital contribution to ESCo	£1,521,893
Developer contribution as a % of total capital cost	60%

To provide a district energy project IRR of 20%:

Additional capital contribution to ESCo	£818,431
Total capital contribution to ESCo	£1,733,211
Developer contribution as a % of total capital cost	69%

To provide a district energy project IRR of 25%:

Additional capital contribution to ESCo	£962,004
Total capital contribution to ESCo	£1,876,784
Developer contribution as a % of total capital cost	75%

North of Reading Station (gas CHP)

Total capital cost of district energy scheme	£9,498,480
Capital cost of conventional energy (from developer)	£3,304,020
Developer contribution to ESCo as % of total capital cost	35%
IRR to provide an NPV of £0	7.0%
NPV with a discount rate of 3.5%	£2,181,521

To provide a district energy project IRR of 10%:

Additional capital contribution to ESCo	£1,264,385
Total capital contribution to ESCo	£4,568,405
Developer contribution as a % of total capital cost	48%

To provide a district energy project IRR of 15%:

Additional capital contribution to ESCo	£2,620,061
Total capital contribution to ESCo	£5,924,081
Developer contribution as a % of total capital cost	62%

To provide a district energy project IRR of 20%:

Additional capital contribution to ESCo	£3,449,387
Total capital contribution to ESCo	£6,753,396
Developer contribution as a % of total capital cost	71%

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

Additional capital contribution to ESCo	£3,990,570
Total capital contribution to ESCo	£7,294,590
Developer contribution as a % of total capital cost	77%

North of Reading Station (biomass CHP)

Total capital cost of district energy scheme	£9,874,800
Capital cost of conventional energy (from developer)	£3,304,020
Developer contribution to ESCo as % of total capital cost	33%
IRR to provide an NPV of £0	4.9%
NPV with a discount rate of 3.5%	£616,065

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

Additional capital contribution to ESCo	£2,184,678
Total capital contribution to ESCo	£5,488,698
Developer contribution as a % of total capital cost	56%

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

Additional capital contribution to ESCo	£3,329,747
Total capital contribution to ESCo	£6,633,767
Developer contribution as a % of total capital cost	67%

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

Additional capital contribution to ESCo	£4,048,713
Total capital contribution to ESCo	£7,352,733
Developer contribution as a % of total capital cost	74%

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

Additional capital contribution to ESCo	£4,527,596

Total capital contribution to ESCo	£7,831,616
Developer contribution as a % of total capital cost	79%

Moving forward and considering the changes to Part L1A and L2A of Building Regulations, which will come into play in the next few years, for central CHP systems to be effective, district energy schemes 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 likely timescale of planning for all sites, development will require compliance with significantly tighter Building Regulations standards (expected 44% carbon reduction from current 2006 levels by 2013) and Code for Sustainable Homes (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 'zero carbon' 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.

1 Introduction

This report presents the results of a feasibility study forming a part of the Climate Berkshire initiative, examining the potential for the development of district or decentralised energy (DE) schemes within Reading borough. The report provides an analysis of a number of areas of significant new development in Reading, including three sites in south Reading appearing within the Sites and Detailed Policies Document to 2026 within the Reading Borough Local Development Framework (LDF), and in addition the proposed development of the existing central Post Office and retail site located in the area between the railway lines at Reading station and Vastern Road.

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 these sites. Advanced energy generation technologies as part of district energy supply are considered, these include biomass fuelled CHP and absorption chiller plant providing central cooling to non-residential development. An expected outcome is for Reading Borough Council to be able to understand the issues of costs and financial viability and therefore be better placed to encourage the engagement of developers and ESCos, in partnership with the Council in bringing these types of schemes forward.

An important aspect of any site with a significant amount of future residential as well as non-residential development is the impact on the energy and hence carbon emissions standards associated with evolving Building Regulations in respect of Part L1A and L2A, in addition to the 'zero carbon' standards anticipated to be required for residential as well as non-residential buildings by 2016 and 2019 respectively.

There exists the potential to expand any new district energy scheme which serves new development to surrounding existing buildings where conditions are suitable, as well as any future development which may progress in phases, and the location of each site provides the opportunity for this to happen in future.

Assessment of the sites has paid particular attention to include the following where appropriate:

1. New buildings, both non-residential and dwellings, are characterised by improved thermal insulation, air tightness and increased electrical efficiency over current build standards, reflecting predicted future Building Regulations requirements, 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. The use of central absorption chiller plant and a chilled water distribution network providing lower carbon cooling to non-domestic buildings;

6. The potential to include biomass fired CHP, either from scheme inception or to replace gas fired CHP in future;
7. Estimates of district energy scheme capital cost offsets of conventional energy plant and infrastructure;
8. Sensitivity analysis considering different levels of discount rate for capital finance applicable to private and public sector owned ESCos.

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

This study is intended to support the ambitions of the Sites and Detailed Policies Document to 2026 with regard to the references made to developing decentralised energy, and the Reading Station Area Framework document, with a view to ultimate delivery of schemes serving these sites in future. One possible delivery mechanism is through the establishment of a partnership agreement between Reading Borough 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 package including finance, design, procurement, installation and operation of the district energy scheme, including the establishment of energy supply contracts with end users and billing.

1.1 Development Site Details

The following sites are considered in this report:

South Reading

Worton Grange

A brownfield site, recently cleared and proposed to receive a mix of development including between 175 and 275 new dwellings and able to accept office buildings up to the equivalent of existing levels of floorspace (36,500sq.m), along with additional small retail and leisure uses. An alternative would be the provision of warehouse type buildings on the site. The site is assessed for district energy based on 225 new dwellings with an average unit floor area of 80sq.m, and a total of 36,500sq.m of new office space, with retail and leisure provision afforded by existing local facilities.

Berkshire Brewery

A brownfield site previously occupied by Courage brewery and proposed to be redeveloped to include between 400 and 750 new dwellings as well as a mix of employment, retail and leisure uses at appropriate scale. The site is assessed for district energy based on 575 new dwellings with an average unit floor area of 80sq.m and a total of 4,000sq.m of new retail and 3,000sq.m of new leisure space (type unknown).

North of Manor Farm Road

A brownfield site currently partially occupied by a number of commercial premises to the west of Basingstoke Road and which also includes open land to the south of Brunel Retail Park. The site is proposed to be redeveloped to include between 350 and 550 new dwellings as well as a mix of small employment and community uses. The site is assessed for district energy based on 450 new dwellings with an average unit floor area of 80sq.m and a total of 3,000sq.m of new retail and 2,000sq.m of new leisure space (type unknown).

The analysis has considered implementation of district energy at these sites as follows:

- Worton Grange and the Berkshire Brewery sites combined due to their proximity. The timing of each development coming forward is unknown and it is likely that they would be completed at different times, however for the purposes of the analysis they are considered to be a single scheme with one energy centre supplying energy to all connected loads from day one. In reality there may be a temporary energy centre using gas boilers to provide heat operating for a limited period prior to the permanent plant building being constructed – this is common practice in the case of phased development. There would be a need to link the two sites with district heating and cooling pipework and an electrical connection passing below the A33.
- North of Manor Farm Road as a stand-alone scheme

North of Reading Station

Royal Mail & Retail Site

This site includes the Royal Mail distribution hub building and the adjacent retail park, and is proposed to receive a mix of residential, retail, office, and leisure including hotel uses. Areas labelled RC1e within the Reading Station Area Framework document includes up to 680 new dwellings, together with 83,600sq.m of commercial/ office space, 15,800sq.m of retail, 1000sq.m of leisure use and 22,800sq.m of hotel type use. These figures are derived from one assessment of the scale of build for non-domestic uses which could be accommodated within the site boundary, and these totals are used within the analysis for district energy. An average unit floor area of 63sq.m for dwellings has been used as stated within the framework document. The expected time period for the build is between 2012 and 2017.

Further predominantly residential development areas to the north and east are expected to follow and any district energy connections to these sites would be expected to compliment the core scheme through greater utilisation of energy plant and improved scheme economics.

All of the sites are either currently connected or local to the mains gas network.

2 Energy Demand Assessment

The following table provides a summary of energy demand estimates associated with the four sites for space heating, hot water, cooling and electricity. Benchmark figures are used for new build commercial and residential development taking into account anticipated reductions in space heating demand in future.

Within the analysis calculation for central energy supplies an estimate of electricity consumption associated with plant services is also included (district heating pumps, energy generation plant parasitic power etc).

New Development Sites

			Heating, Cooling & Electricity Demand							
		Floor space sq.m	HWS kWh/sq.m/yr	Space heat kWh/sq.m/yr	Cooling kWh/sq.m/yr	Electricity (excl. cooling) kWh/sq.m/yr	HWS kWh/yr	Space heat kWh/yr	Cooling kWh/yr	Electricity (excl. cooling) kWh/yr
Worton Grange										
New Build	Residential	18,000	35	25	0	30	630,000	450,000	0	540,000
	Offices	36,500	6	20	40	60	219,000	730,000	1,460,000	2,190,000
TOTAL							**849,000**	**1,180,000**	**1,460,000**	**2,730,000**
Berkshire Brewery										
New Build	Residential	46,000	35	25	0	30	1,610,000	1,150,000	0	1,380,000
	Retail	4,000	3	15	35	80	12,000	60,000	140,000	320,000
	Leisure	3,000	15	40	20	50	45,000	120,000	60,000	150,000
TOTAL							**1,667,000**	**1,330,000**	**200,000**	**1,850,000**
Worton Grange & Berkshire Brewery combined										
TOTAL							**2,516,000**	**2,510,000**	**1,660,000**	**4,580,000**
Manor Farm Road										
New Build	Residential	36,000	35	25	0	30	1,260,000	900,000	0	1,080,000
	Retail	3,000	3	15	35	80	9,000	45,000	105,000	240,000
	Leisure	2,000	15	40	20	50	30,000	80,000	40,000	100,000
TOTAL							**1,299,000**	**1,025,000**	**145,000**	**1,420,000**
North of Station										
New Build	Residential	42,840	35	25	0	30	1,499,400	1,071,000	0	1,285,200
	Offices	83,600	6	20	40	60	501,600	1,672,000	3,344,000	5,016,000
	Retail	15,800	3	15	35	80	47,400	237,000	553,000	1,264,000
	Leisure	1,000	15	40	20	50	15,000	40,000	20,000	50,000
	Hotel	22,800	60	50	30	60	1,368,000	1,140,000	684,000	1,368,000
TOTAL							**3,431,400**	**4,160,000**	**4,601,000**	**8,983,200**

3 Assumptions

3.1 Technical

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 such that it is able to operate for a minimum number of hours per year at equivalent full load (usually considered to be around 5000 hours). This is the most efficient mode of operation for CHP plant.

CHP 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 is set to 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 power 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. In instances where heat demand would allow the gas CHP plant to operate at full output but would result in exporting electricity to the grid (wholesale market) the unit is configured to modulate to match the local electricity load, an so avoid export. Operation of the CHP unit at times when generated electricity will be spilled to the grid will result in reduced financial performance due to the low and unpredictable value of small scale electricity on the wholesale market, compared to direct sale to customers at or close to the equivalent retail rate.

Biomass CHP plant included as an alternative to gas CHP may be configured to operate differently depending on the value of the revenue which can be drawn from incentives offered through the Renewable Heat Incentive (RHI) and Feed In Tariff (FIT). In this case the opportunity to operate the plant during times when electricity is exported to the grid and receives wholesale value, or direct sale to customers during night time tariff periods, may be an advantage as a result of these support measures and the use of a less costly primary fuel, in the case of locally sourced woodchip. Biomass CHP will tend not be as flexible in operation as gas CHP and typically feature higher heat to power ratios by comparison, which reduce electricity generation capability for a given heat load. In addition, the technology choices available at a scale appropriate for this size of connected load and which can be considered commercially viable are limited. For the purposes of the analysis, biomass CHP plant operation has been modeled on updraft gasification/ Stirling engine technology which is understood be the one of the most advanced in terms of years in development, operating hours and flexibility below 500kWth output capacity, and is rapidly approaching commercial viability.

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, providing flexibility during lower heat demand periods, and taking in account proposals currently being put forward for the operation of the RHI in terms of the rate provided for various plant capacity sizes.

Gas boilers are sized to supply minimum loads during summer periods not provided for by CHP or biomass boiler plant, peak loads not supplied by biomass boilers as well as the total peak demand of the entire connected network and in doing so provide full system backup capability.

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.

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

As a result of expected increases in summer daytime temperatures in the future due to the effects of global warming and climate change, the anticipated cooling demand associated with office, and to a lesser extent retail and leisure development is likely to be significant in the case of the combined sites Worton Grange/ Berkshire Brewery. The north of Reading station site includes large office development and significant retail and hotel floorspace, all likely to require active ccoling. The combined cooling load as modelled will include a baseload element serving central IT equipment, a mid load portion to provide cooling outside of the winter period to offset heat loads from human activity and lighting loads, and a peak load portion to reduce gains resulting from higher outside air temperatures and direct solar irradiation occurring in afternoon periods during the summer months. Some of this traditional demand for active cooling can be designed out through the inclusion of appropriate passive building design techniques and the use of high efficiency electrical appliances and light fittings, however a significant cooling load is likely to remain. If a sufficiently large percentage of this demand for active cooling can be provided by central absorption chiller plant supplied with heat from the CHP unit, this would normally lead to an increase in the annual running hours of CHP and hence improve plant economics. Conventional vapour compression chillers would be required to deliver the cooling peaks. A peaky demand profile is not straightforward to deliver efficiently and economically in terms of the capital investment required for absorption chiller equipment, the cost of which can be significant for the chiller, associated heat rejection equipment and additional dedicated district pipe network to deliver chilled water to end users from the central plant location.

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. For the station site a denser development pattern of mostly apartments is more likely given its central urban location.

The following CO_2 emission factors are used; for natural gas 0.194kgCO_2/kWh, UK national grid electricity 0.54kgCO_2/kWh, woodchip 0.025kgCO_2/kWh. The factor for grid supplied electricity uses national data (DUKES) which takes account of the mix of primary fuels, technologies and generating plant efficiencies.

3.2 Financial

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. A remit of this overall project is to consider technically advanced solutions where appropriate and central absorption cooling is included, along with the option of biomass-fuelled CHP plant in place of traditional gas CHP. In all other ways the sites examined in this study are assessed from viewpoint of economic returns and include central plant and infrastructure of type and capacity which are most likely to provide maximum returns for the capital costs incurred.

Recent government announcements relating to the Feed In Tariff (FIT) and proposed Renewable Heat Incentive (RHI) from April 2010 and anticipated to commence in 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.

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. There is also mention of an additional element of support to be given to renewable heat when combined with distribution networks however there are no details available on the level of financial incentive which might be provided. Although currently less than clear as the details of the RHI are under development, 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. It has been assumed in the analysis that the first 500kW boiler will be eligible to receive the RHI at 6.5p/kWh and any larger capacity boiler to receive the RHI at 2.0p/kWh.

It is noted that Renewables Obligation Certificates (ROCs) will continue to be applicable for the electricity generated from biomass CHP below 5MWe capacity, based on 1.5ROCs per MWh of electricity generated, and assumed to have a value of 6.75p/kWh (with the assumption that 1 ROC is worth £45/MWh based on recent market values, although this is variable).

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. 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.

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.

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.

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; 1.2p/kWh$_e$ for gas CHP at ~750kW$_e$ capacity, 1.3p/kWh$_e$ for gas CHP at ~500kW$_e$ capacity, 1.5p/kWh$_e$ for gas CHP at ~150kW$_e$ capacity, 2.2p/kWh$_e$ and 0.85p/kWh$_{th}$ (heat output element also included) for small scale biomass CHP.

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 and is set at a level appropriate to the scale and types of energy plant and infrastructure employed serving each site.

Engineering and project management costs are set at 12% of the total capital cost of each district energy project and ESCo set up costs are included for each project, a figure of £100,000. Engineering and project management costs for conventional energy plant and infrastructure are set at 6% of the total capital cost.

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

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.

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. In the case of new build development as in this case, 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 of the district energy scheme to an ESCo.

A financial appraisal over 20 years is considered as the means of assessing each project for viability. 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.

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.

It is considered unlikely that capital grant funding will be available for district heating schemes which include standard technologies such as gas CHP. It is understood that 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 Aid 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, and/ or combined with absorption chilling and a district cooling network 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

4.1 General

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

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. CHP plant is sized to provide for the year-round base-load heat (as hot water) and in some cases supplemented by cooling demand, operating during the daytime electricity tariff period only for gas CHP, for reasons of economics. The combined electricity demand profile is shown in the graphs, and it can be seen that the electricity output from the CHP plant is configured to modulate and follow the demand profile so avoid export to the grid and therefore model the entire electrical output receiving a retail value based on each type of end user.

Biomass boiler plant provides the majority of the space heating load as well as summer hot water load, and is sized based on capital cost and associated output. Depending on the magnitude of the hot water load the biomass boiler may be turned off outside of the heating season, during the summer months.

Gas boiler plant provides for 100% standby capacity for the entire connected heat load to provide heat in instances of scheduled and unscheduled maintenance, 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, should the biomass boiler be switched off.

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

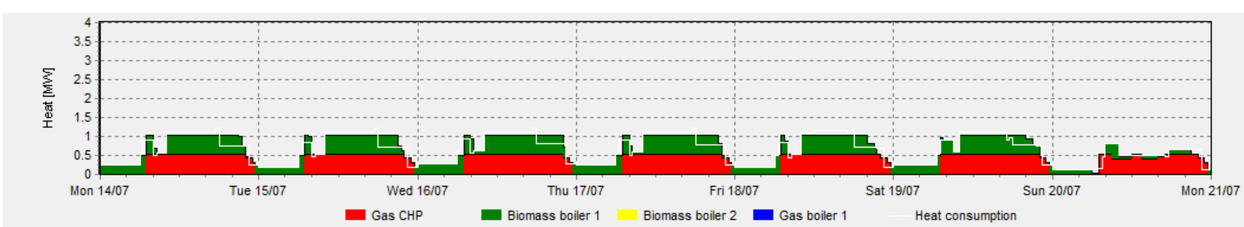
- The location, required building footprint and access requirements for the central energy plant and biomass fuel store;
- Access routes for district energy infrastructure (pipework and electrical cables) within areas of existing development and specifically connecting one site to another;
- Environmental 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

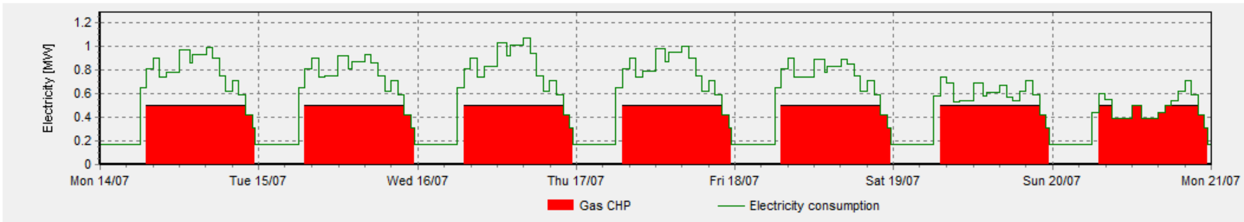
In the following sections, graphs show the seasonal variation in operation of the energy plant selected to serve the combined heat demand profile of all connected loads.

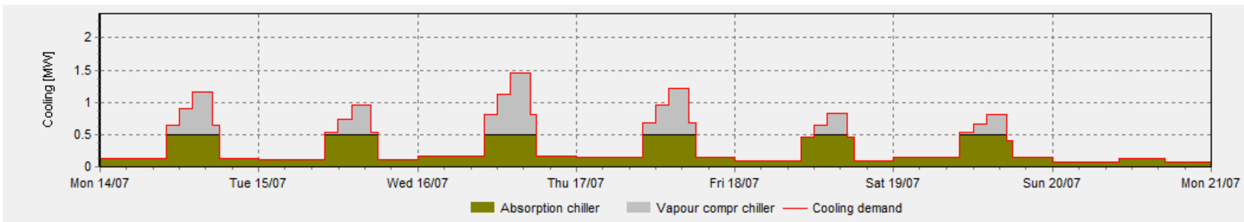
4.2 Worton Grange & Berkshire Brewery – Gas CHP

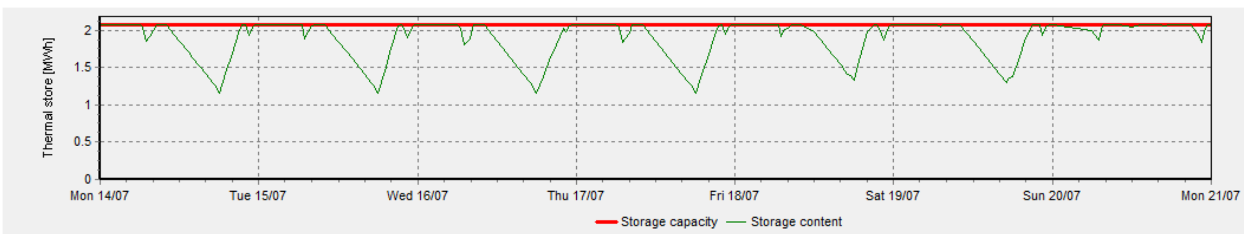
Winter – Typical 7 day profile

Summer – Typical 7 day profile









The woodfuel requirements are approximately 1,420tonnes/yr @30% moisture content.

The gas CHP unit supplies 60% of the total annual electricity demand of the new buildings and energy centre.

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.

DISTRICT ENERGY	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 £
gas CHP	500	£800					£400,000
biomass boiler	500	£180					£90,000
	500	£180					£90,000
gas boilers	1000	£60					£60,000
	2500	£40					£100,000
absorption chiller	500	£400					£200,000
conventional chillers	2000	£100					£200,000
M & E (energy centre)							£200,000
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)					15	£10,000	£150,000
DH end user conns (new dwelling)					800	£1,000	£800,000
DC network flow & return			1,500	£500			£750,000
DC end user conns (new building)					15	£10,000	£150,000
Subtotal							**£5,790,000**
Engineering & Project Management							£694,800
ESCo set up							£100,000
TOTAL							**£6,584,800**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Offices	1,825	£150			10		£273,750
	1,800	£200			10		£360,000
Retail							N/A
Leisure	240	£150			1		£36,000
	150	£300			1		£45,000
Residential	10	£120			800		£960,000
Gas network & metering			3000	£100			£555,000
Subtotal							**£2,229,750**
Engineering & Project Management							£133,785
TOTAL							**£2,363,535**
NET CAPITAL COST							**£4,221,265**
District energy cost net/gross %							**64%**
Conventional/district energy cost %							**36%**

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

Total capital cost of district energy scheme	£6,584,800
Capital cost of conventional energy (from developer)	£2,363,535
Developer contribution to ESCo as % of total capital cost	36%
IRR to provide an NPV of £0	7.0%
NPV with a discount rate of 3.5%	£1,443,934

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 a district energy project IRR of 10%:	
Additional capital contribution to ESCo	£844,122
Total capital contribution to ESCo	£3,207,657
Developer contribution as a % of total capital cost	49%

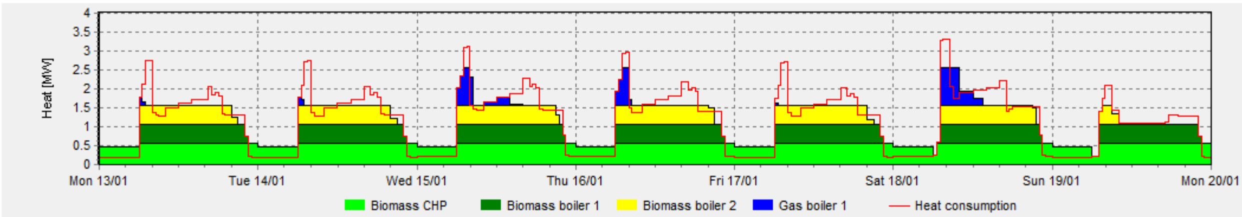
To provide a district energy project IRR of 15%:	
Additional capital contribution to ESCo	£1,761,459
Total capital contribution to ESCo	£4,124,994
Developer contribution as a % of total capital cost	63%

To provide a district energy project IRR of 20%:	
Additional capital contribution to ESCo	£2,330,189
Total capital contribution to ESCo	£4,693,724
Developer contribution as a % of total capital cost	71%

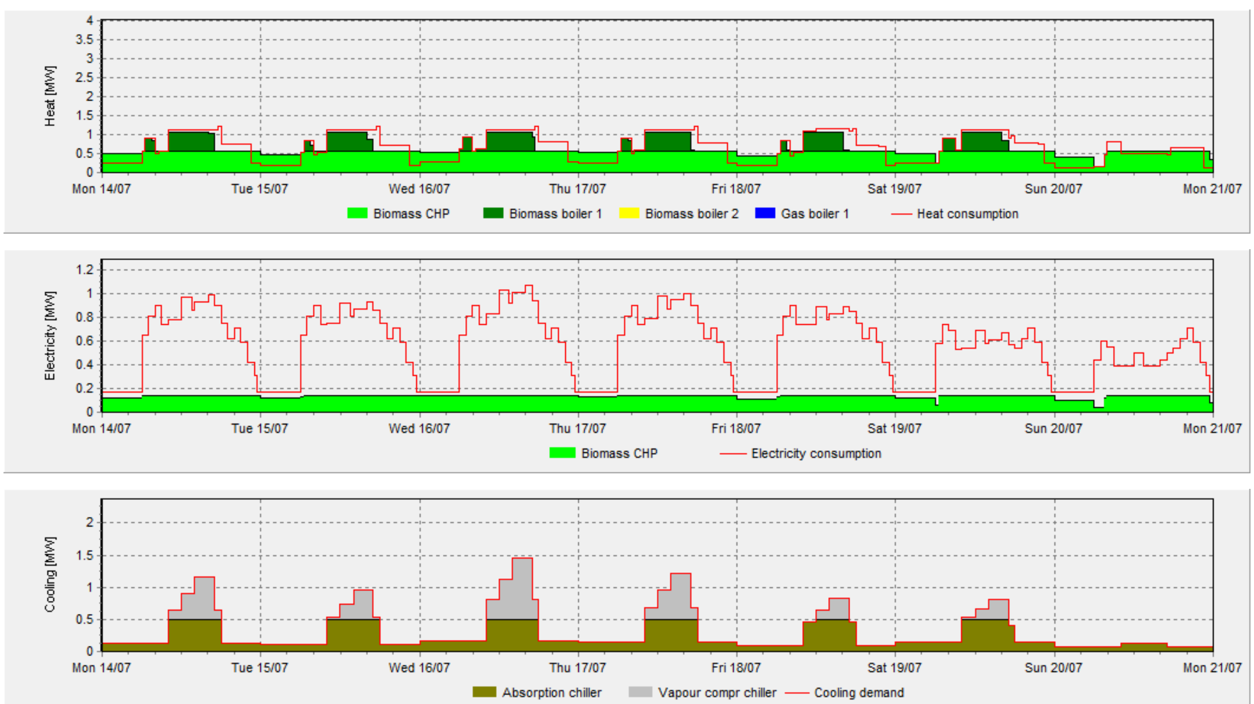
To provide a district energy project IRR of 25%:	
Additional capital contribution to ESCo	£2,705,419
Total capital contribution to ESCo	£5,068,954
Developer contribution as a % of total capital cost	77%

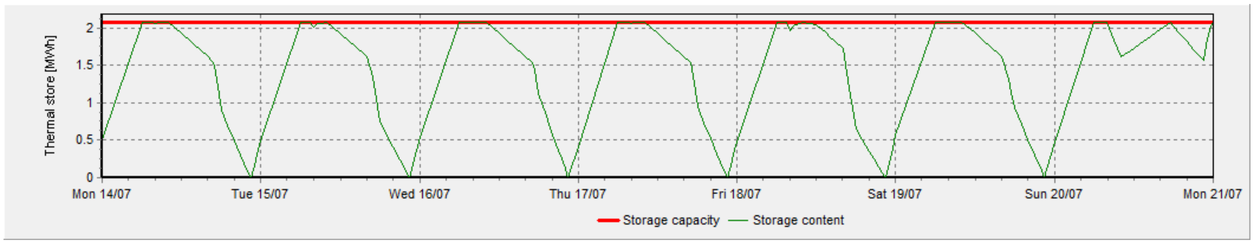
4.3 Worton Grange & Berkshire Brewery – Biomass CHP

Winter – Typical 7 day profile



Summer – Typical 7 day profile





The woodfuel requirements are approximately 2,880tonnes/yr @30% moisture content.

The biomass CHP unit supplies 22% of the total annual electricity demand of the new buildings and energy centre.

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.

	energy plant	energy plant	pipework				Total
DISTRICT ENERGY	o/p capacity kW	installed £/kW	trench length m	pipework installed (incl civils) £/m	End user connections quantity	End user connections £/connection	£
biomass CHP	140	£6,000					£840,000
biomass boiler	500	£180					£90,000
	500	£180					£90,000
gas boilers	1000	£60					£60,000
	2500	£40					£100,000
absorption chiller	500	£400					£200,000
conventional chillers	2000	£100					£200,000
M & E (energy centre)							£200,000
energy centre building, utility conns							£550,000
electricity network (additional)							£100,000
DH network flow & return			4,000	£500			£2,000,000
DH end user conns (new building)					15	£10,000	£150,000
DH end user conns (new dwelling)					800	£1,000	£800,000
DC network flow & return			1,500	£500			£750,000
DC end user conns (new building)					15	£10,000	£150,000
Subtotal							**£6,280,000**
Engineering & Project Management							£753,600
ESCo set up							£100,000
TOTAL							**£7,133,600**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Offices	1,825	£150			10		£273,750
	1,800	£200			10		£360,000
Retail							N/A
Leisure	240	£150			1		£36,000
	150	£300			1		£45,000
Residential	10	£120			800		£960,000
Gas network & metering			3000	£100			£555,000
Subtotal							**£2,229,750**
Engineering & Project Management							£133,785
TOTAL							**£2,363,535**
NET CAPITAL COST							**£4,770,065**
District energy cost net/gross %							**67%**
Conventional/district energy cost %							**33%**

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

Total capital cost of district energy scheme	£7,133,600
Capital cost of conventional energy (from developer)	£2,363,535
Developer contribution to ESCo as % of total capital cost	33%
IRR to provide an NPV of £0	6.9%
NPV with a discount rate of 3.5%	£1,507,599

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 a district energy project IRR of 10%:

Additional capital contribution to ESCo	£923,033
Total capital contribution to ESCo	£3,286,568
Developer contribution as a % of total capital cost	46%

To provide a district energy project IRR of 15%:

Additional capital contribution to ESCo	£1,919,533
Total capital contribution to ESCo	£4,283,068
Developer contribution as a % of total capital cost	60%

To provide a district energy project IRR of 20%:

Additional capital contribution to ESCo	£2,546,721
Total capital contribution to ESCo	£4,910,256
Developer contribution as a % of total capital cost	69%

To provide a district energy project IRR of 25%:

Additional capital contribution to ESCo	£2,965,453

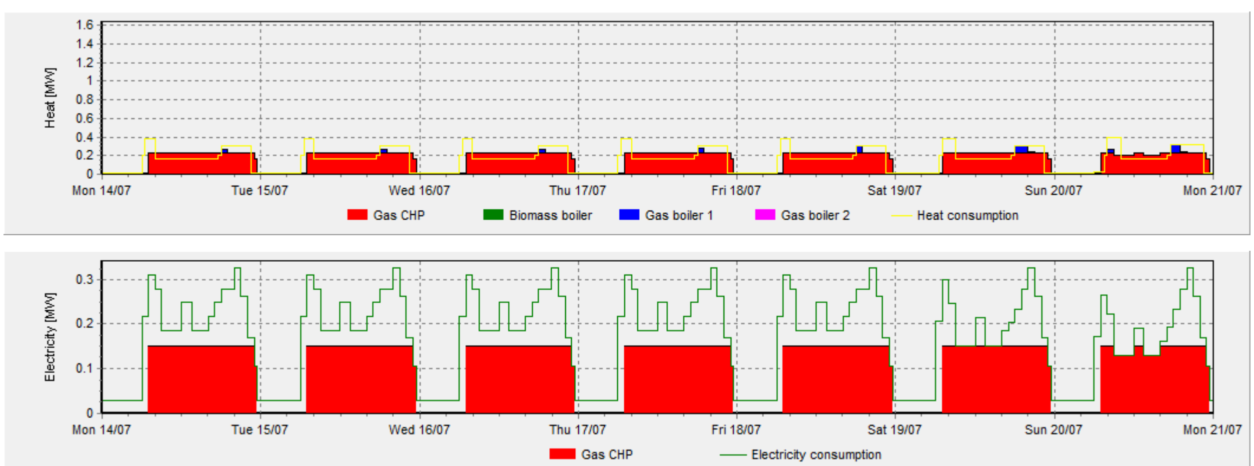
Total capital contribution to ESCo £5,328,988

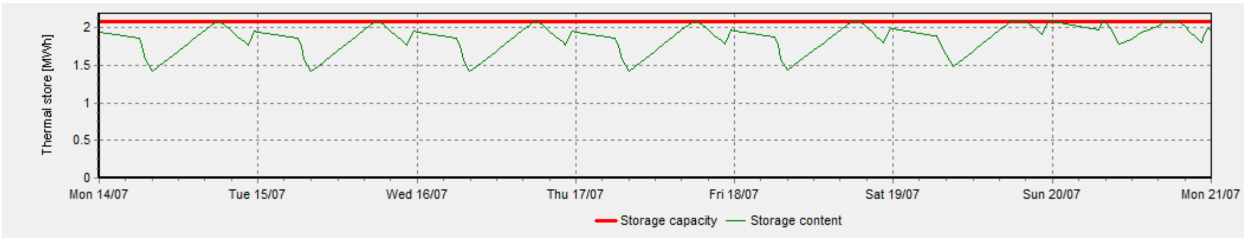
Developer contribution as a % of total capital cost 75%

4.4 North of Manor Farm Road – Gas CHP

Winter – Typical 7 day profile

Summer – Typical 7 day profile





The woodfuel requirements are approximately 330tonnes/yr @30% moisture content.

The gas CHP unit supplies 59% of the total annual electricity demand of the new buildings and energy centre.

Central cooling plant is not included due to the small annual demand of the non-domestic buildings. District energy supplies include heat and hot water to residential users, and heating and hot water to the leisure development. Cooling requirements for the leisure development and heating and cooling demand of the retail space is assumed to be provided by dedicated plant within each of the premises.

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.

DISTRICT ENERGY	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 £
gas CHP	150	£1,000					£150,000
biomass boiler	350	£220					£77,000
gas boilers	250	£80					£20,000
	1250	£60					£75,000
M & E (energy centre)							£100,000
energy centre building, utility conns							£300,000
electricity network (additional)							£100,000
DH network flow & return			1,500	£500			£750,000
DH end user conns (new building)					2	£10,000	£20,000
DH end user conns (new dwelling)					450	£1,000	£450,000
Subtotal							**£2,042,000**
Engineering & Project Management							£245,040
ESCo set up							£100,000
TOTAL							**£2,387,040**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Retail							N/A
Leisure	240	£150			1		£36,000
Residential	10	£120			450		£540,000
Gas network & metering			1,500	£100			£287,000
Subtotal							**£863,000**
Engineering & Project Management							£51,780
TOTAL							**£914,780**
NET CAPITAL COST							**£1,472,260**
District energy cost net/gross %							**62%**
Conventional/district energy cost %							**38%**

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

Total capital cost of district energy scheme	£2,387,040
Capital cost of conventional energy (from developer)	£914,780
Developer contribution to ESCo as % of total capital cost	38%
IRR to provide an NPV of £0	6.3%
NPV with a discount rate of 3.5%	£392,433

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

Additional capital contribution to ESCo	£360,194
Total capital contribution to ESCo	£1,274,974
Developer contribution as a % of total capital cost	53%

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

Additional capital contribution to ESCo	£659,880
Total capital contribution to ESCo	£1,574,660
Developer contribution as a % of total capital cost	66%

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

Additional capital contribution to ESCo	£844,836
Total capital contribution to ESCo	£1,759,616
Developer contribution as a % of total capital cost	74%

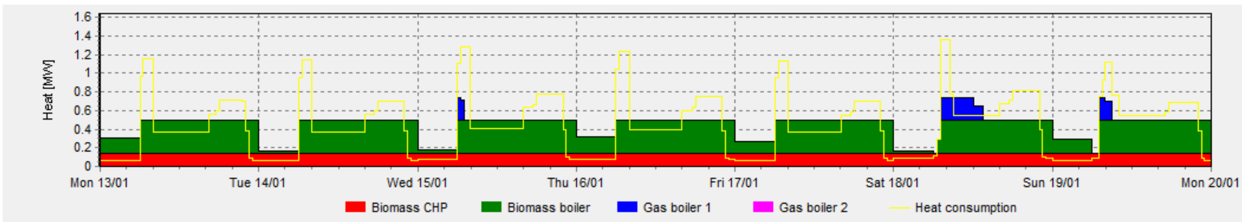
<u>To provide a district energy project IRR of 25%:</u>

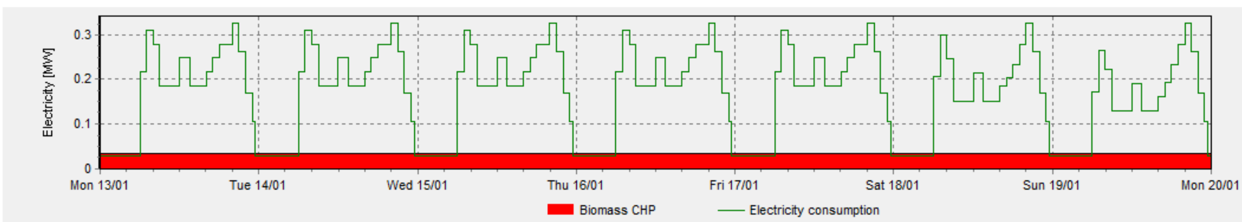
Additional capital contribution to ESCo	£966,442
Total capital contribution to ESCo	£1,881,222

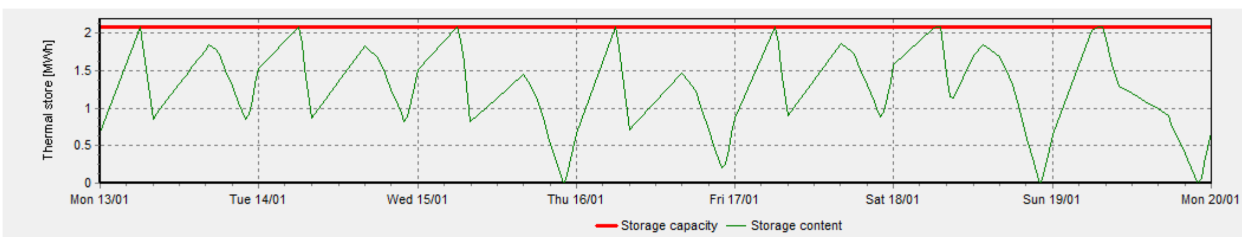
Developer contribution as a % of total capital cost 79%

4.5 North of Manor Farm Road – Biomass CHP

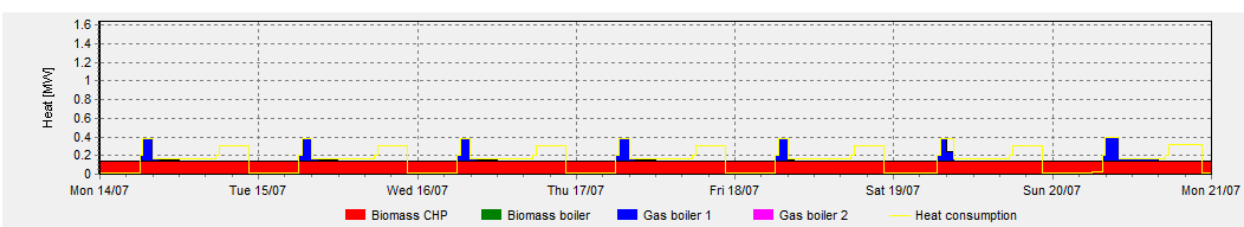
<u>Winter – Typical 7 day profile</u>

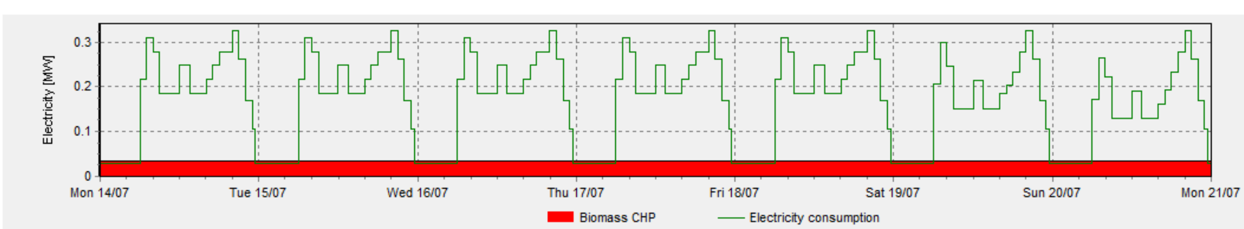


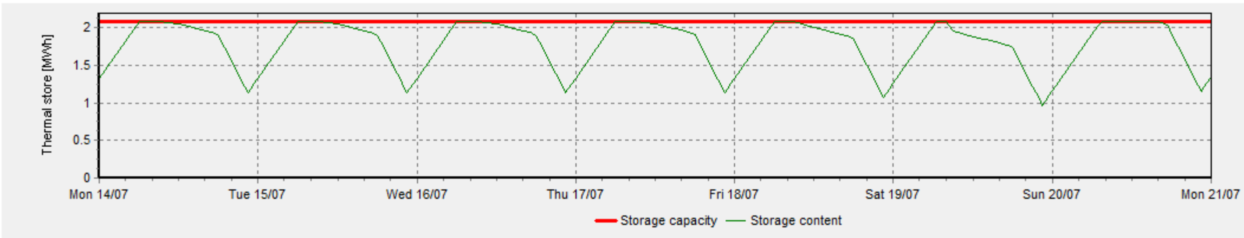




<u>Summer – Typical 7 day profile</u>







The woodfuel requirements are approximately 890tonnes/yr @30% moisture content.

The gas CHP unit supplies 19% of the total annual electricity demand of the new buildings and energy centre.

Central cooling plant is not included due to the small annual demand of the non-domestic buildings. District energy supplies include heat and hot water to residential users, and heating and hot water to the leisure development. Cooling requirements for the leisure development and heating and cooling demand of the retail space is assumed to be provided by dedicated plant within each of the premises.

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.

DISTRICT ENERGY	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 £
gas CHP	35	£8,000					£280,000
biomass boiler	350	£220					£77,000
gas boilers	250	£80					£20,000
	1250	£50					£62,500
M & E (energy centre)							£100,000
energy centre building, utility conns							£300,000
electricity network (additional)							£100,000
DH network flow & return			1,500	£500			£750,000
DH end user conns (new building)					2	£10,000	£20,000
DH end user conns (new dwelling)					450	£1,000	£450,000
Subtotal							**£2,159,500**
Engineering & Project Management							£259,140
ESCo set up							£100,000
TOTAL							**£2,518,640**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Retail							N/A
Leisure	240	£150			1		£36,000
Residential	10	£120			450		£540,000
Gas network & metering			1,500	£100			£287,000
Subtotal							**£863,000**
Engineering & Project Management							£51,780
TOTAL							**£914,780**
NET CAPITAL COST							**£1,603,860**
District energy cost net/gross %							**64%**
Conventional/district energy cost %							**36%**

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

Total capital cost of district energy scheme	£2,518,640
Capital cost of conventional energy (from developer)	£914,780
Developer contribution to ESCo as % of total capital cost	36%
IRR to provide an NPV of £0	7.1%
NPV with a discount rate of 3.5%	£492,158

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

Additional capital contribution to ESCo	£279,101
Total capital contribution to ESCo	£1,193,881
Developer contribution as a % of total capital cost	47%

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

Additional capital contribution to ESCo	£607,113
Total capital contribution to ESCo	£1,521,893
Developer contribution as a % of total capital cost	60%

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

Additional capital contribution to ESCo	£818,431
Total capital contribution to ESCo	£1,733,211
Developer contribution as a % of total capital cost	69%

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

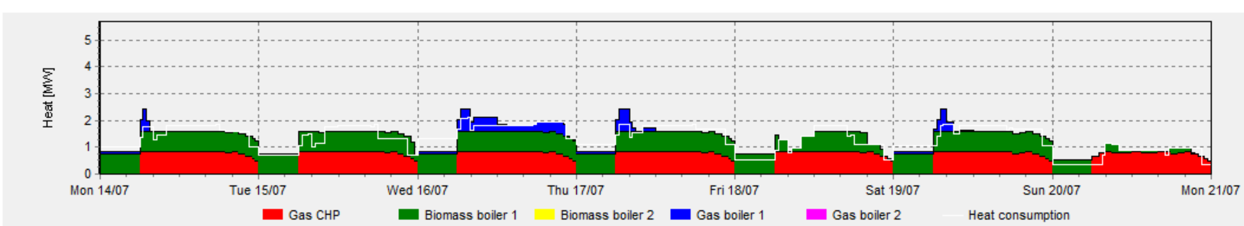
Additional capital contribution to ESCo	£962,004
Total capital contribution to ESCo	£1,876,784

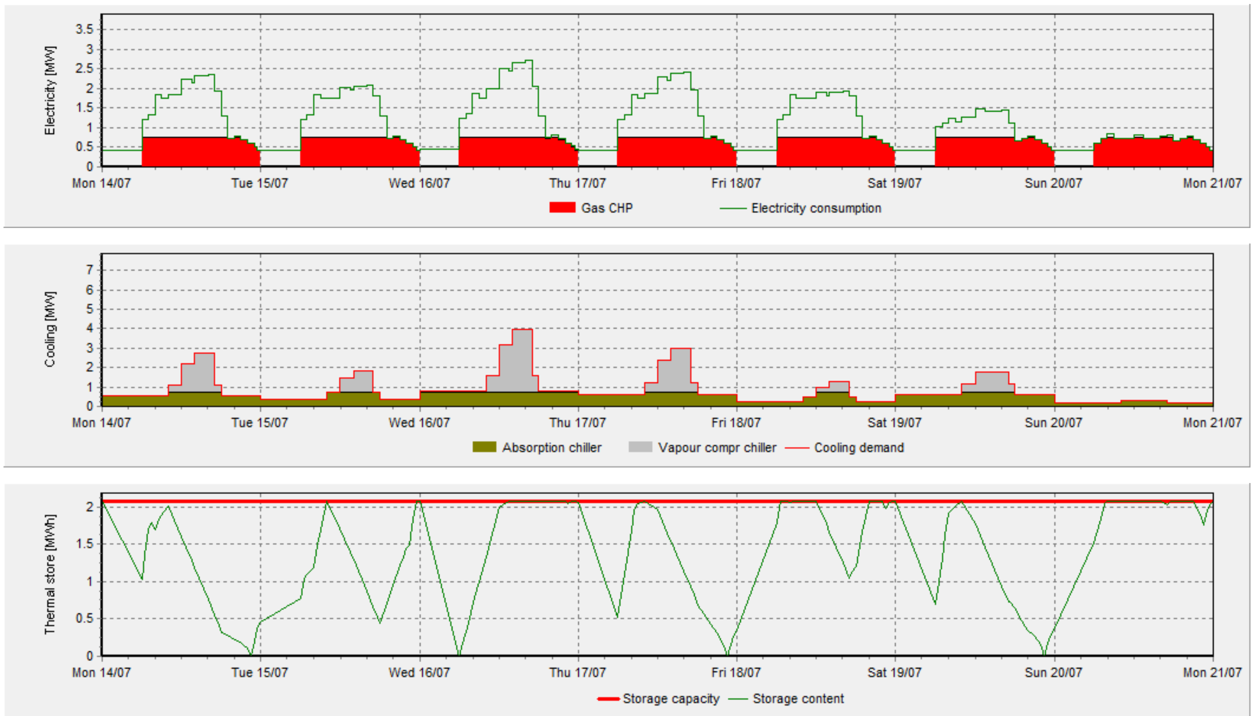
Developer contribution as a % of total capital cost 75%

4.6 North of Reading Station – Gas CHP

Winter – Typical 7 day profile

Summer – Typical 7 day profile





The woodfuel requirements are approximately 2,430tonnes/yr @30% moisture content.

The gas CHP unit supplies 50% of the total annual electricity demand of the new buildings and energy centre.

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.

DISTRICT ENERGY	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 £
gas CHP	770	£700					£539,000
biomass boiler	750	£160					£120,000
	750	£160					£120,000
gas boilers	1000	£60					£60,000
	4000	£30					£120,000
absorption chiller	750	£350					£262,500
conventional chillers	7000	£70					£490,000
M & E (energy centre)							£250,000
energy centre building, utility conns							£500,000
electricity network (additional)							£150,000
DH network flow & return			6,000	£500			£3,000,000
DH end user conns (new building)					30	£10,000	£300,000
DH end user conns (new dwelling)					680	£1,000	£680,000
DC network flow & return			3,000	£500			£1,500,000
DC end user conns (new building)					30	£10,000	£300,000
Subtotal							**£8,391,500**
Engineering & Project Management							£1,006,980
ESCo set up							£100,000
TOTAL							**£9,498,480**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Offices (heat)	4,180	£150			15		£627,000
(cooling)	5,000	£150			15		£750,000
Retail (heating and cooling units)	790	£200					£158,000
Leisure	80	£150			1		£12,000
	100	£200			1		£20,000
Residential	10	£120			680		£816,000
Gas network & metering			5000	£100			£734,000
Subtotal							**£3,117,000**
Engineering & Project Management							£187,020
TOTAL							**£3,304,020**
NET CAPITAL COST							**£6,194,460**
District energy cost net/gross %							**65%**
Conventional/district energy cost %							**35%**

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

Total capital cost of district energy scheme	£9,498,480
Capital cost of conventional energy (from developer)	£3,304,020
Developer contribution to ESCo as % of total capital cost	35%
IRR to provide an NPV of £0	7.0%
NPV with a discount rate of 3.5%	£2,181,521

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 a district energy project IRR of 10%:

Additional capital contribution to ESCo	£1,264,385
Total capital contribution to ESCo	£4,568,405
Developer contribution as a % of total capital cost	48%

To provide a district energy project IRR of 15%:

Additional capital contribution to ESCo	£2,620,061
Total capital contribution to ESCo	£5,924,081
Developer contribution as a % of total capital cost	62%

To provide a district energy project IRR of 20%:

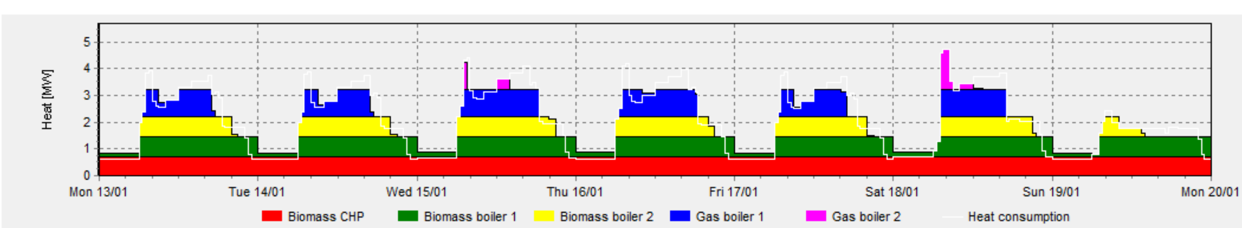
Additional capital contribution to ESCo	£3,449,387
Total capital contribution to ESCo	£6,753,396
Developer contribution as a % of total capital cost	71%

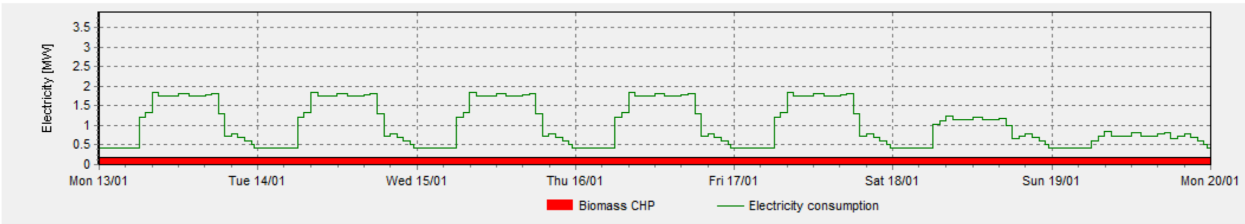
To provide a district energy project IRR of 25%:

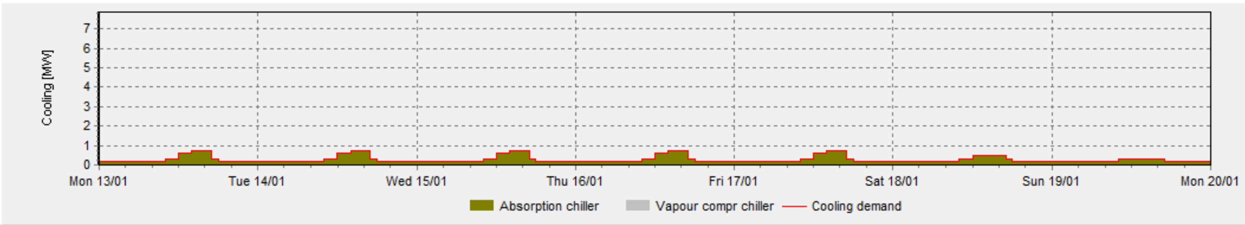
Additional capital contribution to ESCo	£3,990,570
Total capital contribution to ESCo	£7,294,590
Developer contribution as a % of total capital cost	77%

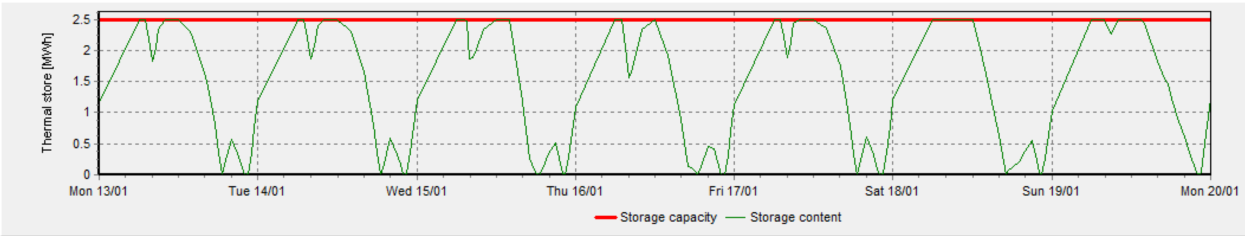
4.7 North of Reading Station – Biomass CHP

Winter – Typical 7 day profile

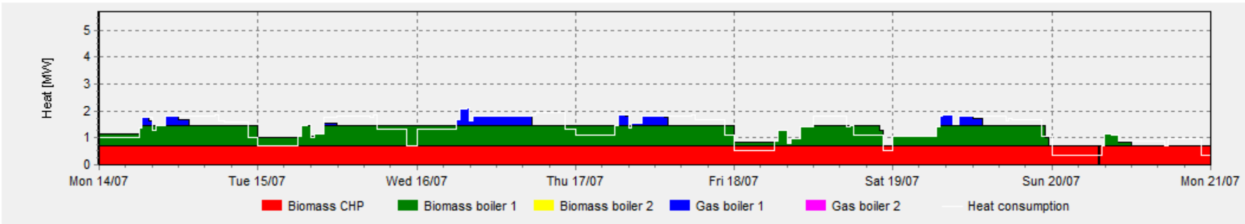


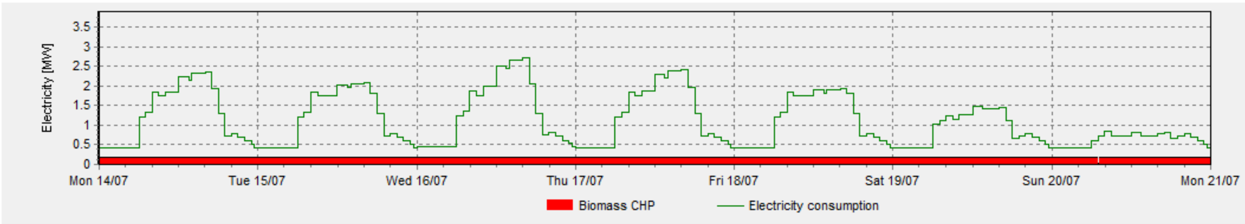


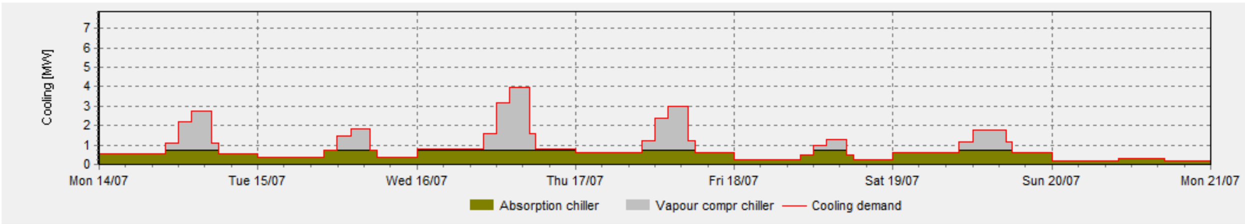


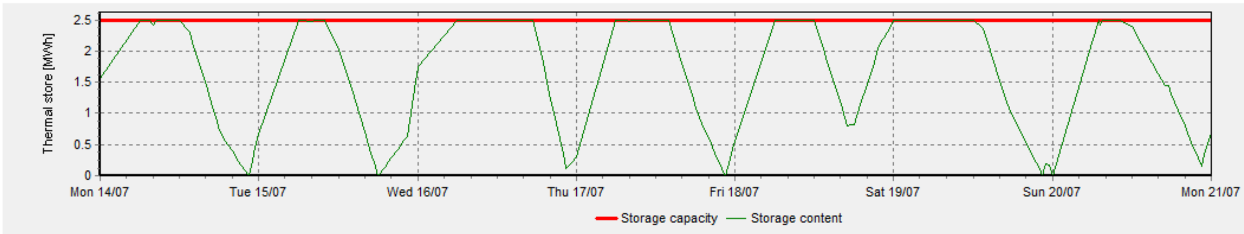


<u>Summer – Typical 7 day profile</u>









The woodfuel requirements are approximately 4,730tonnes/yr @30% moisture content.

The biomass CHP unit supplies 16% of the total annual electricity demand of the new buildings and energy centre.

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.

DISTRICT ENERGY	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 £
biomass CHP	175	£5,000					£875,000
biomass boiler	750	£160					£120,000
	750	£160					£120,000
gas boilers	1000	£60					£60,000
	4000	£30					£120,000
absorption chiller	750	£350					£262,500
conventional chillers	7000	£70					£490,000
M & E (energy centre)							£250,000
energy centre building, utility conns							£500,000
electricity network (additional)							£150,000
DH network flow & return			6,000	£500			£3,000,000
DH end user conns (new building)					30	£10,000	£300,000
DH end user conns (new dwelling)					680	£1,000	£680,000
DC network flow & return			3,000	£500			£1,500,000
DC end user conns (new building)					30	£10,000	£300,000
Subtotal							**£8,727,500**
Engineering & Project Management							£1,047,300
ESCo set up							£100,000
TOTAL							**£9,874,800**
CONVENTIONAL ENERGY							
Individual gas boiler/ cooling systems:							
Offices (heat)	4,180	£150			15		£627,000
(cooling)	5,000	£150			15		£750,000
Retail (heating and cooling units)	790	£200					£158,000
Leisure	80	£150			1		£12,000
	100	£200			1		£20,000
Residential	10	£120			680		£816,000
Gas network & metering			5000	£100			£734,000
Subtotal							**£3,117,000**
Engineering & Project Management							£187,020
TOTAL							**£3,304,020**
NET CAPITAL COST							**£6,570,780**
District energy cost net/gross %							**67%**
Conventional/district energy cost %							**33%**

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

Total capital cost of district energy scheme	£9,874,800
Capital cost of conventional energy (from developer)	£3,304,020
Developer contribution to ESCo as % of total capital cost	33%
IRR to provide an NPV of £0	4.9%
NPV with a discount rate of 3.5%	£616,065

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 a district energy project IRR of 10%:

Additional capital contribution to ESCo	£2,184,678
Total capital contribution to ESCo	£5,488,698
Developer contribution as a % of total capital cost	56%

To provide a district energy project IRR of 15%:

Additional capital contribution to ESCo	£3,329,747
Total capital contribution to ESCo	£6,633,767
Developer contribution as a % of total capital cost	67%

To provide a district energy project IRR of 20%:

Additional capital contribution to ESCo	£4,048,713
Total capital contribution to ESCo	£7,352,733
Developer contribution as a % of total capital cost	74%

To provide a district energy project IRR of 25%:

Additional capital contribution to ESCo	£4,527,596
Total capital contribution to ESCo	£7,831,616
Developer contribution as a % of total capital cost	79%

5 Conclusions

The results show that a developer contribution to the capital cost of providing a new district energy scheme in the case of Worton Grange and Berkshire Brewery sites combined, the North of Manor Farm Road site and the North of Reading Station site would be around one third of the total project cost based on this amount being equal to the cost of providing conventional energy plant and infrastructure. 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 in order to provide a development which complies with planning requirements, Building Regulations Part L and Code for Sustainable Homes levels with respect to energy provision and associated carbon emissions is uncertain. This is particularly relevant 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 go towards offsetting a portion of the total capital cost of the district energy scheme as borne by an ESCo, the results of the financial analysis show increasing project viability as greater capital contribution is provided from outside the ESCo, as would be expected. Some or all of this additional capital contribution may be realised through the need for developers to adhere to Reading Borough Council's current planning requirement of a 20% reduction in carbon emissions from Building Regulations standards through additional energy efficiency measures and Low and Zero Carbon technologies for new developments. Historically these requirements have been satisfied in part through the inclusion of individual, building integrated micro-generation technologies, along with improvements in building energy efficiency and hence lower energy demand. Further increases in carbon performance in order to comply with higher energy and carbon emissions standards associated with future updates of Part L of Building Regulations and Code for Sustainable Homes levels will drive the move from individual building integrated micro-generation technologies to district energy provision.

Assuming a district energy project capital contribution from the offset costs of conventional energy supplies, the resulting project IRRs for all sites at around 7% are not considered especially attractive to an ESCo, and therefore at a lower limit for financial viability within the private sector. A 15% IRR might be expected to offer a financially attractive investment to an ESCo in a competitive arena within the private sector, and would demand that each project received over 60% of the total capital cost external to the ESCo. In the case of the Worton Grange and the Berkshire Brewery sites this equates to approximately £1.76m and £1.92m, for the North of Manor Farm Road site equals around £1.57m and £1.52m, and for the North of Reading Station site equals around £2.62.m and £3.33.m, for the gas CHP and biomass CHP projects respectively. An IRR of 25% would require each project to receive roughly 75% of the capital cost of the district energy project from outside the ESCo.

Examination of individual elements within the financial assessment points to the fact that an attractive scheme relies heavily on revenues from the Renewable Heat Incentive, and ROCs in the case of biomass CHP. In the absence of capital grants these revenue based support measures become crucial in providing financial viability.

In the case of the North of Manor Farm Road site the financial performance figures are slightly worse than the Worton Grange and the Berkshire Brewery sites due to the smaller scheme in terms of the total connected load, due to many of the operating costs being fixed costs. The

North of Reading Station site again features slightly lower performance, due to the site being relatively spread out based on the building layout.

The financial performance of the larger schemes Worton Grange & Berkshire Brewery and the North of Reading Station is thought to be hampered in this instance through the inclusion of central cooling and the use of absorption chilling. The additional cost of central cooling plant and distribution infrastructure is high at around £1.4m by comparison to the revenues which would be realised by the ESCo through the sale of chilled water to provide cooling services. The cooling demand as modelled is relatively peaky and does not allow the absorption chiller to be utilised in an economically efficient way, and in any case with a significant summer time heat load on the CHP plant from the domestic hot water requirement there is no benefit to be gained through increased CHP running hours as it is already operating at its peak capacity, given the hot water and electricity demand profiles.

Comparing the overall financial performance of gas CHP and biomass CHP options, there is little to choose between the two, although the biomass CHP capital cost is around double that of gas CHP with similar heat output capacity. This additional cost is recovered mainly through ROC revenues, additional RHI revenues in the case of the North of Manor Farm Road site where the biomass boiler is sized below 500kW, and the use of less costly biomass fuel compared to gas, and which also allows greater benefit to be gained from the RHI payment given that the CHP heat output capacity is around 500kW. The total electricity generated is reduced however, compared to gas CHP, due to the higher heat to power ratio of biomass CHP plant. This highlights the limitations of biomass CHP on its own as a means to facilitate zero, or close to zero carbon development at this scale, in this case only 22% of the total annual electricity demand can be delivered from the central CHP plant, whereas by comparison the total heat demand, and for that matter cooling demand given sufficient biomass fuelled and absorption chiller plant capacity, can be delivered through renewable energy sources relatively straightforwardly. This shortfall in local renewable electricity generation required to serve the entire development is typical, and additional quantities would need to be supplied by a combination of other technologies, for example one or more wind turbines and extensive use of roof mounted solar PV, considerably adding to the overall capital cost of the district energy scheme.