Project Number: S0941
Version: 2
Checked by: GG
Date of issue: 04/01/2017

Atherstone Airfield Heat Mapping and Masterplanning Study

Prepared for: Stratford-on-Avon District Council

Prepared by: Dr Penny Challans (SE)
Dr Gabriel Gallagher (SE)
Lee Evans (SE)

07889 723848
lee@sustainable-energy.co.uk

DOCUMENT CONTROL				
Document Reference	**Version**	**Date Issued**	**Produced by**	**Reviewed by**
Atherstone Airfield Heat Mapping and Masterplanning Draft Project ref: S0941	2	04/01/2017	Dr Penny Challans Lee Evans	Dr Gabriel Gallagher

Contents

List of Figures

List of Tables

List of Abbreviations

ADE	Association for Decentralised Energy
BEIS	Department of Business Energy and Industrial Strategy (incorporating DECC)
BSRIA	Building Services Research and Information Association
CHP	Combined heat and power
CoP	Code of Practice
CIBSE	Chartered Institute of Building Services Engineers
CAPEX	Capital expenditure
DEN	District energy network
EfW	Energy from Waste
GSHP	Ground source heat pump
HNDU	Heat Network Delivery Unit
IRR	Internal rate of return
kWh	Kilowatt hour
LTHW	Low temperature hot water
MTHW	Medium temperature hot water
MWh	Megawatt hour
NPV	Net present value
RHI	Renewable heat incentive
SDC	Stratford-on-Avon District Council
SEL	Sustainable Energy Limited
SPF	Seasonal performance factor (for heat pumps)

Glossary

Electricity demand	The electricity requirements of a building or site, usually shown as an annual figure in megawatt hours (MWh) or kilowatt hours (kWh)
Energy demand	The heat and electricity demand of a building or site
Electricity export	Electricity generated by a CHP that is not utilised in via private wire arrangements is exported to the national grid (usually at a lower tariff than would be available for private wire arrangements)
Gas to grid injection	Biomethane is produced from biodegradable matter such as food waste, sewage or energy crops and can be upgraded (where required) and injected into the gas grid
Heat clusters	A group of buildings/sites based on heat demand, location, barriers, ownership and risk
Heat demand	The heat requirements of a building or site, usually shown as an annual figure in megawatt hours (MWh) or kilowatt hours (kWh)
Hurdle rate	The minimum internal rate or return that is required for a network to be deemed financially viable
Linear heat density	Total cluster heat demand divided by indicative pipe trench length between buildings/sites within the cluster, although linear heat density does not consider pipe diameter it provides a high-level indicator for the potential viability of network options and phases
Peak and reserve plant	Gas or oil boilers which produce heat to supply the network at times when heat demand is greater than can be supplied by the renewable or low carbon technology or when the renewable or low carbon technology is undergoing maintenance (also called auxiliary boilers)
Private wire	Electricity generated by a CHP that is supplied to network connections as part of private wire arrangements where underground cables connect the buildings to the energy centre
Renewable technologies	Technologies that produce energy from resources which are naturally replenished such as sunlight, wind, geothermal heat, or water source heat
Strategic site	A planned development site of strategic importance to the Local Authority

EXECUTIVE SUMMARY

This report presents the findings of the Atherstone Airfield Heat Mapping and Masterplanning Study (2016). The purpose of the project is to identify and evaluate opportunities to develop a new district heating network at Atherstone Airfield.

Stratford-on-Avon District Council's main objective and driver for this project is to identify, validate or confirm the site as a district heating priority area as set out in Policy CS.3. Other objectives and drivers include:

- Reducing commercial carbon emissions
- Reducing operational / energy costs for local businesses
- Assessing the potential for utilising local energy sources
- Improve energy security and resilience against rising energy prices
- Reducing fuel poverty and improving health, wellbeing and independence of local communities

Data Collection and Review

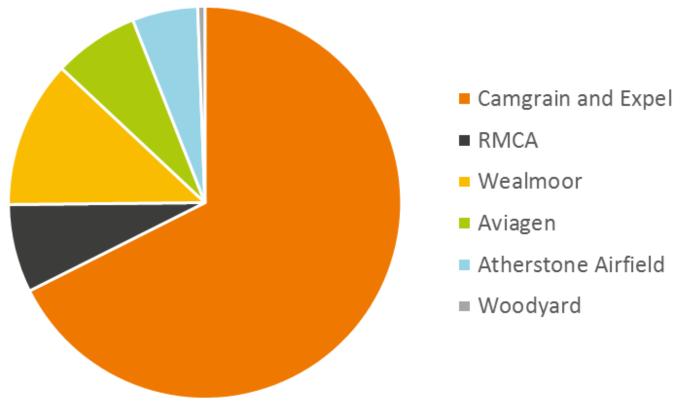
The first stage of the work involved a data collection exercise that required site visits, discussions with Stratford-on-Avon District Council and meetings, teleconferences and email correspondence with key stakeholders. Building energy data and other relevant information was sought from existing building operators, potential developers and other stakeholders.

The Atherstone Airfield area includes a number of stakeholders including: Camgrain, Expel Oil Seed Processing Ltd, Syn2gen, RMCA, Wealmoor, Aviagen as well as the Alscot Estate. The project team outlined the project and received feedback from key stakeholders including the Alscot Estate and Syn2gen.

Key planning documents were reviewed and Council planning officers were consulted to establish the nature of developments and the likelihood of them being brought forward. The project team met with the Estates Director from the Alscot Estate who provided high level information on the proposed Atherstone Airfield development.

Energy Demand Assessment

Energy demand models were produced for existing buildings and future developments and the heat demand profiles were combined to assess the overall demand for heat clusters and various network options. Cooling demands were assessed for their potential to be met by a heat network and absorption cooling plant. Electricity demands were assessed to investigate options for private wire arrangements.



The pie chart shows the heat demands within the heat map area categorised by building ownership. A significant proportion of the demand arises from Camgrain and Expel.

Within the Atherstone Airfield site, the largest heat and electricity demands both arise from the combined demands for Camgrain and Expel Oil Seed Processing Ltd planned development. Significant existing cooling demands were identified at Wealmoor cold store and packaging warehouse and the Aviagen chick hatchery. A cooling demand was also included for the Wealmoor planned development.

Energy Supply Assessment

Planned energy sources with potential to supply networks at the subject sites were investigated. The proposed anaerobic digesters and small biogas CHP adjacent to Whitehall Farm were ruled out as a potential energy source as the planning indicates that biogas will be mainly injected into the gas grid. The proposed Syn2gen biomass CHP plant, part of the Expel Oil Seed Processing Ltd planned development, may provide a potential energy source. High level plans for this scheme indicate that the biomass CHP plant developer intends to provide energy to the Camgrain site and the proposed Expel Oil Seed Processing Ltd planned development and is in early discussions with Wealmoor.

Technology Assessment

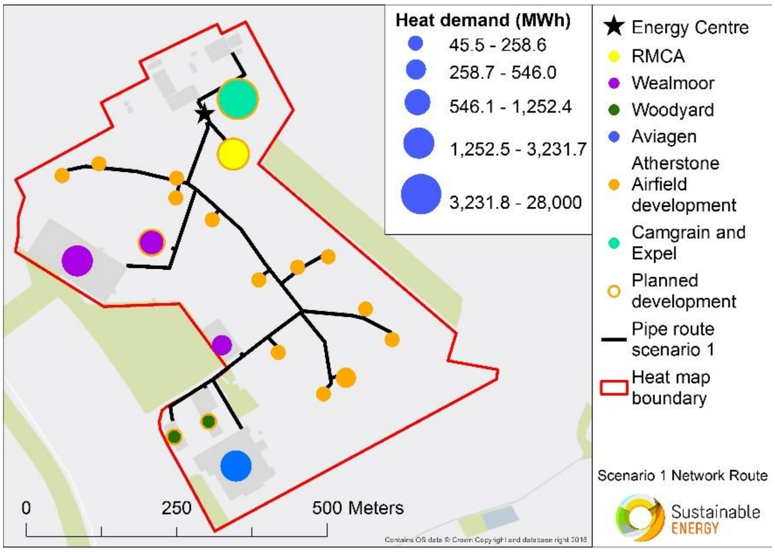
Anaerobic digestion, biomass heat, biofuel CHP, EfW, gas CHP, deep geothermal, GSHP, WSHP and heat offtake from the Syn2gen biomass CHP were assessed for technical suitability. Biomass heating, biomass CHP, GSHP and heat offtake were selected for further assessment for potential network options.

High Level Financial Assessment of Potential Schemes and Networks

Initial network options were considered for all potential network scenarios. Potentially viable network options, that may potentially exceed (or were close to) the 12 % assumed private sector hurdle rate, were then identified and these scheme scenarios are shown below.

A network is only likely to be developed if larger existing heat loads connect to the network; Atherstone Airfield development connections reduce overall financial viability of projects. Development plans indicate that the potential development at the Atherstone Airfield site will consist of B2/B8 units and will include some existing businesses from the Canal Quarter. These businesses are likely to require heat for mainly space heating and domestic hot water with low night time and summer demands. Therefore, they are unlikely to provide viable network connection opportunities when considered in isolation.

Scenario 1 assumes the Expel Oil Seed Processing Ltd development in brought forward without the biomass CHP. This scenario considers network options to serve all heat demands identified within the heat map area and all electricity demands with the exception of Smiths Concrete (due to its low energy demand). The layout of the Scenario 1 network is shown below:



Total network heat demand	42,258 MWh
Estimated number of building connections	22
Network heat loss	2 %
Key heat loads: - Camgrain and Expel - RMCA	

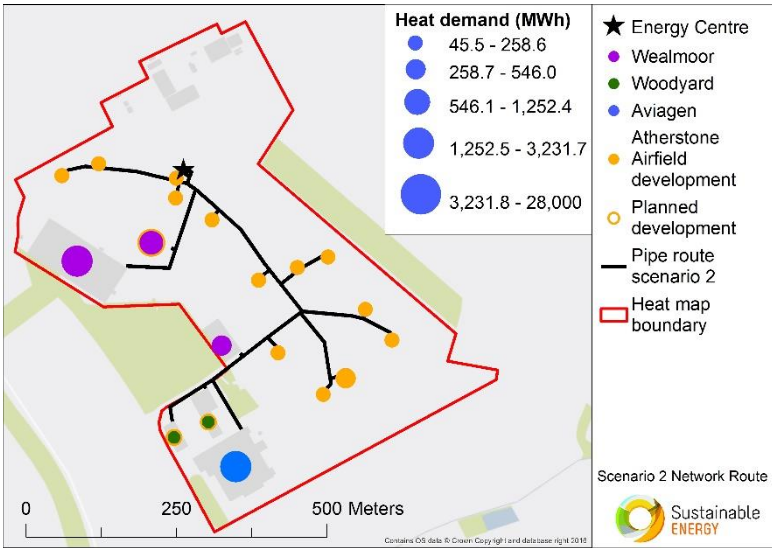
The following table summarises the high level financial assessment and key sensitivity parameters and risks:

Technology	Network trench length	Estimated CAPEX	Carbon savings	25 year financial case			40 year financial case		
				Simple payback	IRR	NPV	Simple payback	IRR	NPV
Biomass heat 5 MW	1.9 km	£9,767,532	13,009 tpa	6 years	18.2 %	£20,740,475	6 years	17.4 %	£24,368,134
Biomass CHP 4.1 MW		£10,278,953	13,843 tpa	5 years	21.8 %	£29,167,434	6 years	21.2 %	£36,803,641

Key sensitivity parameters	- Heat sales income - Cost of woodfuel - CAPEX - RHI income - Private wire (electricity) income	
Key opportunities	- Likely to be financially viable achieving the assumed hurdle rate required for private sector development and investment (>12 %) - Risk would be reduced if key stakeholders can be engaged and RHI confirmed - £659/tCO_2 (CAPEX per tonne of carbon saving) for biomass heat option - £619/tCO_2 for biomass CHP option	
Key risks and issues	- Scenario assumes that Syn2gen biomass CHP is not brought forward - Biomass heat revenue includes highest potential RHI tariff – scheme is currently under consultation and future of scheme likely to be clarified in March 2017 - Engagement with diverse range of private sector stakeholders including Camgrain and Expel, RMCA, Wealmoor, Aviagen and Woodyard and Atherstone Airfield developers - Atherstone Airfield development connections reduce overall IRR and are unlikely to be attractive to a private sector developer	**Risk Rating**

	- Attempts were made to obtain detailed information from Expel Oil Seed Processing Ltd, Wealmoor and Aviagen but the consultant team received limited feedback on their energy consumption/generation and future development plans - Private sector network developers may not be motivated to connect smaller, less viable heat demands such as the proposed Atherstone Airfield development without incentives such as developer connection costs or heat sale premiums - Presents a high risk opportunity - Assessment based on high level plans for Atherstone Airfield development	

Scenario 2 assumes energy is supplied to Camgrain, Expel Oil Seed Processing Ltd development and RMCA development by the Syn2gen biomass CHP. This scenario considers network options for the remainder of heat map area. The layout of the Scenario 2 network is shown below:



Total network heat demand	11,097 MWh
Estimated number of building connections	19
Network heat loss	6 %
Key heat loads: - Wealmoor, cold store - Aviagen	

The following table summarises the high level financial assessment and key sensitivity parameters and risks:

Technology	Network trench length	Estimated CAPEX	Carbon savings	25 year financial case			40 year financial case		
				Simple payback	IRR	NPV	Simple payback	IRR	NPV
Biomass heat 1.2 MW	1.9 km	£4,685,438	2,965 tpa	12 years	6.3 %	£1,535,018	13 years	6.5 %	£2,070,773
Biomass CHP 2.1 MW		£6,669,210	4,058 tpa	11 years	7.6 %	£3,346,979	12 years	7.9 %	£4,681,298
GSHP 1.2 MW		£6,827,168	1,937 tpa	12 years	6.7 %	£2,463,625	13 years	6.9 %	£3,377,201
Heat offtake from Syn2gen biomass CHP		£3,360,638	3,275 tpa	11 years	8.8 %	£2,408,792	11 years	9.7 %	£4,170,906

Key sensitivity parameters	- Heat sales income - Capital costs - Cost of woodfuel for biomass heat and biomass CHP options - Cost of heat offtake for heat offtake option - RHI income	
Key opportunities	- Network options may be financially viable if grant funding available or a longer term private sector investment model available - Risk would be reduced if key stakeholders can be engaged and RHI levels confirmed - £1,175/tCO_2 (CAPEX per tonne of carbon saving) for biomass heat option, £1,263/tCO_2 for biomass CHP option, £2,906/tCO_2 for GSHP option, £660/tCO_2 for heat offtake option	
Key risks and issues	- Engagement with diverse range of private sector stakeholders including Wealmoor, Aviagen and Woodyard and Atherstone Airfield developers (no stakeholders engaged at this stage - Biomass heat revenue includes highest potential RHI tariff – scheme is currently under consultation and future of scheme likely to be clarified in March 2017	**Risk Rating**

	- Initial contact was made with Syn2gen however no response was received to requests for detailed information - Atherstone Airfield development connections reduce overall IRR - Assessment assumes Syn2gen plant has sufficient capacity to provide heat to wider network at an assumed competitive rate - Private sector network developers may not be motivated to connect smaller, less viable heat demands such as the proposed Atherstone Airfield development without incentives - Presents a high risk opportunity - Assessment based on high level plans for Atherstone Airfield development	

The Scenario 2 network provides a high-risk proposition and the high level financial cases for the presented schemes have IRRs of <12 %, this would restrict financing and development opportunities. This network is only likely to be a viable proposition if developed by, or with financial support from developers, with a grant, or with a mix of grant funding and public sector borrowing.

As the development of a network at the Atherstone Airfield site in isolation is not financially viable, the site will not be allocated as a priority heat network area (unless heat/cooling intensive businesses with consistent heat demands are to locate at the site). If heat intensive businesses are to locate at the site, or the Council decide to encourage heat intensive businesses to the site, then this study could be referenced to demonstrate that connection to a district heat network may be technically and financially viable.

Due to the nature of the existing businesses and planned developments, it is unlikely that any of the schemes are suited to public sector ownership and would be private sector led.

Stratford-on-Avon Council have several options to consider and these include doing nothing or playing a supporting and facilitating role for any network developments. Stratford-on-Avon District Council may decide to undertake a series of corporate actions to promote and enable a scheme including:

- Facilitating engagement between key stakeholders namely Expel Oil Seed Processing Ltd, Syn2gen, RMCA, Wealmoor and Aviagen
- Engagement and support with planning consents and any highways activities for a proposed network
- Encouraging heat/cooling intensive businesses (potential key anchor loads) to locate at the site

Stratford-on-Avon District Council should consider the following next steps and recommendations.

Recommendations	Indicative Timeline
1. Consider the findings of this study to decide how best to support district energy developments at Atherstone Airfield	*Immediate*
2. Engage with Syn2gen at senior level to establish their strategy for the site	
3. Ensure effective early engagement and continue to work with Alscot Estate to further understand the nature of the development plans being brought forward	
4. When the developments are brought forward and, more detailed information made available, if heat/cooling intensive businesses are to locate the site then network options should be reassessed	*Short and medium term*
5. Engage with and support planning consents and highways activities	
6. Ensure the technical and financial work undertaken in this study will provide an evidence base for planning policy	
7. Encourage heat/cooling intensive businesses (potential key anchor loads) to locate at the site	

1 INTRODUCTION

1.1 General

This report presents the findings of the Atherstone Airfield Heat Mapping and Masterplanning Study (2016). The project is funded and supported by Stratford-on-Avon District Council (SDC). The purpose of the project is to identify and evaluate opportunities to develop a new district heating network through energy mapping and masterplanning.

The work was conducted by Sustainable Energy and the consultant team were commissioned to complete the work and the project was initiated on 8th September 2016.

1.2 Project Scope

The consultant team were commissioned to undertake the following:

- An energy mapping study to identify potential key energy demands and potentially useful heat supplies
- Development of a district energy masterplan to identify and evaluate potential district energy networks and priority areas and consider all potential opportunities and constraints
- Identify viable network and scheme options
- Provide key economic, governance, planning and development advice to enable Stratford-on-Avon District Council to determine the best approach to deliver priority district energy network opportunities
- Identify key stakeholders with a role to play in the delivery of district energy networks

1.3 Project Background

Sustainable Energy were commissioned to complete heat mapping and masterplanning for existing buildings and planned developments at Atherstone Airfield. A number of key stakeholders were identified and these included internal stakeholders at Stratford-on-Avon District Council, Alscot Estate, Syn2gen and Expel Oil Seed Processing Ltd, Camgrain, Wealmoor and Aviagen.

Atherstone Airfield was included as a strategic site in a modification to the Core Strategy in March 2016 as site SUA.4. It is proposed by SDC that the site will be used for the relocation of businesses from the Canal Quarter Regeneration Zone with Use Classes B1c, B2 or B8 or suitable sui generis uses. The development could be brought forward as part of Core Strategy phase 2 (2016/17) and phase 4 (2030/31).

1.4 Project Drivers and Objectives

Stratford-on-Avon District Council's main objective and driver for this project is to identify, validate or confirm the site as a district heating priority area as set out in Policy CS.3 'Sustainable Energy') which states:

"The Council will encourage the use of decentralised energy systems, which incorporate either heating (District Heating) or heating, power and cooling (Combined Heat and Power) or power (micro-grid) into new developments. Large developments should supply decentralised energy to the site, or provide for future connection to a decentralised scheme where it is viable to do so."

Other objectives and drivers include:

- Reducing commercial carbon emissions
- Reducing operational / energy costs for local businesses
- Assessing the potential for utilising local energy sources
- Improve energy security and resilience against rising energy prices
- Reducing fuel poverty and improving health, wellbeing and independence of local communities

2 HEAT MAPPING

2.1 Review of the Heat Map Area

The consultant team reviewed and provided advice regarding Stratford-on-Avon District Council's proposed heat map area. After investigations and site visits the red line boundary shown in Figure 1 was confirmed.

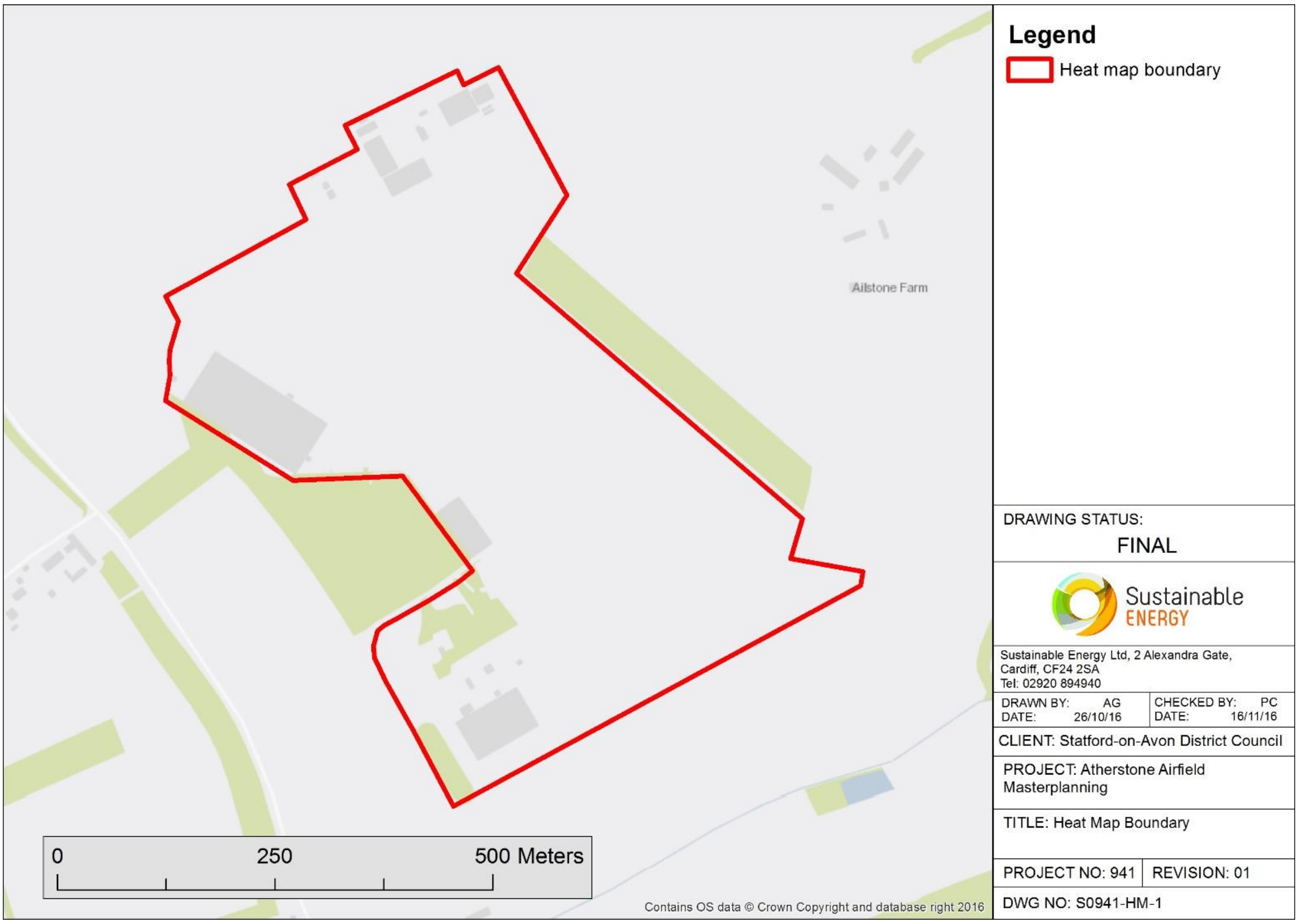


Figure 1: Atherstone Airfield heat map area

2.2 Data Collection

The purpose of the data collection exercise was to enable detailed energy mapping of existing and future energy demands and potential heat sources. An extensive list of potential heat loads and key energy sources within the heat map area was compiled. This was completed in discussion with clients and stakeholders and followed external site inspections.

2.2.1 Planned Developments

Planned developments may provide significant energy demands that should be considered when assessing district energy scheme options. There are opportunities to safeguard and futureproof layout and design to allow compatibility with and connection to existing or planned district energy networks. Engagement with developers is discussed further in chapter 5.

One of the main risks associated with the energy mapping exercise was the accessibility of accurate and up to date development information. The consultant team met with both Stratford-on-Avon District Council planners and representatives from the Alscot Estate. This was followed up with emails and telephone calls to request and discuss available data.

The consultant team reviewed strategic documents and development plans to ensure that all future heat demands inform network development. This involved liaison with relevant individuals within Stratford-on-Avon District Council's planning department and included assessment of density, timeframe and phasing. It also included a review of Stratford-on-Avon District Council's planning policy.

The key documents reviewed were the:

- Core Strategy (adopted July 2016)
- Local Development Framework
- Development masterplans
- Planning applications
- Recent planning permissions

There are a number of risks associated with energy mapping and basing network assumptions around planned developments, these include:

- The planned development not coming forward - there is no certainty as to whether all of the planned developments will come forward or that planning permission will be granted
- Permitted developments not being built out
- Changes to the density, scale and timing of planned developments
- Connection risk - the developers not engaging with the heat network process and/or the potential network provider so that new buildings are not 'network-ready' or do not connect to an existing network

Conversely, there may be potential for the density of developments to increase and this higher linear heat density could improve the viability of networks. Risks are considered further in section 4.3.

Atherstone Airfield Planned Developments

Figure 2 shows the planned developments identified within the Atherstone Airfield heat map area. Further details of these are shown in Table 1.

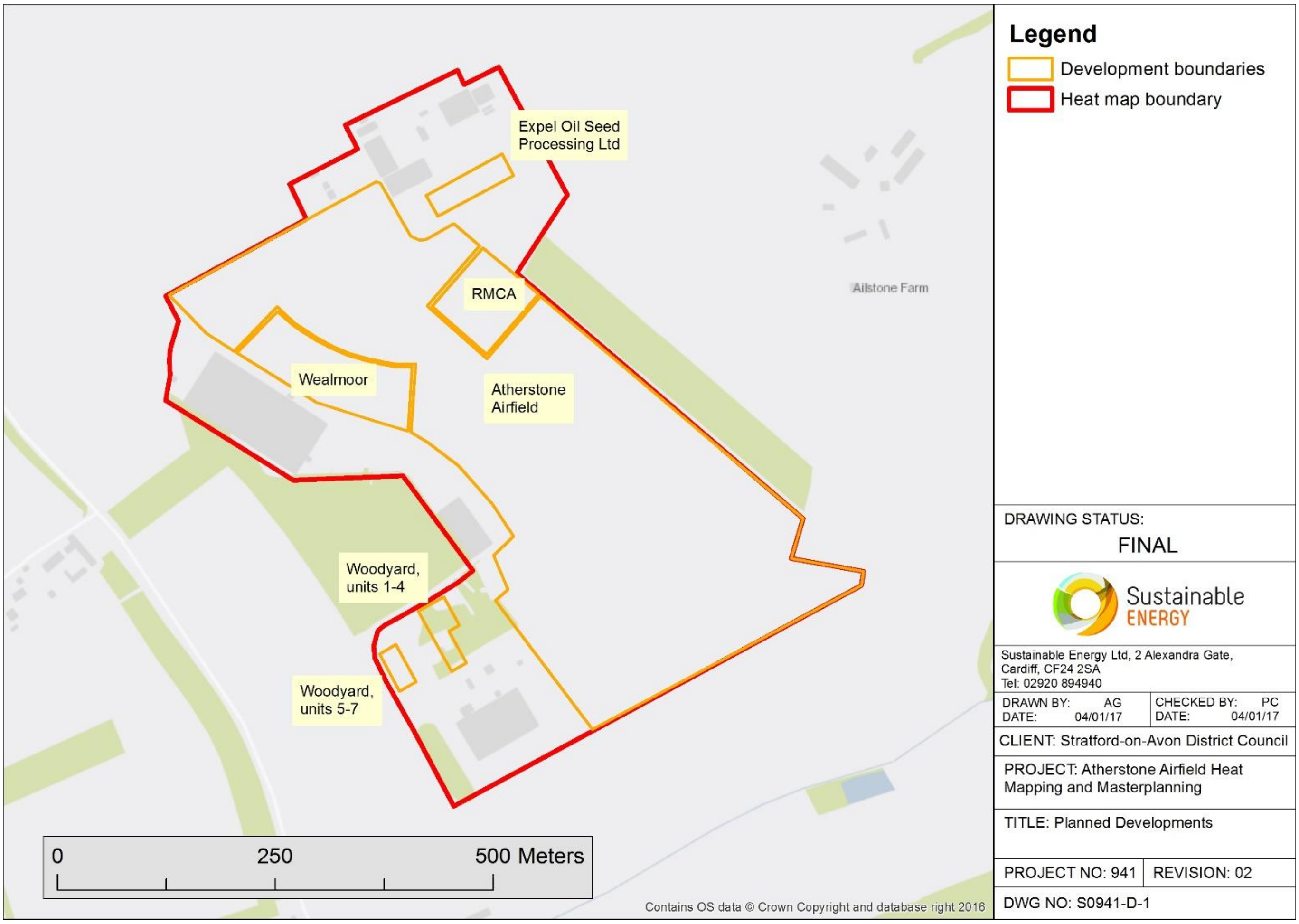


Figure 2: Atherstone Airfield planned developments

Table 1: Current information for planned developments

Development name	Available information	Planning details
Expel Oil Seed Processing Ltd/Syn2gen[1]	- Oil seed processing and solid biomass drying with erection of single storey building and the production of renewable energy from solid biomass fuels for heating, drying and processing	- Application reference: 13/00952/FUL - Planning application approved with conditions 18/09/2013 - Variation of conditions pending consideration as of 08/12/2016
RMCA	- Oil seed processing facility	- No planning application as of 08/12/2016
Wealmoor	- Exotic fruit storage and distribution (adjacent to existing Wealmoor warehousing)	- No planning application as of 08/12/2016
Atherstone Airfield	- Only high level information available at this stage: ○ Approximately 450,000 sq ft of Class B2/B8 ○ Potentially 12 units with 5 % office space and one café	- No planning application as of 08/12/2016
Woodyard	- 7 small business units of Class B1/B2/B8	- Application reference: 16/00857/FUL - Planning application approved with conditions 19/08/2016

[1] Site being developed by Syn2gen and Expel Oil Seed Processing Ltd

2.2.2 Existing Buildings

Figure 3 shows the existing buildings and sites within the Atherstone Airfield heat map area. Further details of these are shown in Table 2.

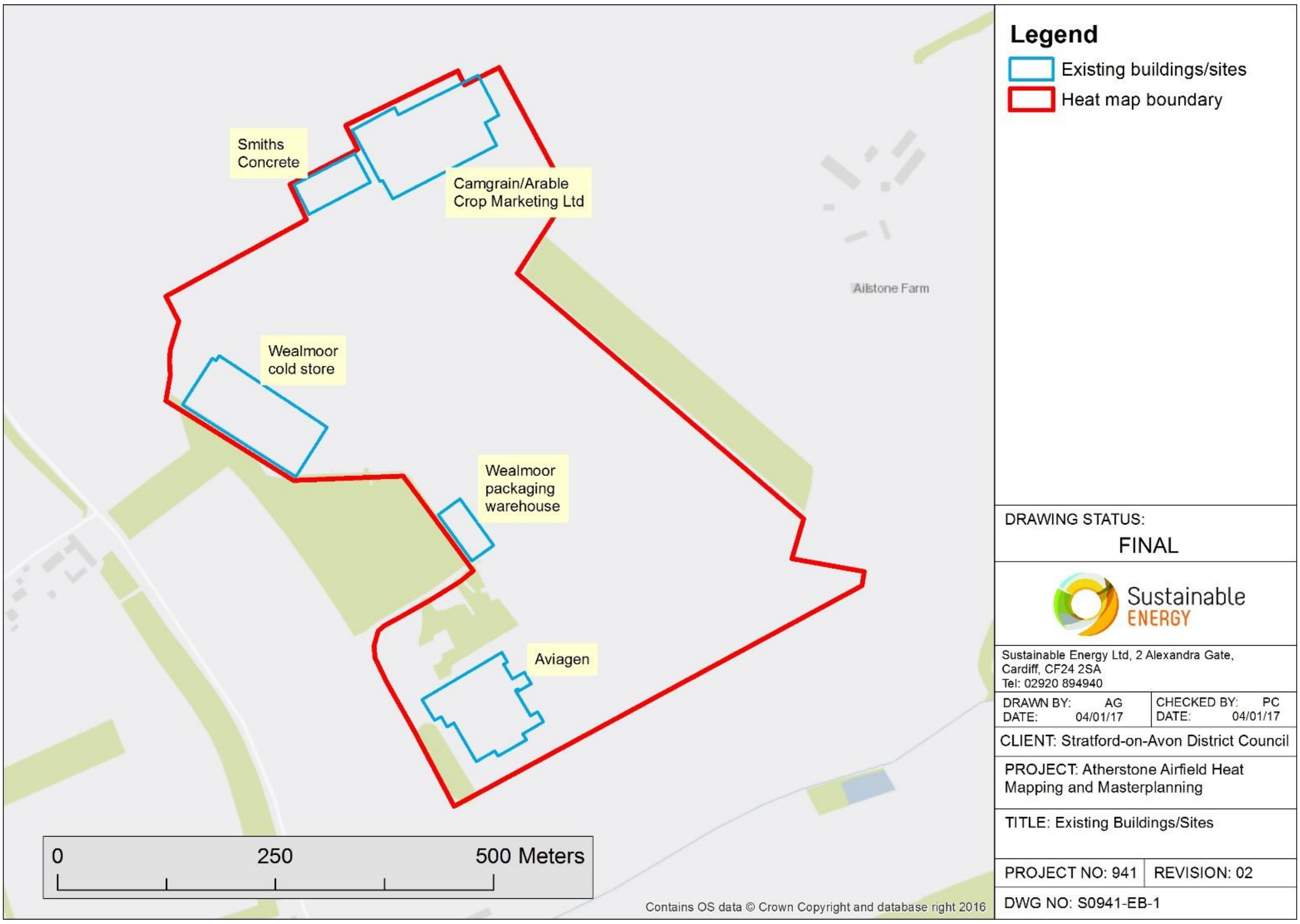


Figure 3: Atherstone Airfield existing buildings

Table 2: Current information on existing buildings

Building/site name	Available information
Camgrain/Arable Crop Marketing Ltd	- Grain drying and storage facility (27,000 tonnes of grain storage)
Smiths Concrete	- Ready-mix concrete, sand and gravel supplier - Open site with no large buildings - Low energy user
Wealmoor, cold store and packaging warehouse	- Exotic fruit storage and distribution warehouses - Cold store has areas cooled to 3, 7 and 10 °C - Small blast cooler and hydro cooler
Aviagen	- Chick hatchery (1 million eggs per week) - Hot water is used to bring eggs to incubation temperature and maintain constant temperature - Recent planning application mentions a new on-site substation and external generators - Central domestic hot water generated by high efficiency direct gas fired condensing water heaters (98 % efficient)

2.2.3 Key Stakeholder Engagement

The consultant team contacted potential heat load stakeholders, in order to obtain information such as site contact lists, building and site plans showing locations and floor areas, building use and potential occupancy levels and patterns (see Appendix 1 – Key Organisations Contacted). Information requests were presented to stakeholders by email, where possible, after telephone calls or meetings (where stakeholders were amenable) to engage with the relevant site contacts. A summary of this activity is shown in Table 3.

Table 3: Summary of stakeholder engagement

Potential key heat load stakeholder	Sector	Comments
Alscot Estate	Private	- Meeting held with Estates Director - Only high level information available
Syn2gen	Private	- Contact established but limited information received

2.2.4 Existing Energy Sources

Existing energy sources were discussed with the Council and research was conducted by the consultant team. Two potential energy sources were identified:

- Planned Biomass CHP designed by Syn2gen for Expel Oil Seed Processing Ltd (planning permission granted September 2013, variation of conditions pending consideration as of 08/12/2016)
- Planned anaerobic digesters and biogas CHP by Future Biogas Ltd (planning permission pending consideration as of 08/12/2016)

Site developers were contacted in order to discuss the nature and scale of schemes and energy resources. Contact was initially established with Syn2gen however no response was received from further information requests. Further stakeholder engagement will be required if this site is progressed to the feasibility stage.

2.2.5 Fossil Fuel Consumption Benchmarking

Where actual energy data was not available non-domestic and industrial benchmarks were used to verify the expected fossil fuel consumption to be used in energy profiling (the source of all data has been identified in Appendix 2 – Energy Data and in section 3.5 in relation to priority network options; this has also been considered in section 4.3). The fossil fuel consumption value was calculated; using gross floor area determined from the building plans or masterplans (where available) and assumed areas where no data exists. A tried and tested approach was then used to generate demand profiles verified by the benchmarked fossil fuel consumption, building type and use. The consultant team has a database of hundreds of hourly annual demand profiles for a wide range of building types and these were adapted to provide an indicative heat demand profile for each site.

CIBSE Guide F, Energy Efficiency in Buildings (2008), *CIBSE TM46* (2008), heat loss calculations and previous consultant experience were used for benchmarks.

2.2.6 Electrical Consumption Benchmarking

Electricity profiles for key electricity loads were derived according to building use, process details, profiles of similar buildings and processes and consultant experience. Where data was unavailable benchmarks from *CIBSE Guide F, Energy Efficiency in Buildings* (2008) and *CIBSE TM46* (2008) were used to verify consumption.

2.2.7 Cooling Demand Benchmarking

Cooling profiles for key cooling loads (Wealmoor and Aviagen) were derived. Where data was unavailable benchmarks from *CIBSE TM46* (2008) and previous experience was used to verify consumption. For Wealmoor cold store and packaging warehouse, the heat and electricity demands were benchmarked using TM46 – cold storage/refrigerated warehouse. It has been assumed that 60% of the total energy demand (heat and electricity) arose from cooling. Cooling requirements for Aviagen were calculated based on the cooling capacity given in the ChickMaster datasheet attached to their recent planning application. This can be seen in Appendix 3 – Planned Developments.

2.3 Energy Demands

Annual fossil fuel consumption values from historical data and benchmark values were used to determine an annual heat demand value for each potential key heat load within the heat map areas. The calculated annual heat demand values are listed in Appendix 2 – Energy Data.

2.3.1 Heat Demand Profiling

In order to further analyse heat demands for network options, hourly heat demand profiles were constructed. The profiles were generated using in-house modelling software which apportions the annual heat demand figure into hourly loads over the year, taking into account degree day data[2] and building use and occupancy.

For each building/phase, the annual demand model was then used to identify the average, maximum and minimum hourly demand throughout the year. An example average, maximum and minimum heat demand profile is shown in Figure 4 (for Woodyard units 1-4).

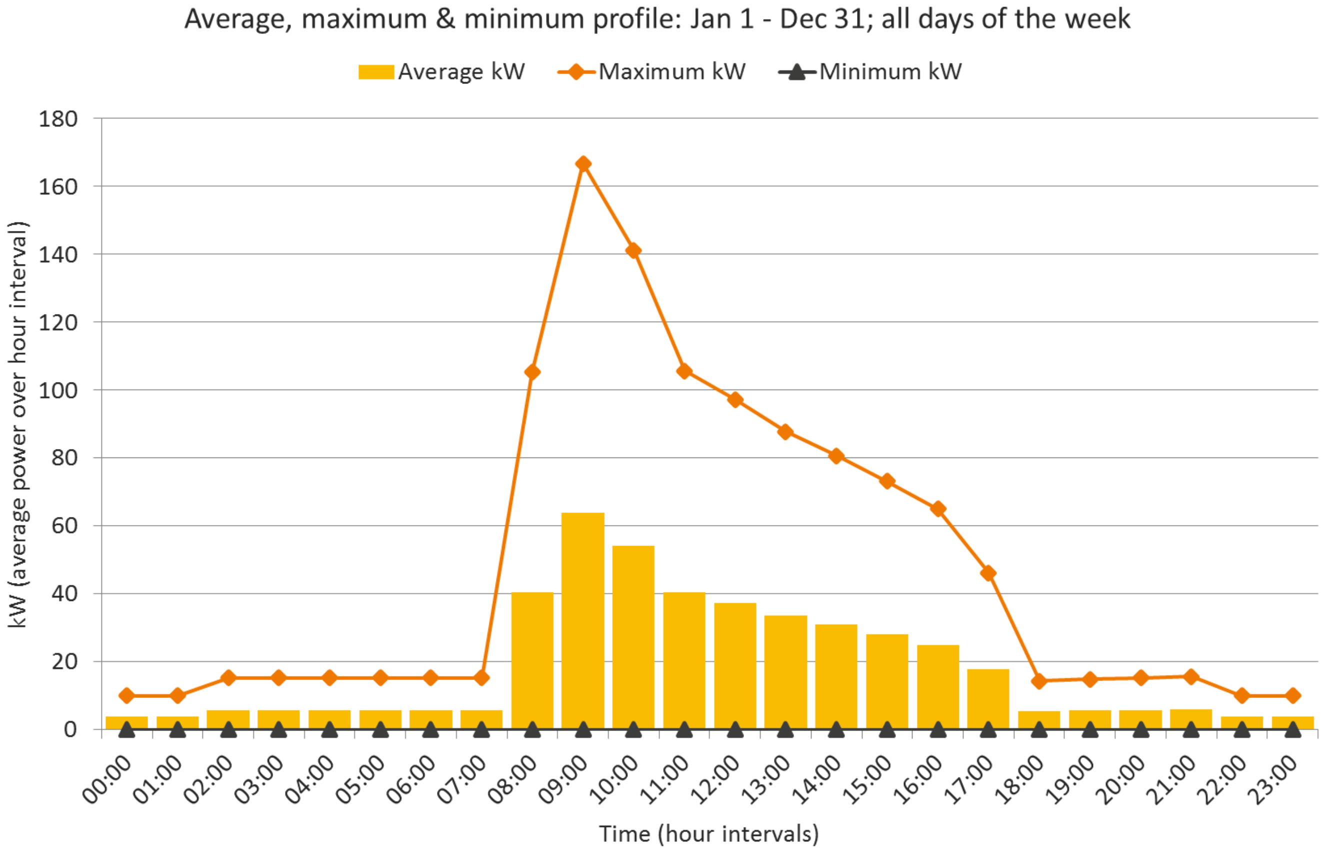


Figure 4: Annual heat demand profile for Woodyard units 1-4

The profiles of typical winter and summer days were also produced to identify the demand variation on both a day-by-day and seasonal basis. The typical winter and summer profiles for Woodyard units 1-4 are shown in Figure 5 and Figure 6. The yellow area shows the average daily heat demand, the orange and black lines correspond with the maximum and minimum demands respectively.

[2] Degree days are a type of weather data calculated from outside air temperature readings. Heating degree days and cooling degree days are used extensively in calculations relating to building energy consumption. They are used to determine the heating requirements of buildings, representing a fall of one degree below a specified average outdoor temperature (15.5°C) for one day.

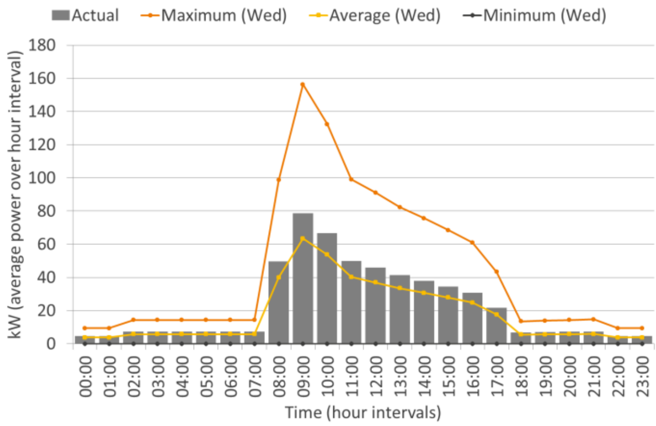


Figure 5: Daily heat demand profile for Woodyard units 1-4 – Wednesday 10th January 2018

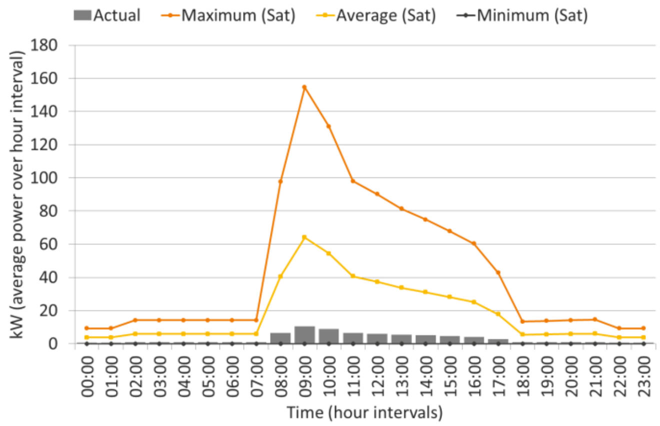


Figure 6: Daily heat demand profile for Woodyard units 1-4– Saturday 7th July 2018

2.3.2 Electricity Demand Profiling

To allow analysis of significant potential energy demands for network options, hourly heat electricity demand profiles were constructed. The profiles were generated using in-house modelling software which apportions the annual electricity demand figure into hourly loads over the year, taking into account building use and occupancy.

For each key electricity load, the annual demand model was then used to identify the average, maximum and minimum hourly demand throughout the year. An example average, maximum and minimum heat demand profile is shown in Figure 7 (Woodyard units 1-4).

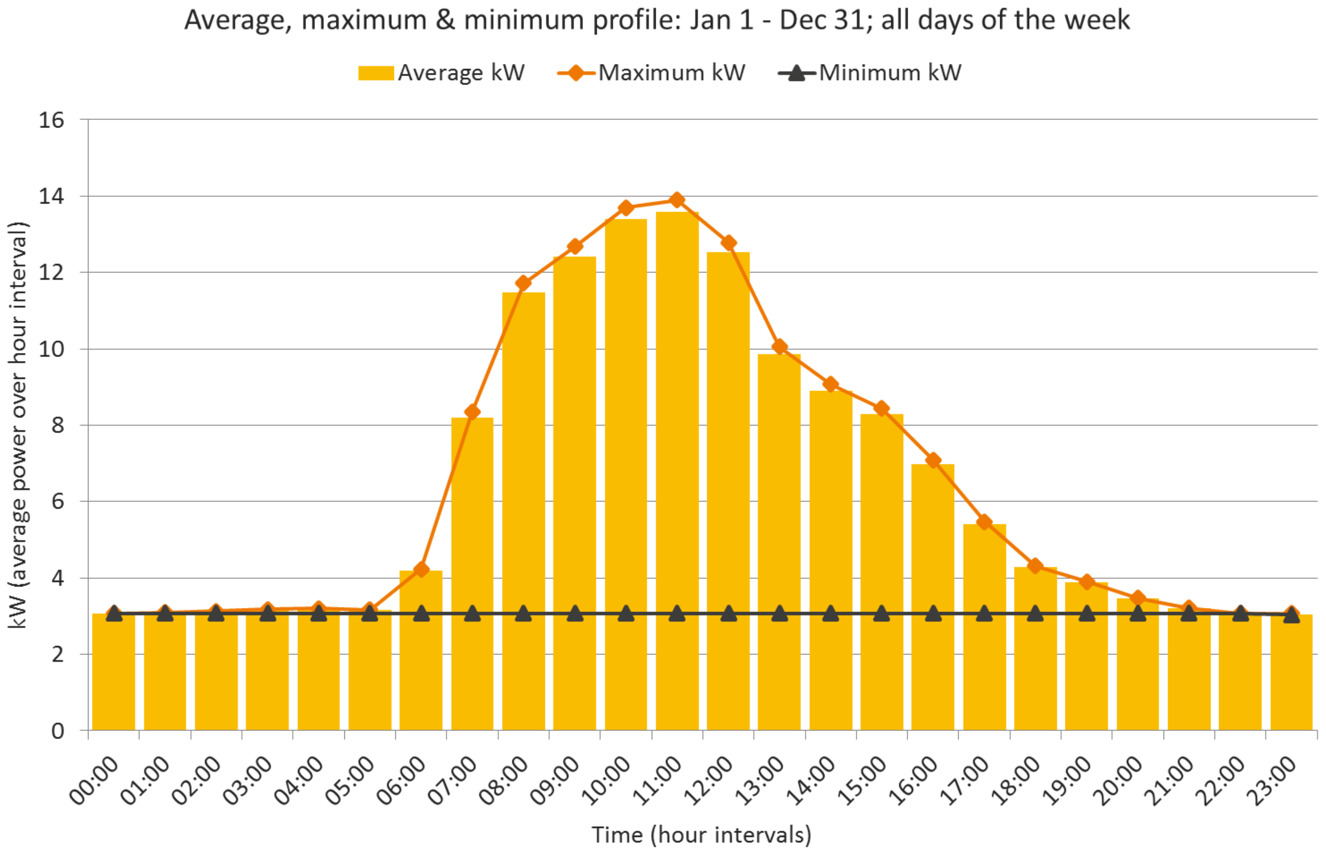


Figure 7: Annual electricity demand profile for Woodyard units 1-4

2.4 Energy Mapping Results

Geographic Information System (ArcGIS) software was used to map the identified heat demands and key electricity demands for the Atherstone Airfield heat map area. The symbols show the site location and graduate in size according to energy demand to depict the nature of the energy loads within the heat map area. The larger the symbol, the greater the energy demand. The demands for all buildings/sites are shown in Appendix 2 – Energy Data.

2.4.1 Heat Demands

The key heat demands within the Atherstone Airfield heat map area are shown in Figure 8 and Table 4. The largest heat demand arises from the combined demand for Camgrain and the Expel Oil Seed Processing Ltd planned development (28,000 MWh) located to the north east of the heat map area. The heat demand for this site was derived from the energy statement for the Expel Oil Seed Processing Ltd planning application which stated a combined demand for both Camgrain and the Expel development and has been included as a combined demand in the study. Other large heat demands include the RMCA planned development, Wealmoor cold store and Aviagen.

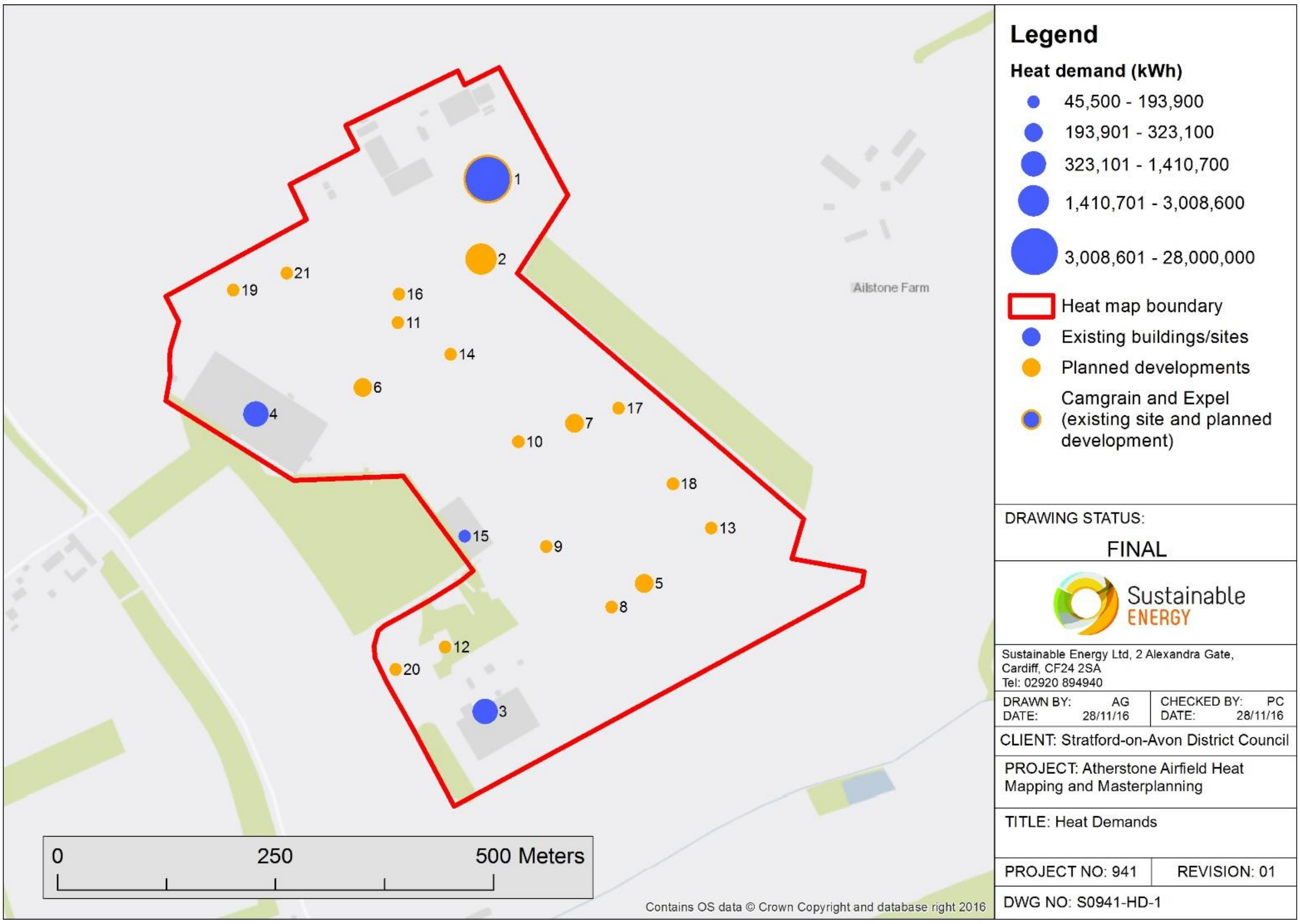


Figure 8: Atherstone Airfield heat demands

Table 4: Atherstone Airfield heat demands

Ref	Name	Building use	Status	Heat demand, kWh
1	Camgrain and Expel development	Existing grain drying and storage, planned oil seed processing facility	Existing site and planned development	28,000,000
2	RMCA development	Oil seed processing facility	Planned development	3,008,600
3	Aviagen	Chick hatchery	Existing	1,410,700
4	Wealmoor, cold store	Exotic fruit storage and distribution warehouse	Existing	853,200
5	Atherstone Airfield 6	Class B2/B8	Planned development	323,100
6	Wealmoor development	Exotic fruit storage and distribution warehouse	Planned development	312,500
7	Atherstone Airfield 2	Class B2/B8	Planned development	258,600
8	Atherstone Airfield 7	Class B2/B8	Planned development	193,900
9	Atherstone Airfield 8	Class B2/B8	Planned development	193,900
10	Atherstone Airfield 9	Class B2/B8	Planned development	193,900
11	Atherstone Airfield 11	Class B2/B8	Planned development	193,900
12	Woodyard, unit 1-4	Small industrial/retail units	Planned development	162,600
13	Atherstone Airfield 5	Class B2/B8	Planned development	161,600
14	Atherstone Airfield 10	Class B2/B8	Planned development	155,100
15	Wealmoor packaging store	Exotic fruit packaging warehouse	Existing	129,700
16	Atherstone Airfield 1	Class B2/B8	Planned development	129,200
17	Atherstone Airfield 3	Class B2/B8	Planned development	129,200
18	Atherstone Airfield 4	Class B2/B8	Planned development	129,200
19	Atherstone Airfield 12	Class B2/B8	Planned development	129,200
20	Woodyard, unit 5-7	Small industrial/retail units	Planned development	83,500
21	Atherstone Airfield 13	Cafe	Planned development	45,500

2.4.2 Electricity Demands

The electricity loads, shown in Figure 5 and Figure 9, have been assessed to allow potential private wire opportunities to be investigated. The largest existing electricity demand arises from Camgrain and Expel Oil Seed Processing Ltd combined demand (8,400 MWh) located to the north east of the heat map area. Other large electricity demands arise from Wealmoor cold store and the RMCA planned development.

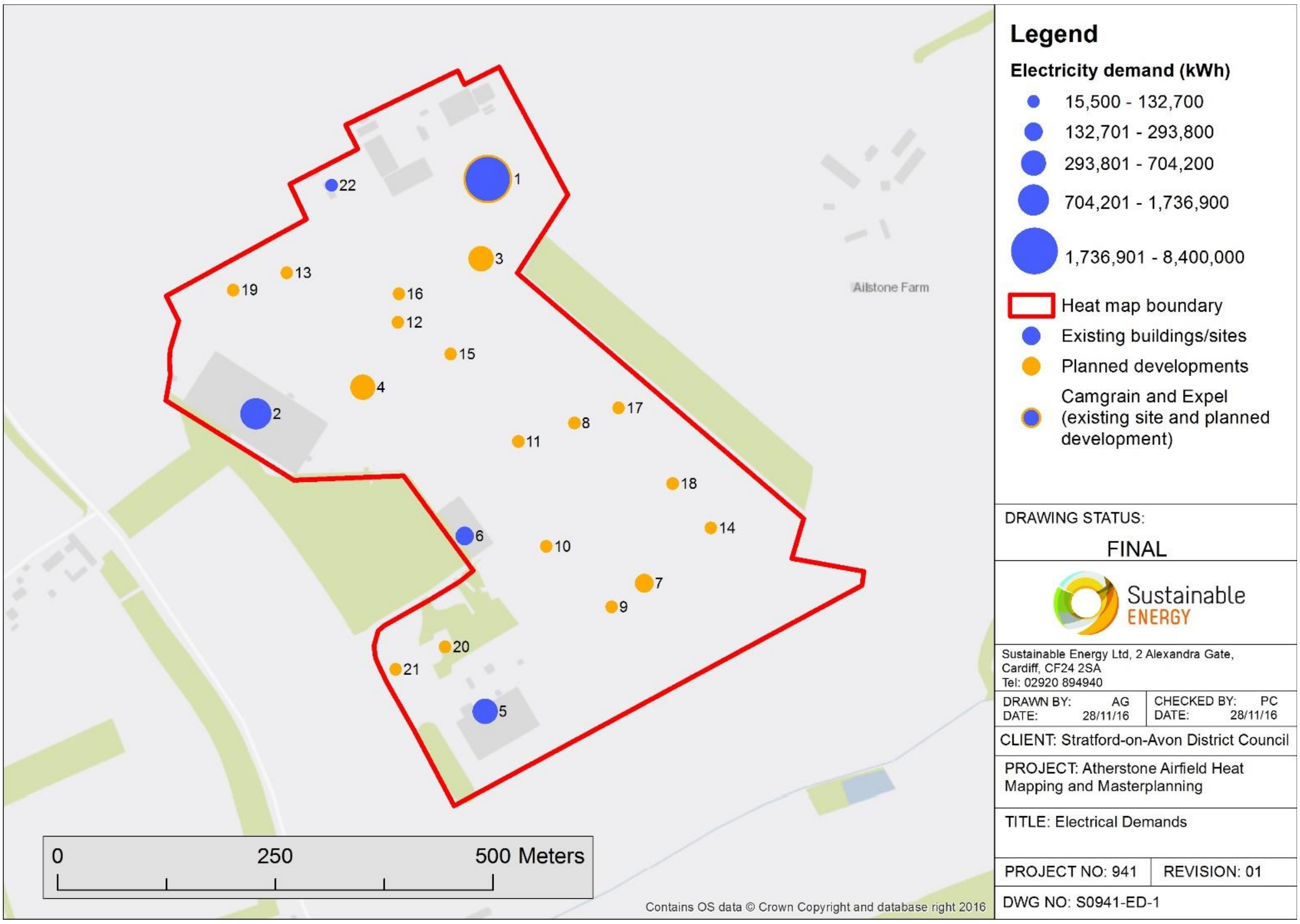


Figure 9: Atherstone Airfield electricity demands

Table 5: Atherstone Airfield electricity demands

Ref	Name	Building/site use	Status	Electricity demand, kWh
1	Camgrain and Expel development	Existing grain drying and storage, planned oil seed processing facility development	Existing site and planned development	8,400,000
2	Wealmoor cold store	Exotic fruit storage and distribution warehouse	Existing	1,736,900
3	RMCA development	Oil seed processing facility	Planned development	704,200
4	Wealmoor development	Exotic fruit storage and distribution warehouse	Planned development	643,300
5	Aviagen	Chick hatchery	Existing	593,200
6	Wealmoor packaging store	Exotic fruit packaging warehouse	Existing	293,800
7	Atherstone Airfield 6	Class B2/B8	Planned development	165,900
8	Atherstone Airfield 2	Class B2/B8	Planned development	132,700
9	Atherstone Airfield 7	Class B2/B8	Planned development	99,500
10	Atherstone Airfield 8	Class B2/B8	Planned development	99,500
11	Atherstone Airfield 9	Class B2/B8	Planned development	99,500
12	Atherstone Airfield 11	Class B2/B8	Planned development	99,500
13	Atherstone Airfield 13	Cafe	Planned development	91,500
14	Atherstone Airfield 5	Class B2/B8	Planned development	83,000
15	Atherstone Airfield 10	Class B2/B8	Existing	79,600
16	Atherstone Airfield 1	Class B2/B8	Planned development	66,400
17	Atherstone Airfield 3	Class B2/B8	Planned development	66,400
18	Atherstone Airfield 4	Class B2/B8	Planned development	66,400
19	Atherstone Airfield 12	Class B2/B8	Planned development	66,400
20	Woodyard, unit 1-4	Small industrial/retail units	Planned development	56,600
21	Woodyard, unit 5-7	Small industrial/retail units	Planned development	29,000
22	Smiths Concrete	Ready-mix concrete supplier	Existing	15,500

2.4.3 Cooling Demands

The key cooling loads are shown in Figure 10 and detailed in Table 6. The largest cooling demand arises from Wealmoor cold store. Other cooling demands arise from Aviagen, Wealmoor planned development and the existing Wealmoor packaging warehouse. Wealmoor cooling demands have been estimated as a percentage of overall electricity consumption using benchmark figures and verified using actual data from similar existing cold storage and refrigerated warehouse facilities. The cooling demand for Aviagen has been calculated based on the cooling capacity shown in the ChickMaster data sheet, see Appendix 3 – Planned Developments. To assess cooling requirements Wealmoor and Aviagen were contacted, however no responses were received.

If the project is progressed to the feasibility stage, and more detailed development plans and planning applications identifying building use and location are made available, then the opportunity to supply cooling to other units within the Atherstone Airfield development area should be further investigated.

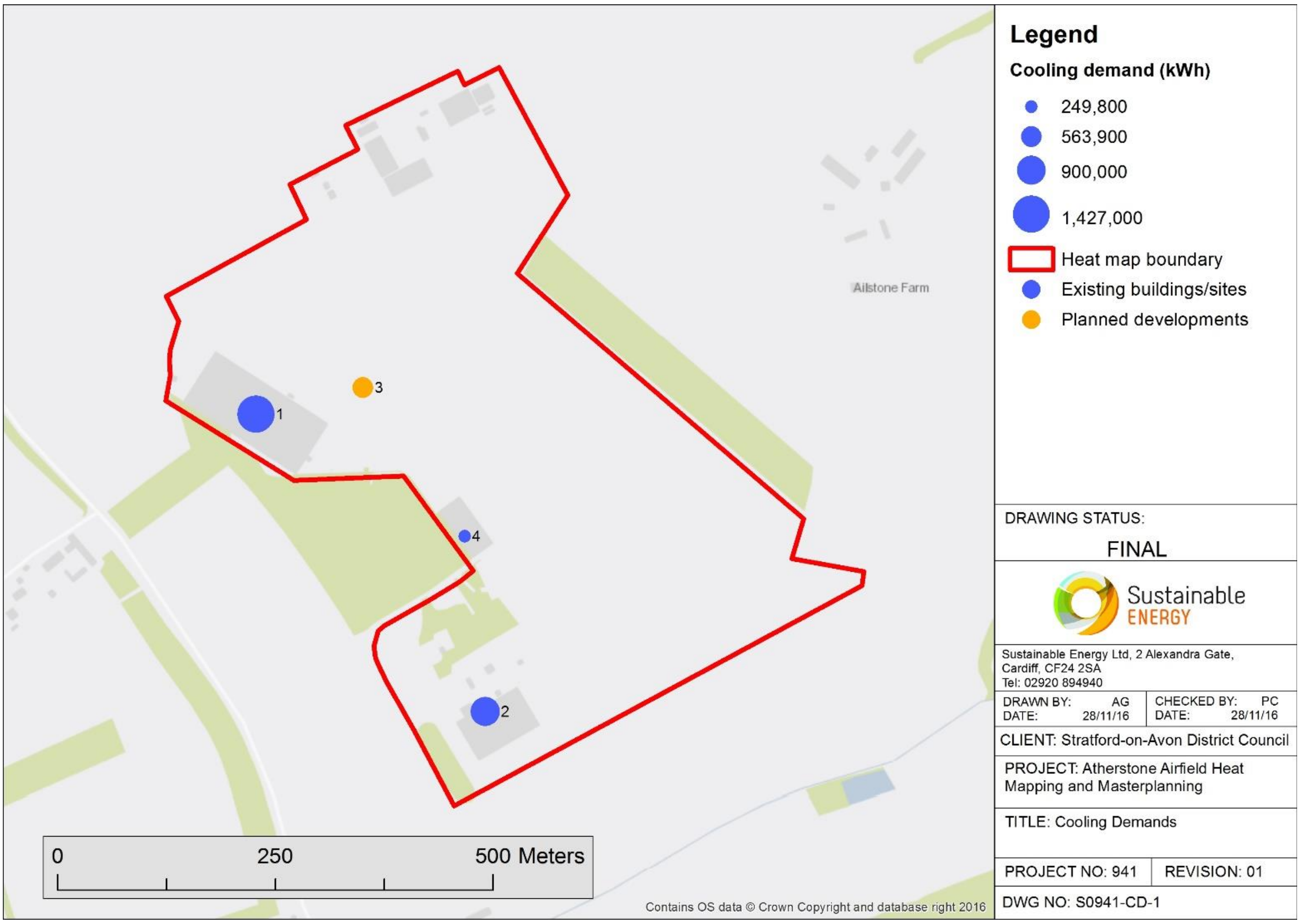


Figure 10: Atherstone Airfield cooling demands

Table 6: Atherstone Airfield cooling demands

Rank	Name	Building use	Status	Cooling Demand, kWh
1	Wealmoor, cold store	Exotic fruit storage and distribution	Existing	1,427,000
2	Aviagen	Chick hatchery	Existing	900,000
3	Wealmoor development	Exotic fruit storage and distribution	Planned development	563,900
4	Wealmoor packaging store	Exotic fruit packaging warehouse	Existing	249,800

2.5 Potential Energy Sources

Energy sources with potential to supply a network at Atherstone Airfield were investigated. Figure 11 shows the planned energy sources identified. A summary of these potential energy sources is shown in Table 7.

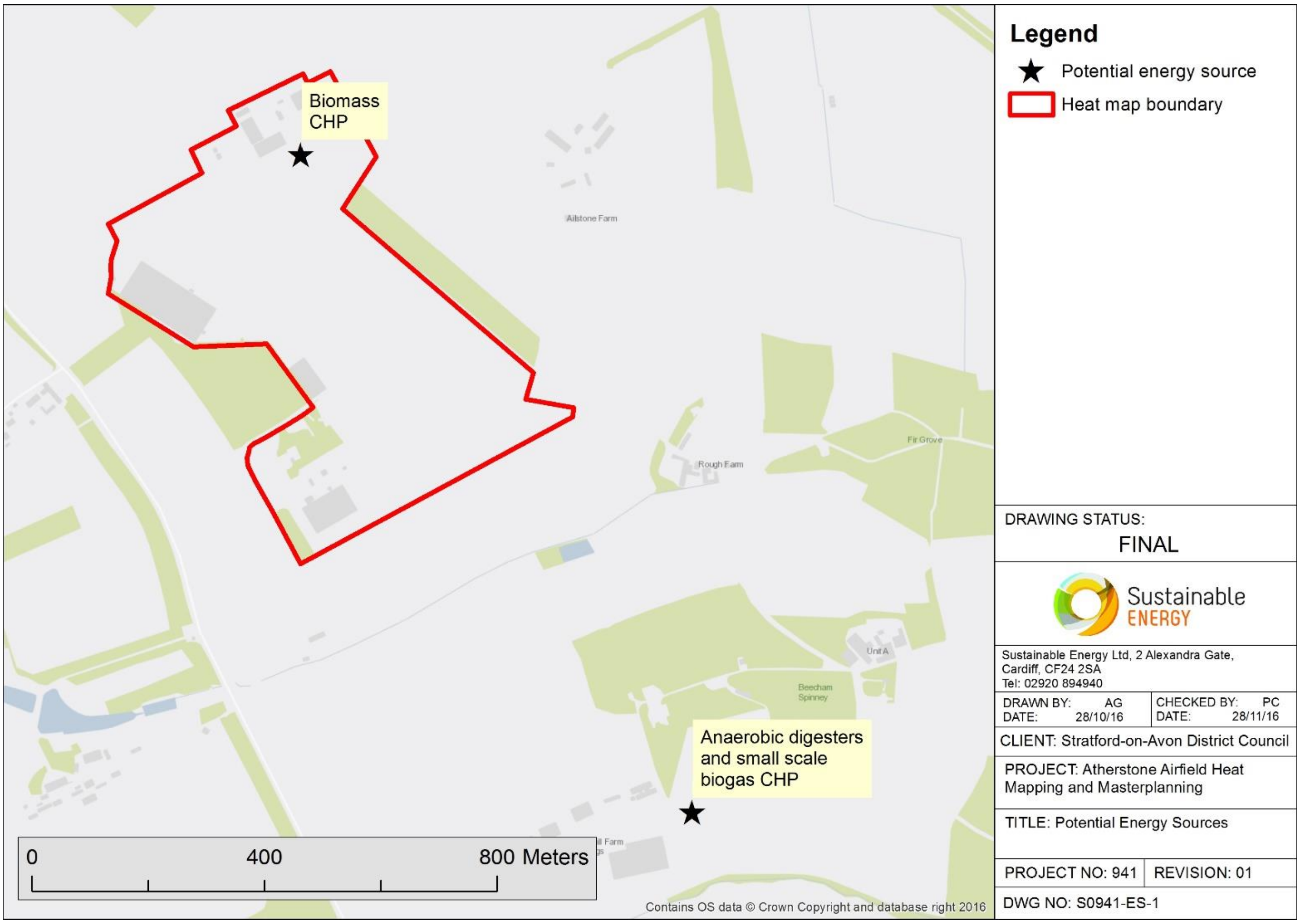


Figure 11: Potential energy sources

Table 7: Summary of potential energy sources

Potential Energy Source	Developer / Owner	Status	Assessment of potential to supply energy to network	Taken forward?
Biomass CHP	Syn2gen / Expel Oil Seed Processing Ltd	Planned development	- Developer discussions indicate potential for 2 MWth supply capacity - Syn2gen have expressed initial interest in supplying heat to a network at Atherstone Airfield - Planning application approved 2013, variation of conditions currently pending consideration - Timing of development unknown	Yes
Anaerobic digesters and small scale biogas CHP	Future Biogas Ltd	Planned development	- Significant distance from heat map area (~700 m) - Planning application currently pending consideration - Timing of development unknown - Biogas CHP sized to provide electricity and process heat to plant, therefore unlikely to be significant spare capacity - 90 % of produced biogas planned to be exported to grid (via gas to grid plant) which may be more profitable than supplying Atherstone Airfield development (dependant on RHI)	No

Following an initial assessment, it was decided that Future Biogas Ltd.'s anaerobic digesters and small scale biogas CHP would not be taken forward for further consideration. This is due to the significant distance from the site to the Atherstone Airfield development and also because exporting gas to the grid is likely to be significantly more profitable than supplying a network at Atherstone Airfield. The proposed Syn2gen biomass CHP which is part of the Expel Oil Seed Processing Ltd planned development was taken forward for further consideration. Syn2gen have expressed an interest in supplying a network at Atherstone Airfield and developer discussions suggest that there may be 2 MW of spare capacity. However, this is a high risk option as although contact was initially established with Syn2gen, no response was received from further request for information and the potential for spare capacity has not been confirmed. The development is currently subject to planning application.

2.6 Potential Site Barriers

Existing key utilities and other infrastructure (including planned upgrades), local designations (such as Conservation Areas and local wildlife sites), site topography, areas of Stratford-on-Avon District Council owned land and development barriers were investigated to determine whether they pose any potentially significant risks to the development of district energy networks.

Figure 12 highlights potential site barriers, risks and issues for network development, pipe routes and energy centre locations.

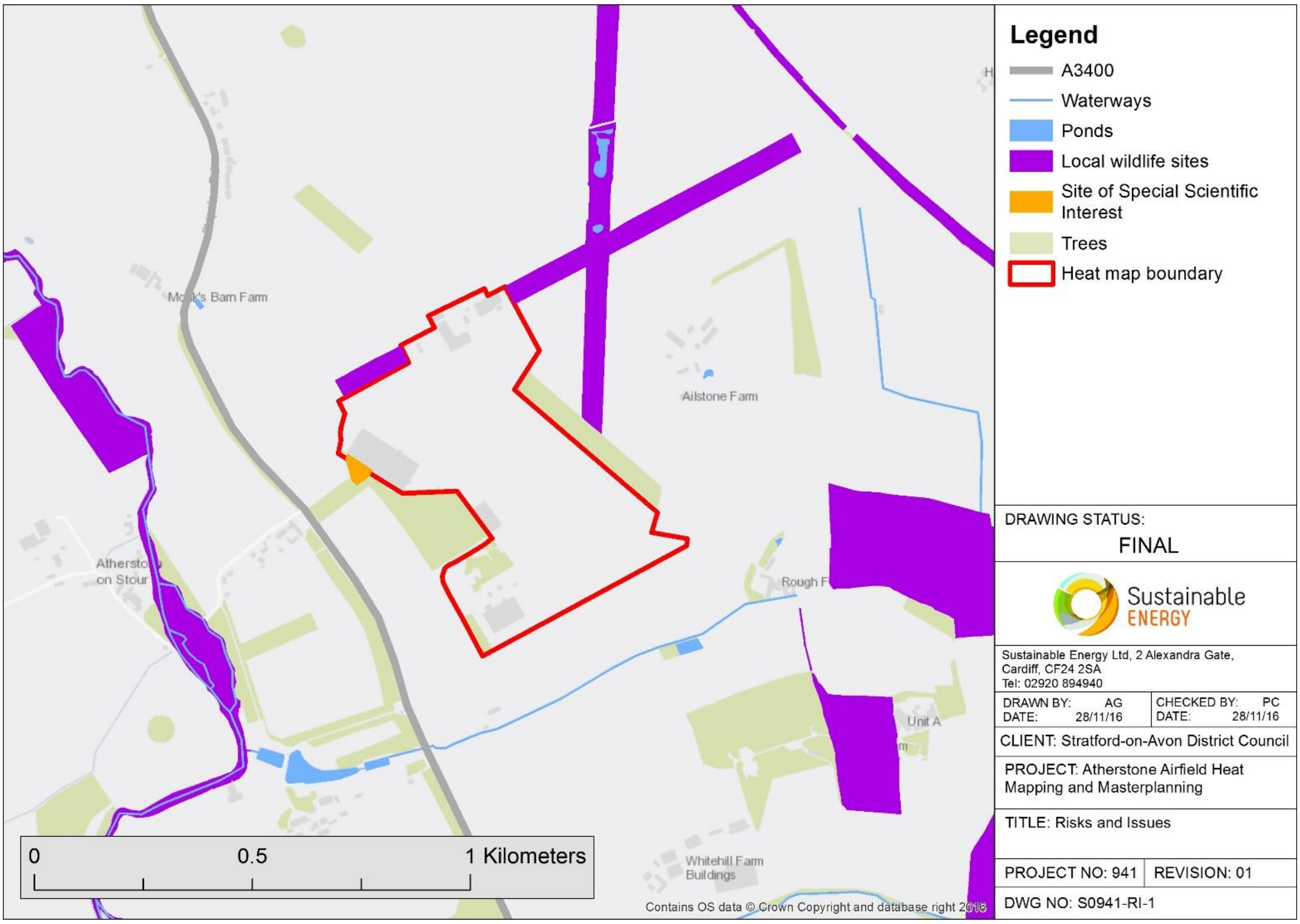


Figure 12: Potential site barriers, risks and issues for district energy network development

No significant barriers, risks and issues have been identified within the heat map area. Surrounding this area there is a small SSSI to the west of the heat map area behind the Wealmoor cold store. In addition to this, there are several local wildlife sites and woodland areas, however it is not known if there are any tree protection areas on these sites. No significant archaeological constraints were identified within the heat map area.

Figure 13 shows the high level terrain for the Atherstone Airfield heat map area. Gradient is unlikely to pose a risk to the development of a heat network or the location of the energy centre and the changes in elevation present no significant technical challenge to the pumping requirements of a district heat network.

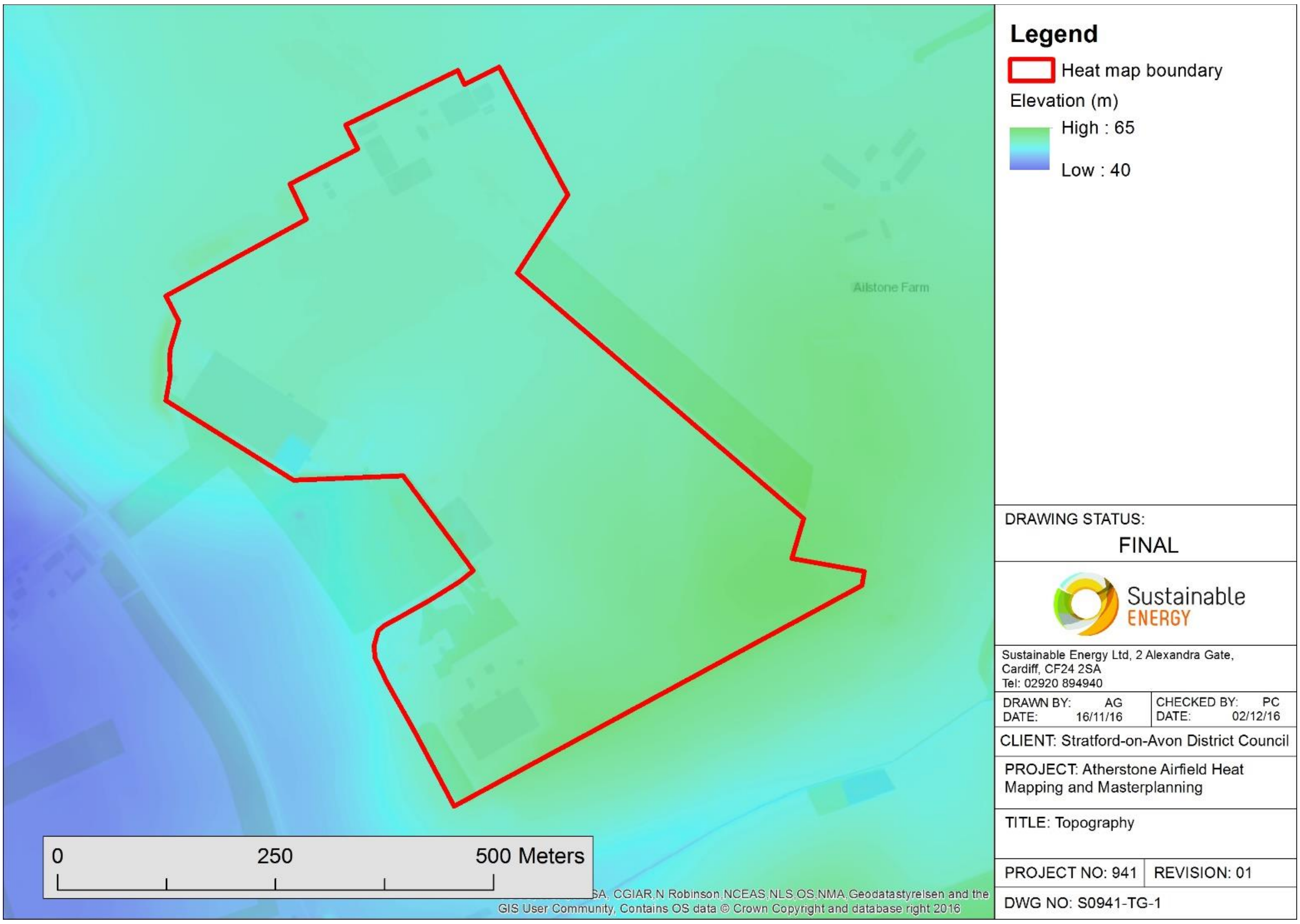


Figure 13: Terrain map for heat map area

3 MASTERPLANNING & PRIORITISATION

The outputs from the energy mapping exercise were assessed to inform the development of low carbon district energy network options for Atherstone Airfield. This energy masterplan identifies, evaluates and prioritises potential district energy scheme opportunities and constraints. All work meets the objectives and sub-objectives within Section 2 of the CIBSE/ADE Heat Networks Code of Practice (relevant to this stage of work).

It has been assumed that the cooling requirements for Wealmoor and Aviagen can be met by a heat network with absorption chillers. The cooling demands for these buildings have therefore been converted to a heat demand using an assumed absorption chiller efficiency of 60 %.

An assessment of technology options has been undertaken to establish potentially technically viable energy sources. This is shown in section 3.2 and the full technology assessment shown in Table 9.

Following the energy demands and technology assessments, initial network options have been considered for the technically viable technologies. Network route selection methodology involved consideration of the energy demands and the impact that pipe routes and connections have on the high level financial and technical viability (considering heat demand, peak, pipe size, diameter and length, losses, ground conditions and physical barriers). Hourly demand profiles for each proposed connection on the initial network options were added together to produce a combined heat demand profile and combined electricity demand profile for each hour of the year. An hourly heat loss figure (based on pipe size and heat loss rates for pre-insulated pipe) was added to the combined profile, with the assumption of constant heat loss through the network.

Indicative pipe routes were outlined to consider maximum cost-efficiency, by minimising pipe length and following routes with easier digging conditions where possible. At this stage it was assumed that the trench used by the distribution pipe could also contain the cable for electricity distribution for private wire arrangements[3].

Potential locations for standalone energy centres were identified considering proximity to heat demands, environmental constraints, topography, site infrastructure for fuel deliveries, minimising of heat distribution losses and standing losses and land ownership.

Existing key utilities and other infrastructure were considered to determine whether they pose any potentially significant risks to the development of district energy networks. None were identified within the heat map area. Site topography was also considered in relation to potential energy centre locations and to consider any landscape or development barriers.

The initial network options are discussed in section 3.4 and the high level 25 year IRR for each option shown in Table 10. The assessments of initial network options highlighted 2 potentially viable networks scenarios within the heat map area to be taken forward for further consideration. Further details of these prioritised networks are shown in section 3.5.

Full details of high level financial cases for each of the initial network options and the prioritised networks as well as pipe sizes and pipe specifications are show in Appendix 7 – Financial Viability Assessments.

[3] This would usually be in ducts that allow cables to be pulled after the excavation work is complete.

3.1 Cluster Assessment

The heat demands within the heat map area have been split into clusters that have then been assessed for their potential to become part of a network. As no significant site barriers were identified, cluster boundaries have been assessed in accordance with site ownership and planned developments. The clusters identified are shown in Figure 14. Smiths Concrete has not been included in a cluster due to the significantly low energy demand.

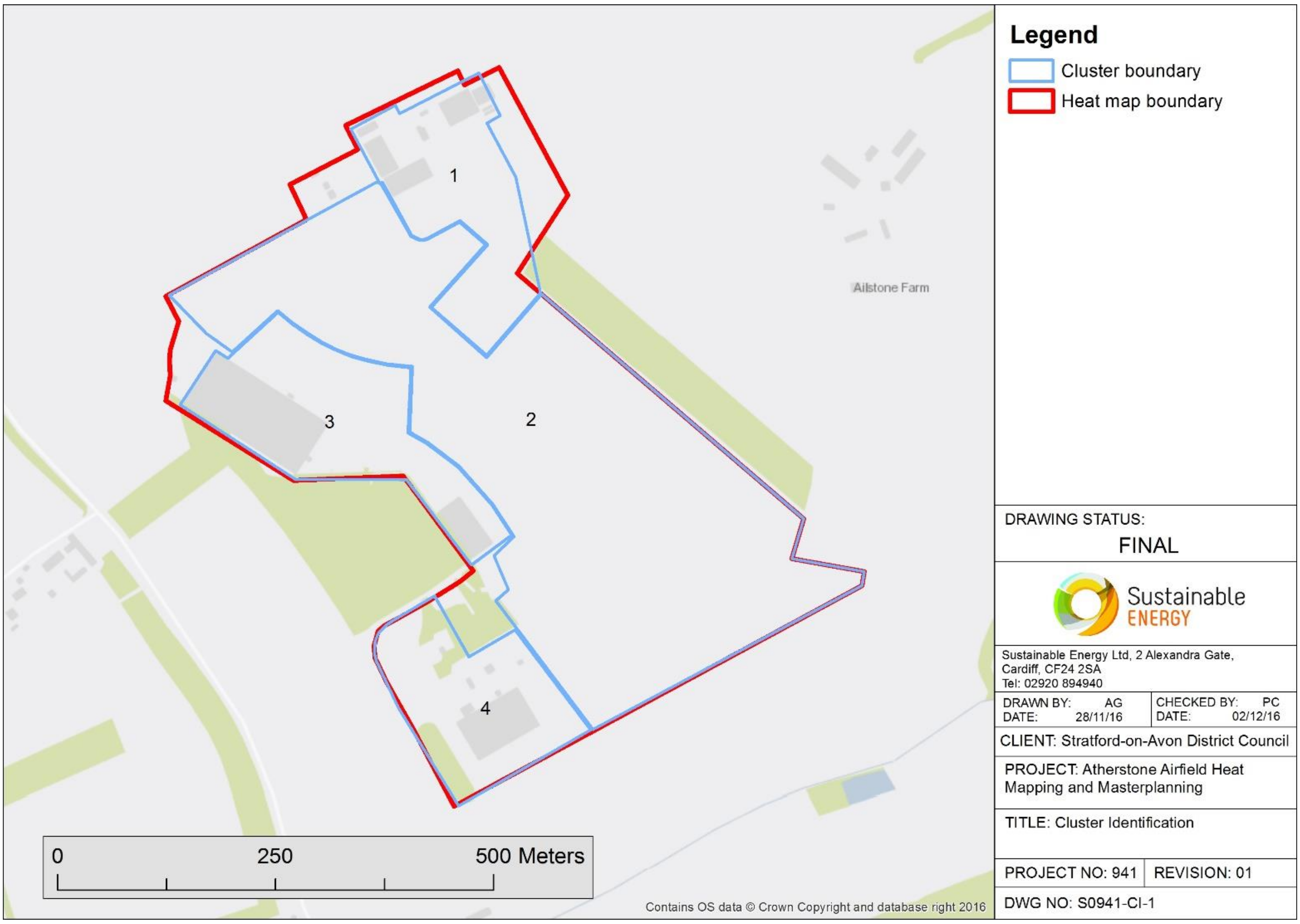


Figure 14: Cluster identification

Figure 15 and Table 8 show the linear heat demand density for the identified heat demand clusters within the heat map area. This calculation is based on total cluster heat demand divided by indicative pipe trench length. Linear heat density was assessed as areas of higher linear heat density provide a greater annual load whilst minimising capital costs and heat loss on distribution pipework. Although linear heat density does not consider pipe diameter it provides a high level indicator for the potential viability of network options and phases.

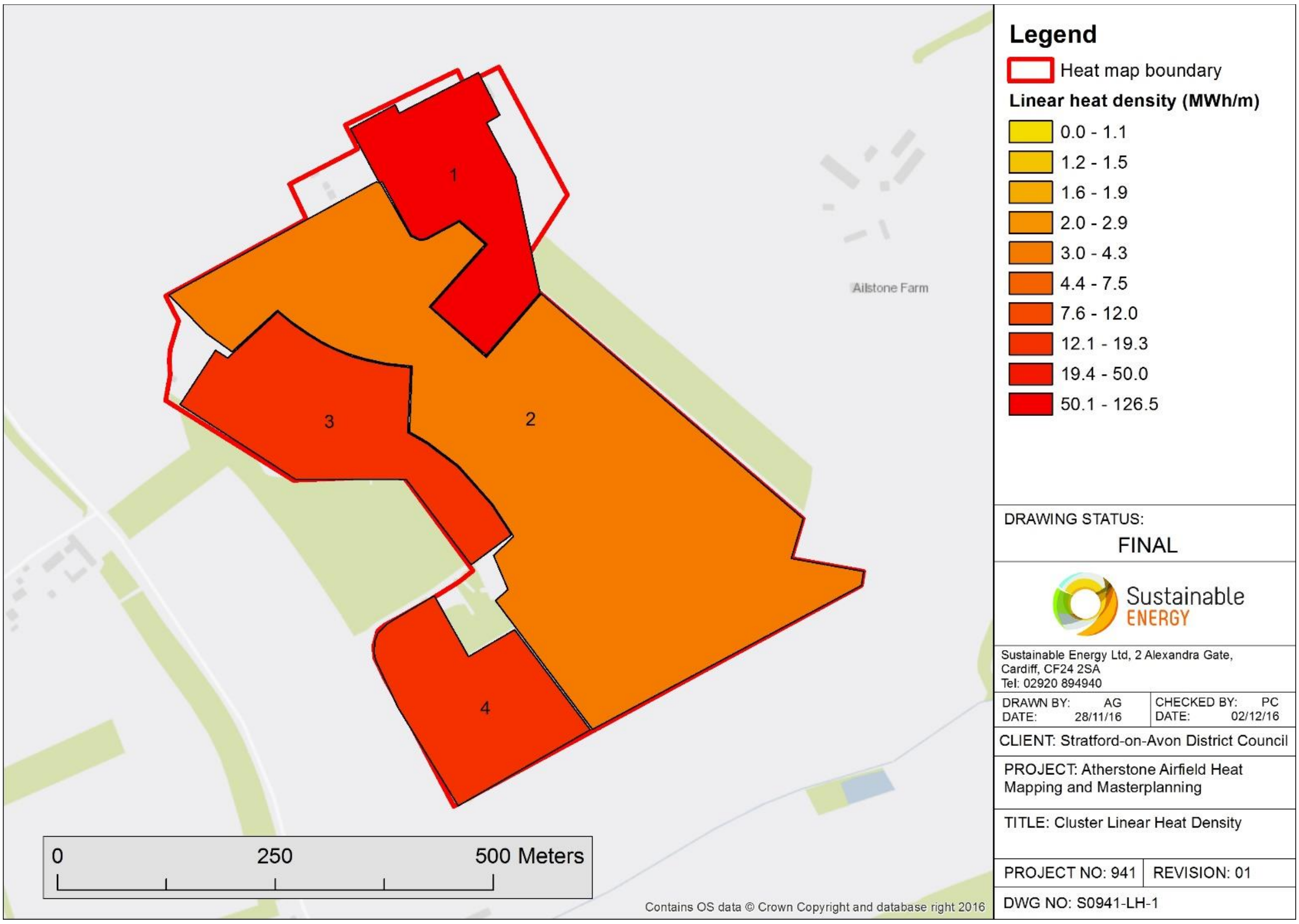


Figure 15: Linear heat density for the heat map area

The linear heat density for cluster 1 (Camgrain and Expel) is significantly higher (126 MWh/m) than any of the other clusters. Cluster 2 (Atherstone Airfield) has the lowest linear heat density at 3 MWh/m.

Table 8 outlines risks and issues for all clusters. This includes details of building use, linear heat density and risks, barriers and potential issues and concludes which clusters have been taken forward for further consideration.

Table 8: Cluster assessment

Cluster number	Cluster name	Total heat demand, MWh	Total electricity demand, MWh	Trench length, m	Linear heat density, MWh/m	Est. no. buildings	Key building uses	Risks and issues	Risk	Taken forward for further consideration?
1	Camgrain, Expel and RMCA	31,009	9,104	245	126	5	- Grain drying and storage - Oil seed processing	- Energy demands for RMCA planned development estimated based on actual demands for similar process - Energy profiles not available, consistent energy demand profiles have been assumed for process heat for grain drying and oil seed processing - Planned Syn2gen biomass CHP to supply energy to Camgrain and Expel development - Contact initially establish although further information requested not received	High	Yes
2	Atherstone Airfield	3,485	1,298	1,070	3	13	- Class B2/B8 (general industrial, storage or distribution)	- Limited development information currently available - Energy demands based on building uses similar to the Canal Quarter Regeneration Area - Development plans may change - Masterplan not yet developed - Opportunity for planners to engage with developers	High	Yes
3	Wealmoor	5,030	433	260	19	3	- Refrigerated storage, distribution and packaging warehouses	- Heat, electricity and cooling demands have been verified using CIBSE benchmark data and similar existing process from consultant database - Assumed cooling requirements could be met by heat network with absorption chiller - Contact not established - Timing of Wealmoor development unknown	High	Yes
4	Aviagen and Woodyard	3,157	679	210	15	3	- Chick hatchery - Small business units	- Heat, electricity and cooling demands for Aviagen have been calculated using information from plant specification - Heat and electricity demands for Woodyard have been verified using CIBSE benchmarks	High	Yes

3.2 Technology Options Assessment

Potential existing and planned energy sources within the heat map area have been assessed and are shown in Figure 11. The consultant team assessed the identified energy supply opportunities in relation to the technical suitability, key requirements and the cost implications on potential heat networks viability. The planned biomass CHP at Expel Oil Seed Processing Ltd has been identified as a potential energy source for the heat map area. High level technical viability considerations for alternative potential energy sources are summarised in Table 9.

Table 9 shows that biomass heat, biofuels CHP, and GSHP may be technically viable. Anaerobic digestion, energy from waste, gas CHP, deep geothermal and WSHP have not been taken forward for further assessment.

Table 9: Summary of potential heat sources

Technology	High level technical viability considerations	Taken forward for further consideration?
Anaerobic digestion	- Compatible with operating conditions of connecting buildings / processes - No plans for anaerobic digester facility within reasonable distance (Future Biogas Ltd facility ~0.7 km from heat map area)	No
Biomass heat	- Compatible with operating conditions of connecting buildings / processes - Unlikely to be potential for supply of wood fuel from Alscot Estate - Potentially cost effective carbon reduction technology (£ per tonne carbon) - Air quality - Likely to be sufficient space for energy centre and woodfuel delivery area in or surrounding heat map area	Yes
Biofuel CHP	- May be compatible with operating conditions of connecting buildings / processes - Improved financial viability achieved through private wire sales - Air quality - Potentially cost effective carbon reduction technology (£ per tonne carbon) - Uncertainty of long term future of RHI (ORC conditions recently changed) - Likely to be sufficient space for energy centre and woodfuel delivery area in or surrounding heat map area	Yes
Energy from Waste	- No plans for EfW within a feasible area - *Potentially* compatible with existing operating conditions - Potential air quality and visual impact issues	No
Gas CHP	- Gas not available at site	No
Deep geothermal	- The geothermal heat flow value for the Atherstone Airfield area is approximately 30-40 mW/m^2 and is unlikely to present a viable opportunity[4]	No
Ground source heat pump	- Likely to be sufficient space for vertical array in or surrounding heat map area - Lower water temperatures unlikely to be compatible with oil seed processing other than for pre-heat (steam required), potentially compatible with operating conditions of other buildings/sites	Yes, expect for Camgrain, Expel and RMCA
Water source heat pump	- No sufficiently large water sources identified in close proximity to heat map area (River Stour >600 m from heat map area)	No

[4] Figure from British Geological Survey heat flow map http://www.bgs.ac.uk/research/energy/geothermal/

3.3 Key Parameters for High Level Viability Assessment

3.3.1 Hydraulic Modelling

High level optimisation of the distribution network routes was assessed along with energy centre locations and considered issues such as:

- Routing through soft dig or development land as much as possible
- Trench excavation, backfilling and reinstatement costs for different ground conditions
- Hydraulic modelling of the network to generate a high level indicative network specification and calculation of heat distribution losses throughout the network
- Best practice and in accordance with the Heat Networks Code of Practice

The high level technical requirements for proposed developments were also considered to allow connection to the potential district energy network options including temperature, flow rates and other relevant requirements.

3.3.2 Technology / Heat Source Assessment

A high-level technology assessment was conducted to assess technical, financial, sustainability and environmental criteria of potential heat sources. These criteria include:

- Technology suitability/risk
- Financial performance including key sensitivities
- Availability of financial support
- Availability and sustainability of fuel and security of supply
- CO_2 reduction potential
- Cost per tonne of CO_2 saved (initial and potential) and other environmental impacts
- Development risk
- Timeframe for deliverability
- Cost savings to customers and developers
- Potential investment leverage including grant funding opportunities

Following a review of technical viability of selected technologies, the specific energy supply options that would be viable for both short term and long term for each specific option were identified.

3.3.3 Energy Centre Location

Potential energy centre locations have been considered based on land ownership, planned development sites, the barriers and risks identified in section 2.6 and discussion with planning officers from Stratford-on-Avon District Council. No areas of Council owned land where identified within or surrounding the heat map area and the only significant barrier identified is the SSSI to the west of the site. It has been assumed for these high level financial assessments that heat will either be supplied to a network from the Syn2gen biomass CHP or from an energy centre close to their site within the Atherstone Airfield development area. This area is shielded from view from nearby roads and dwellings, therefore increasing the likelihood that planning may be approved.

3.3.4 Plant Sizing and Thermal Storage

For each viable technology supply option, an indicative plant sizing exercise was undertaken to allow the hourly energy outputs from heating and CHP plant and thermal storage to be linked and modelled against the hourly heat and electricity demand profiles developed during the heat mapping stage. The outputs from the plant sizing software include a financial model that outlines savings on energy costs against base case, income from government incentives (taking into account ineligible distribution losses), indicative plant servicing and maintenance costs, alternative fuel costs, cost of parasitic electrical loads and carbon savings.

3.3.5 Private Wire Opportunities

In order to determine the potential for electricity supply via a private wire, the consultant team assessed the findings from the energy mapping and plant sizing exercises to identify the electrical demand within the key identified buildings and the anticipated output from a CHP plant within the designated networks. The identified network distribution route was then assessed for suitability to run a private wire alongside (in order to minimise costs). Indicative cable sizing will be undertaken based on supply capacity, length of distribution route and indicative costs sought for electrical connection and metering. The economic and technical advantages of a private wire versus exporting to the grid were then investigated.

3.3.6 High Level Financial Assessment

The high level financial assessment for each network option is presented to assess the financial case for building the entire network option presented. The capital costs for all identified opportunities includes costs for plant and equipment supply and installation, energy centre construction, distribution pipe work supply and installation, trench excavation and re-instatement. Indicative costs were also identified for the necessary integration works within existing buildings to connect to a district heating network. Network costs were varied in accordance with identified network constraints, e.g. decreased trenching costs for development areas.

Energy sale prices for network options are based on a 5 % reduction on current customer tariffs or current tariffs for similar buildings (specific to customer category) within the local area. Oil and electricity purchase prices for energy centres are derived from current tariffs for the area taken from utility company quotes. Woodfuel costs are derived from appropriate current costs.

RHI has been included on all network options that incorporate eligible technologies (biomass heat, biomass CHP and GSHP). The maximum tariffs proposed for 2017 have been used and sensitivity applied in 4.2.2. RHI has not been included for network options served by heat offtake as it has been assumed that the heat generator would receive the income from RHI, as opposed to the network operator. The benefit of RHI income received by the heat generator has been reflected in the assumed heat offtake tariffs for the network assessments.

3.4 Initial Network Options

An assessment of initial network options has been undertaken for all technology options identified in section 3.2. Table 10 summarises the initial network options. The network options taken forward for further consideration are shown in orange, networks with less favourable financial viability are shown in light grey and options that were not technically viable or not assessed are shown in dark grey.

Four scenarios have been assessed as follows:

- Scenario 1: Expel Oil Seed Processing Ltd development is brought forward without biomass CHP
- Scenario 2: Assumed energy to Camgrain, Expel development and RMCA development is supplied by Expel biomass CHP, separate network developed for remainder of heat map area
- Scenario 3: Network connects Atherstone Airfield development and all Wealmoor buildings
- Scenario 4: Network connects Atherstone Airfield development only

Heat offtake from the Syn2gen biomass CHP has not been assessed for Scenario 1 as this scenario assumes that the planned biomass CHP is not brought forward. For the remaining scenarios it has been assumed that the Syn2gen biomass CHP is brought forward with a spare capacity of 2 MW for 8,000 hours a year, and the network operator would purchase the heat from the biomass CHP operator at a fixed heat offtake tariff. A heat offtake tariff[5] of 2.5 p/kWh has been assumed for the above initial network assessments. Sensitivity analysis has been undertaken to show the effect that an increase or decrease of heat offtake tariff as on the high level IRR, this is shown in 4.2.2. In addition to the heat offtake tariff, the biomass CHP operator could also receive RHI on the heat sold to the network operator therefore receiving approximately 4.5 p/kWh for heat.

A GSHP is not technically viable for Scenario 1 as the oil seed processing facilities require a high temperature network. GSHP may be technically viable for Scenario 2 if the Wealmoor cooling demands and Aviagen heat and cooling demands can be met by a low temperature network (using absorption chillers for the cooling).

Table 10: Initial network options

Cluster number	Cluster name	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	Camgrain, Expel and RMCA				
2	Wealmoor				
3	Atherstone Airfield				
4	Aviagen and Woodyard				
Low carbon technology		**High level 25 year IRR**			
Biomass heat		18.2 %	6.3 %	-8.6 %	No IRR
Biomass CHP		21.8 %	7.6 %	-6.1 %	No IRR
GSHP		Not technically viable	6.7 %	-2.0 %	-8.0 %
Heat offtake from Syn2gen biomass CHP (assumed heat offtake tariff of 2.5 p/kWh)		Not assessed	8.8 %	-1.9 %	-7.1 %

Networks at Atherstone Airfield are likely to require private sector investment, therefore, a hurdle rate of 12 % has been assumed. Network options with IRRs of over 5 % have been taken forward for further consideration to identify the requirements for these to reach the hurdle rate for private sector investment (e.g. increase in heat sales tariffs, decrease in wood fuel costs, etc.).

Of the network options assessed, scenarios 1 and 2 have been identified for further assessment. These network options, shown in orange in Table 10, are discussed further in section 3.5. High level financial cases for all network options shown in Table 10 can be found in Appendix 7 – Financial Viability Assessments. Sensitivity analysis has been undertaken for these network options and is shown in section 1.1. Sensitivity analysis has also been undertaken for the Scenario 3 network served by heat offtake from the Syn2gen biomass CHP in order to establish the requirements for this network option to reach the assumed hurdle rate. This is shown in section 4.2.3.

[5] The heat offtake tariff is the tariff for purchasing heat from the Syn2gen biomass CHP. This has been assumed as 2.5 p/kWh based on previous project experience.

3.5 Network Option Assessment

3.5.1 Scenario 1

The Scenario 1 network is shown in Figure 16 with details shown in Table 11 and Table 12. The network connects all buildings within the heat map area with the exception of Smiths Concrete.

Table 11: Scenario 1 network summary

No. connections	Trench length	Total heat demand	Peak heat demand	Heat losses	Key heat loads
22	1.9 km	42,258 MWh	6,224 MW	2 %	- Camgrain and Expel Oil Seed Processing Ltd planned development - RMCA planned development

Table 12: Scenario 1 network connections

Map ref.	Name	Ownership	% overall heat demand	% overall private wire demand	Source of energy data
1	Camgrain and Expel	Camgrain and Expel Oil Seed Processing Ltd	68 %	73 %	Planning application energy statement
2	RMCA	RMCA	7 %	6 %	Verified based on data for similar process
3	Wealmoor planned development	Wealmoor	3 %	<1 %	Verified using benchmark data (CIBSE TM46)
4	Wealmoor, cold store	Wealmoor	8 %	3 %	Verified using benchmark data (CIBSE TM46)
5	Atherstone Airfield planned development	Planned development	5 %	11 %	Verified using benchmark data (CIBSE Guide F)
6	Wealmoor, packaging store	Wealmoor	1 %	<1 %	Verified using benchmark data (CIBSE TM46)
7	Woodyard, units 5-7	Planned development	<1 %	<1 %	Verified using benchmark data (CIBSE Guide F)
8	Woodyard, units 1-4	Planned development	<1 %	<1 %	Verified using benchmark data (CIBSE Guide F)
9	Aviagen	Aviagen	7 %	5 %	Calculated based on ChickMaster datasheet from planning application

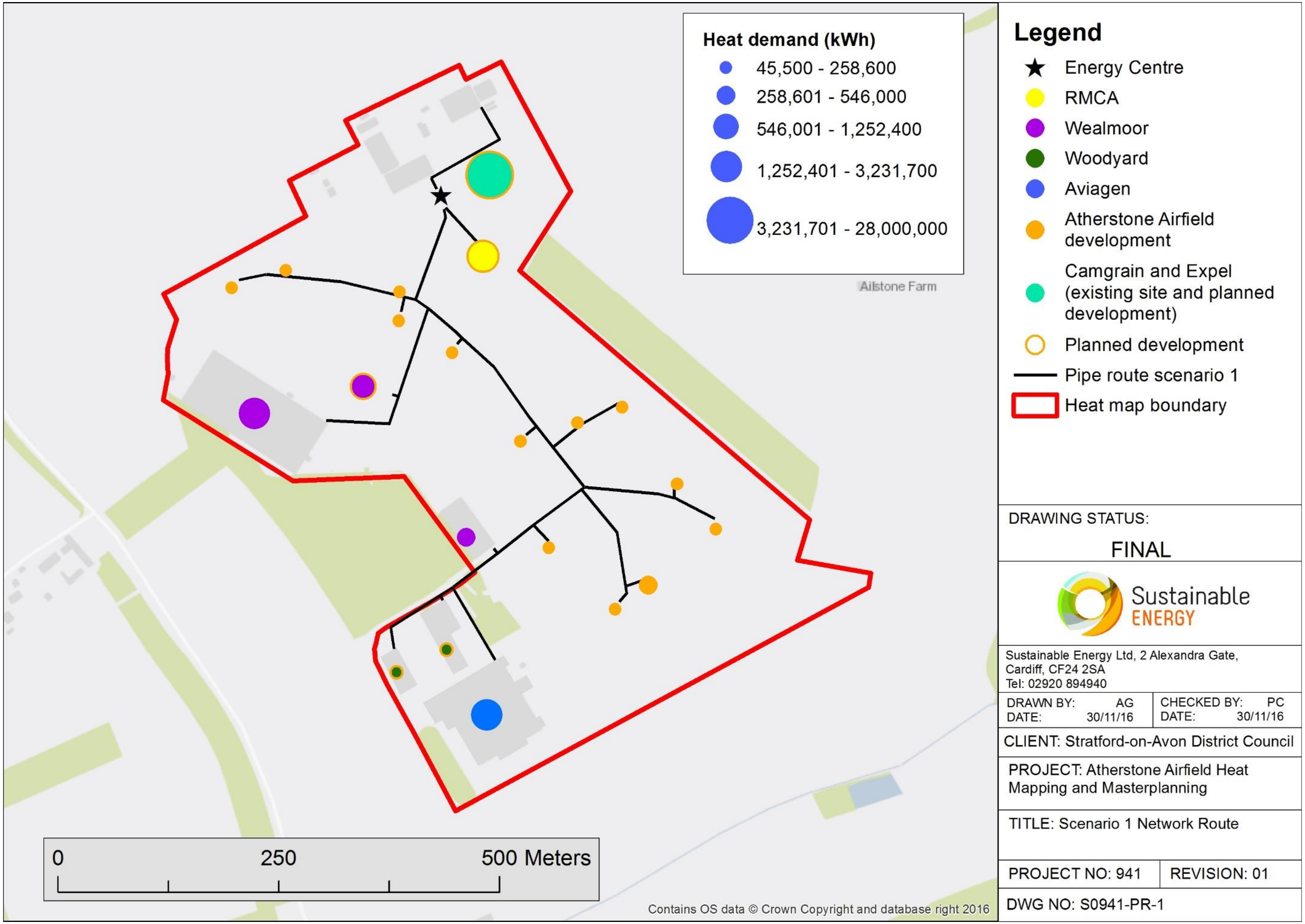


Figure 16: Scenario 1 network route

Heat Demand Categories

Figure 17 categorises the ownership of key heat loads within the network based on the total heat demand. 68 % of the heat demand arises from Camgrain and the Expel Oil Seed Processing Ltd planned development combined heat demand. 5 % arises from the Atherstone Airfield development.

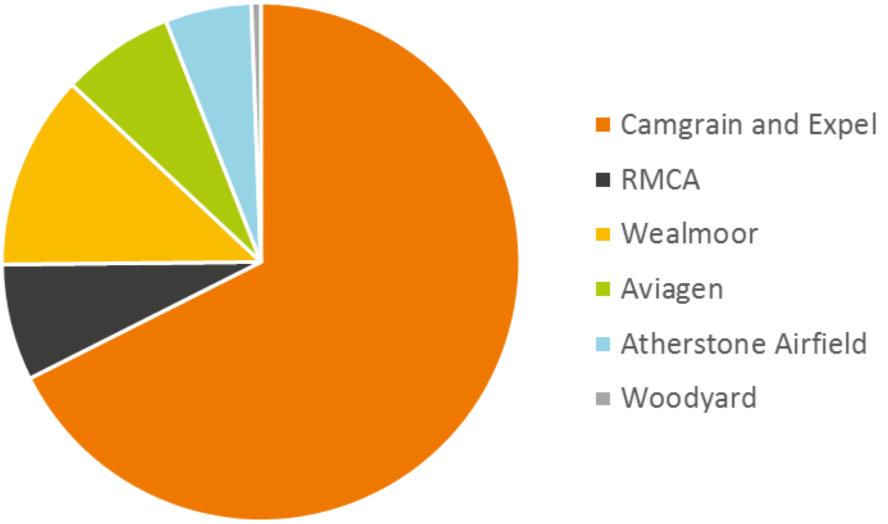


Figure 17: Scenario 1 heat demand ownership

Hourly Heat Demand Profile

The combined hourly heat demand profile for all network connections and including network heat losses is shown in Figure 18. The average, maximum and minimum heat demands for the network are shown in yellow, orange and black respectively over 24 hours. The peak heat demand can be seen as approximately 6.2 MW occurring at 09:00 am. Daily profiles for a winter and summer month are shown in Appendix 6 – Heat Demand Modelling.

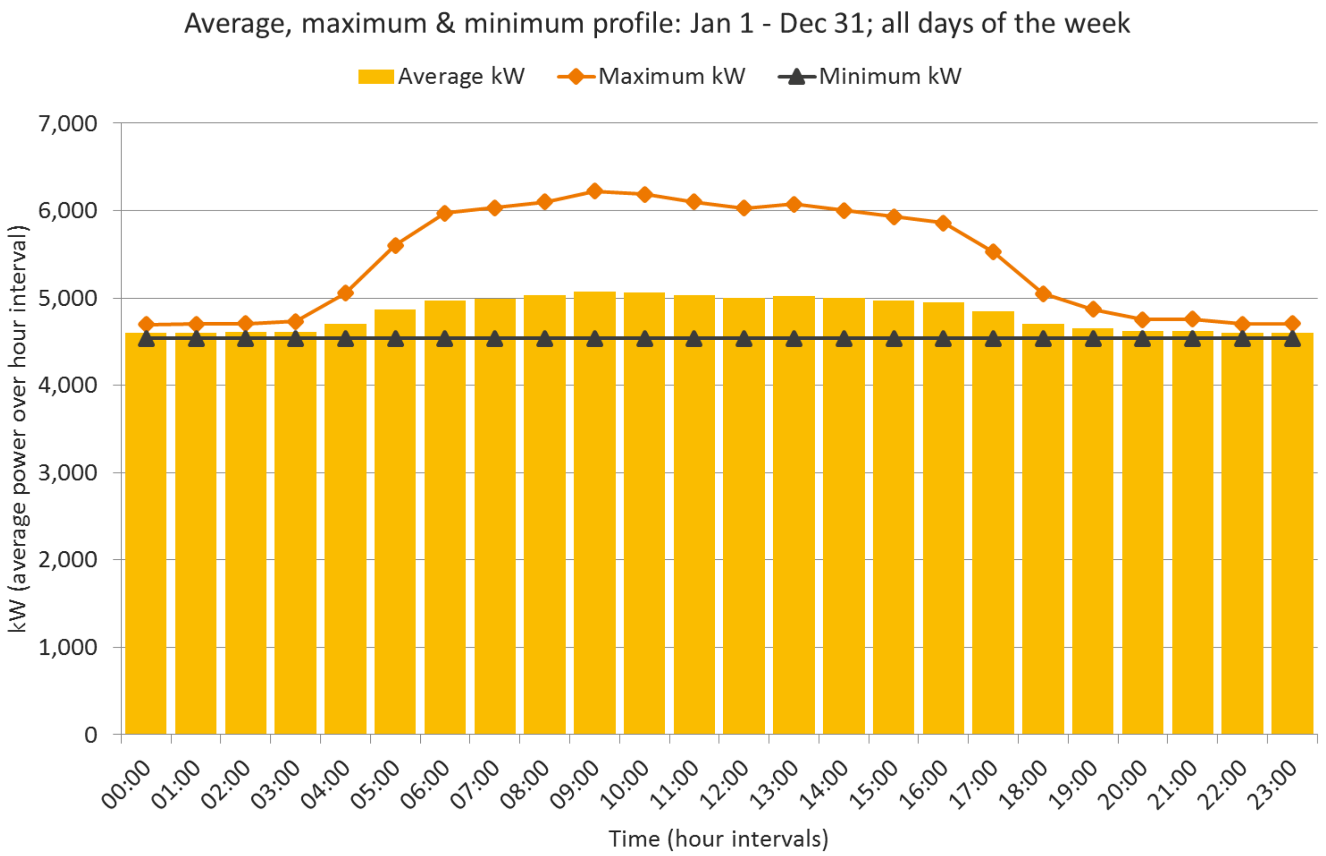


Figure 18: Scenario 1 network average daily heat demand

Figure 19 shows the hourly network heat demand for every hour of a year ordered from highest to lowest. The orange line shows the maximum heat output from the biomass CHP and the black line shows the maximum heat output from the biomass boiler; the demand above theses lines will be met by the thermal storage and peak and reserve oil boilers. The biomass CHP (with thermal storage) will be able to meet over 85 %[6] of the total network heat demand, including heat losses in the network. The biomass boiler will be able to meet over 90 % of the total network heat demand. The financial cases for both biomass heat and biomass CHP have been modelled with 2 biomass CHP units or 2 biomass boiler units (both single and multiple unit CHP options have been assessed, the most viable option has been presented here). A thermal store size of 100,000 litres has been assumed based on previous project experience and high level thermal store sizing. Thermal store sizing should be reassessed at the feasibility stage.

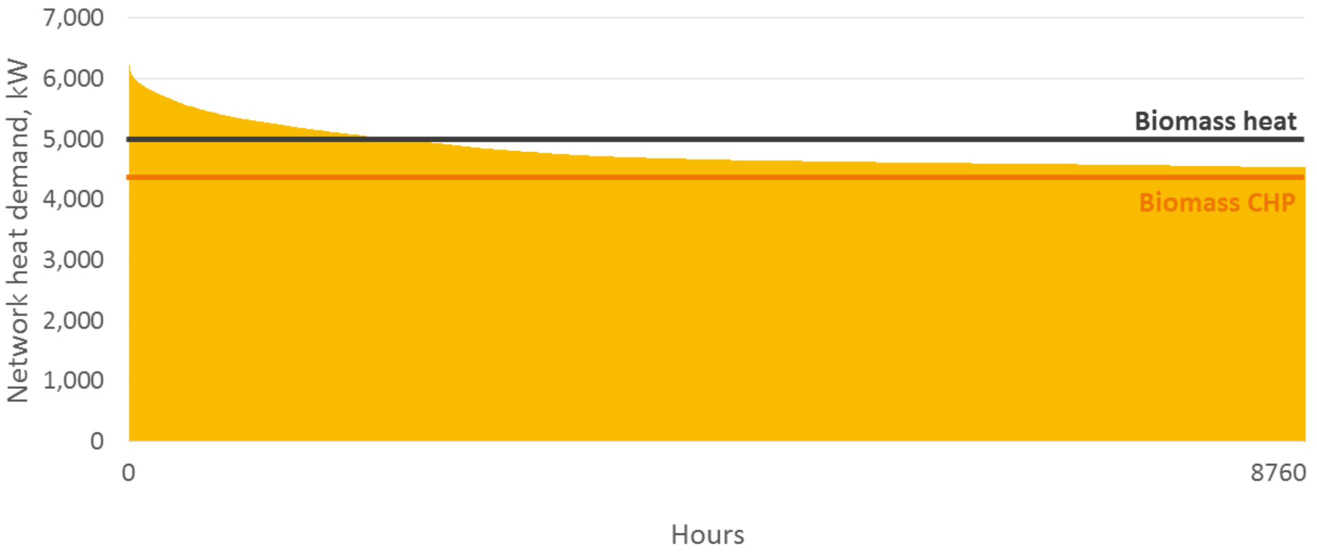


Figure 19: Load duration curve for Scenario 1 network

Operating conditions

Operating conditions assume that the network is a steam network for Camgrain, Expel and RMCA with a step-down to a LTHW system for the remainder of the network. As the LTHW network supplies existing buildings as well as planned developments, target network distribution flow temperatures in peak demand periods are likely to be 85 °C and return temperatures may be optimised to a maximum of 55 °C (maintaining ΔT 30 °C), whereas summer demands could be met with reduced flow temperatures of 75 °C and average return temperatures of 45 °C. Design for the system network would be that seasonal heat losses to not exceed 10 % of the sum of the estimated annual heat consumption of all the buildings connected[7].

The existing buildings considered for connection incorporate secondary systems that may include calorifiers, AHUs and ChickMaster units (see Appendix 3 – Planned Developments) that will impact on the target flow and return temperatures. If this project is progressed to the feasibility stage then detailed plant room and building surveys should be conducted to assess these issues, highlight potential impacts upon network operation and make practical recommendations to minimise potential impacts (such as replacing calorifiers with plate heat exchangers). As buildings are modified to improve efficiency, network temperatures should be lowered.

Energy Centre

An energy centre and woodfuel delivery area to accommodate either a 5 MW biomass boiler or a 4.1 MWth biomass CHP would require a land area of approximately 3,000 m^2. It has been assumed that this would be located to the north of the heat map area in place of the planned Syn2gen biomass CHP within the Expel Oil Seed Processing Ltd planned development.

High Level Financial Appraisal

The 25 year and 40 year high level financial cases for a biomass boiler or a biomass CHP are shown in Table 13.

[6] CIBSE Heat Networks Code of Practice states that best practice would be for the primary low carbon heat source to deliver 75 to 80% of the annual heat demand

[7] The CIBSE/ADE Heat Networks Code of Practice states that the calculated annual heat loss from the network up to the point of connection to each building when fully built out is typically expected to be less than 10 %

Table 13: 25 and 40 year high level financial cases for the Scenario 1 network

		Biomass heat		Biomass CHP	
Financial case period		**25 years**	**40 years**	**25 years**	**40 years**
Low carbon technology heat output		5,000 kWth		4,100 kWth	
Low carbon technology electrical output		-		950 kWe	
Number of units		2		2	
% network heat demand supplied by low carbon technology		>90 %		>80 %	
Annual electricity generated		-		7,767 MWh	
% generated electricity sold via private wire[8]		-		100 %	
Capital expenditure	**Energy source costs**	£5,251,000		£5,021,000	
	Network costs	£2,888,610		£3,544,794	
	Contingency	20 %		20 %	
	Total	£9,767,532		£10,278,953	
IRR		18.2 %	17.4 %	21.8 %	21.2 %
Net present value		£20,740,475	£24,368,134	£29,167,434	£36,803,641
Simple payback		6 years	7 years	5 years	6 years
Annual carbon saving		13,009 tonnes		13,843 tonnes	

If the majority of potential heat demands connect to the network then, under the assumptions stated in Table 28 in Appendix 7 – Financial Viability Assessments, a network served by either biomass heat or biomass CHP is likely to be financially viable.

Building connection costs have been included for existing buildings and varied based on heat, electricity and cooling demand. Building connection costs have not been included for planned developments as it has been assumed that developers would install HIUs / plate heat exchangers in place of boilers. Trench costs have been varied in accordance with digging conditions with lower costs applied for trenches crossing development land as it has been assumed the heat and private wire network could be installed at the same time as the planned development is built out.

Key Network Risks and Considerations

This network option is likely to be financially viable achieving the hurdle rate required for private sector development and investment (>12 %).

The key risks associated with developing this network include:

- If the planned biomass CHP at Expel Oil Seed Processing Ltd is brought forward to supply Camgrain, the Expel development and the RMCA development then this scenario is not an option
- Atherstone Airfield development connections reduce overall IRR and so will not be attractive to the private sector.
- Engagement with and between a diverse range of private sector stakeholders
- Identifying and agreeing a suitable land area for an energy centre within proximity to the network

Until all key heat loads are engaged in the project, and an energy centre location can be agreed, this scenario presents a medium to high risk opportunity. High level financial case sensitivity and risk for this option are further assessed in Chapter 4.

[8] Percentage of power generated by CHP plant supplied to network via private wire arrangements, the remainder of the power generated is exported to the grid

3.5.2 Scenario 2

The Scenario 2 network is shown in Figure 20 with details shown in Table 14 and Table 15. The scenario assumes that energy for Camgrain, Expel and the RMCA development is supplied by the proposed Syn2gen biomass CHP. The Scenario 2 network therefore connects all other buildings within the heat map area with the exception of Smiths Concrete.

Table 14: Scenario 2 network summary

No. connections	Trench length	Total heat demand	Peak heat demand	Heat losses	Key heat loads
19	1.6 km	11,097 MWh	2,663 MW	6 %	- Wealmoor, cold store - Aviagen

Table 15: Scenario 2 network connections

Map ref.	Name	Ownership	% overall heat demand	% overall private wire demand	Source of energy data
3	Wealmoor planned development	Wealmoor	12 %	3 %	Verified using benchmark data (CIBSE TM46)
4	Wealmoor, cold store	Wealmoor	31 %	13 %	Verified using benchmark data (CIBSE TM46)
5	Atherstone Airfield planned development	Planned development	21 %	52 %	Verified using benchmark data (CIBSE Guide F)
6	Wealmoor, packaging store	Wealmoor	5 %	2 %	Verified using benchmark data (CIBSE TM46)
7	Woodyard, units 5-7	Planned development	<1 %	1 %	Verified using benchmark data (CIBSE Guide F)
8	Woodyard, units 1-4	Planned development	2 %	2 %	Verified using benchmark data (CIBSE Guide F)
9	Aviagen	Aviagen	28 %	25 %	Calculated based on ChickMaster datasheet from planning application

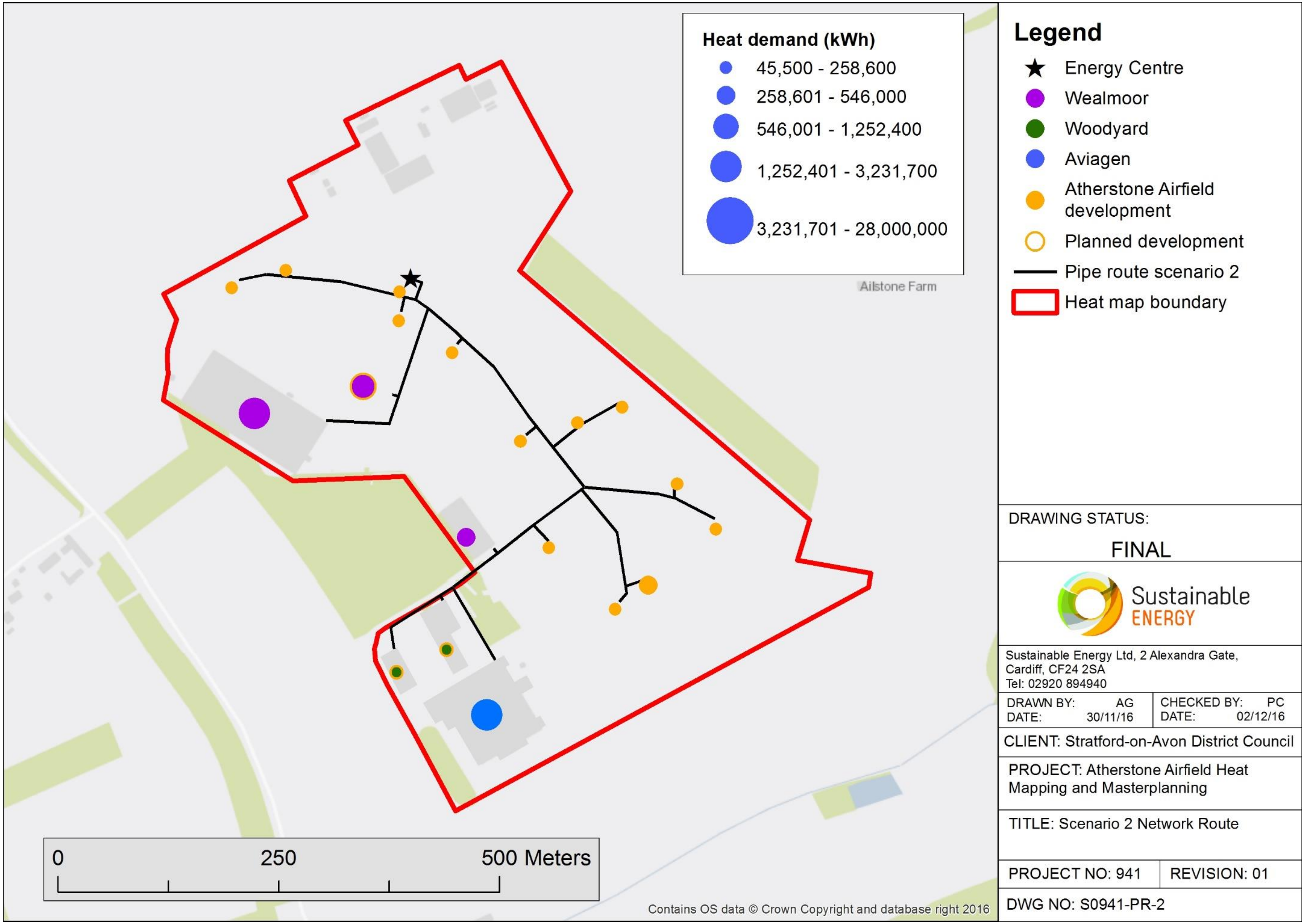


Figure 20: Scenario 2 network route

Heat Demand Categories

Figure 21 categorises the ownership of key heat loads within the network based on the total heat demand. 48 % of the heat demand arises from Wealmoor and 21 % arises from the Atherstone Airfield development.

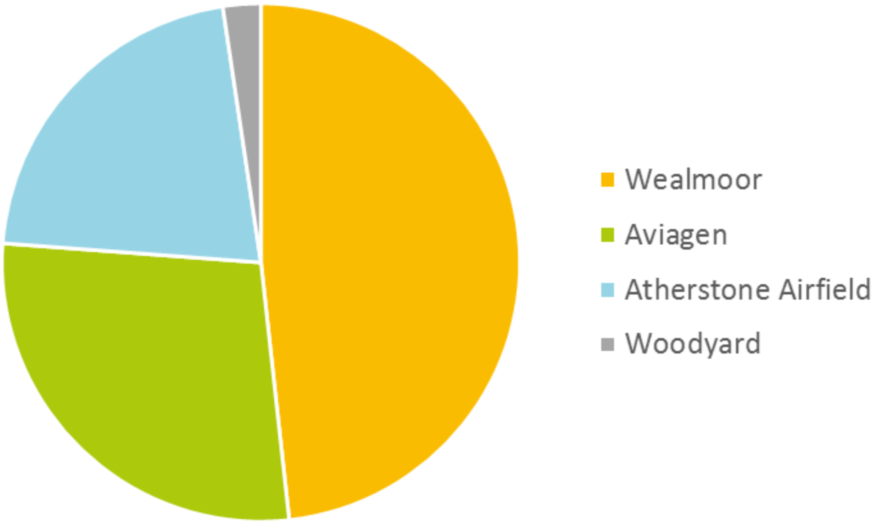


Figure 21: Scenario 2 heat demand ownership

Hourly Heat Demand Profile

The hourly heat demand profile showing the average, maximum and minimum heat demands for the network over 24 hours is shown in Figure 22. The peak heat demand can be seen as approximately 2.6 MW occurring at 09:00 am. Daily profiles for a winter and summer month are shown in Appendix 6 – Heat Demand Modelling.

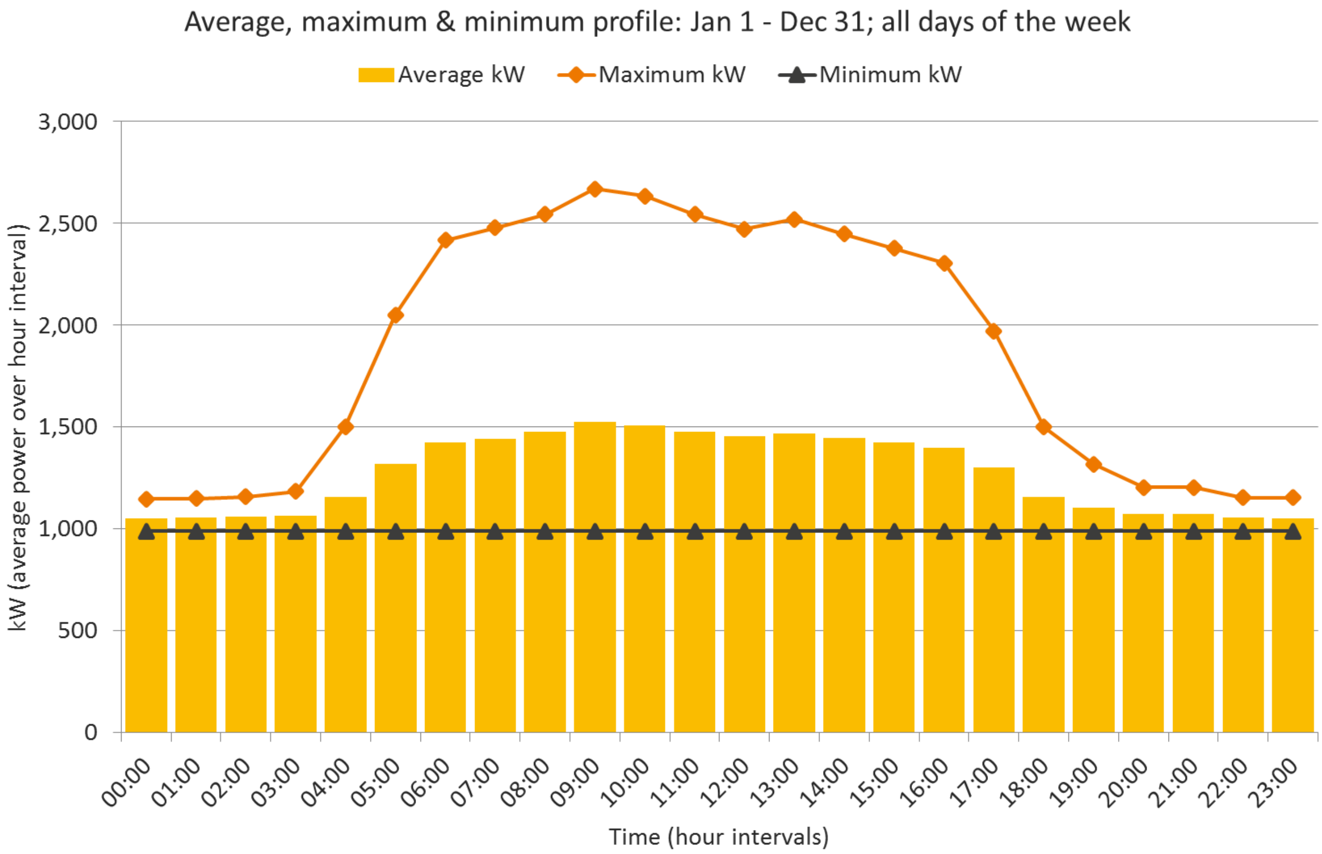


Figure 22: Scenario 2 network average daily heat demand

Figure 23 shows the hourly network heat demand for every hour of a year ordered from highest to lowest. The orange line shows the maximum heat output from the biomass boiler or GSHP and the black line shows the maximum heat output from the biomass CHP or the heat offtake capacity; the demand above theses lines will be met by the thermal storage and peak and reserve oil boilers. The biomass CHP or GSHP (with thermal storage) will be able to meet over 85 %[9] of the total network heat demand, including heat losses in the network. The biomass boiler or heat offtake will be able to meet over 95 % of the total network heat demand. The financial cases for both biomass heat and biomass CHP have been modelled with 1 biomass CHP unit or 1 biomass boiler unit (both single and multiple unit CHP options have been assessed, the most viable option has been presented here). A thermal store size of 50,000 litres has been included. Thermal store sizing should be reassessed at the feasibility stage.

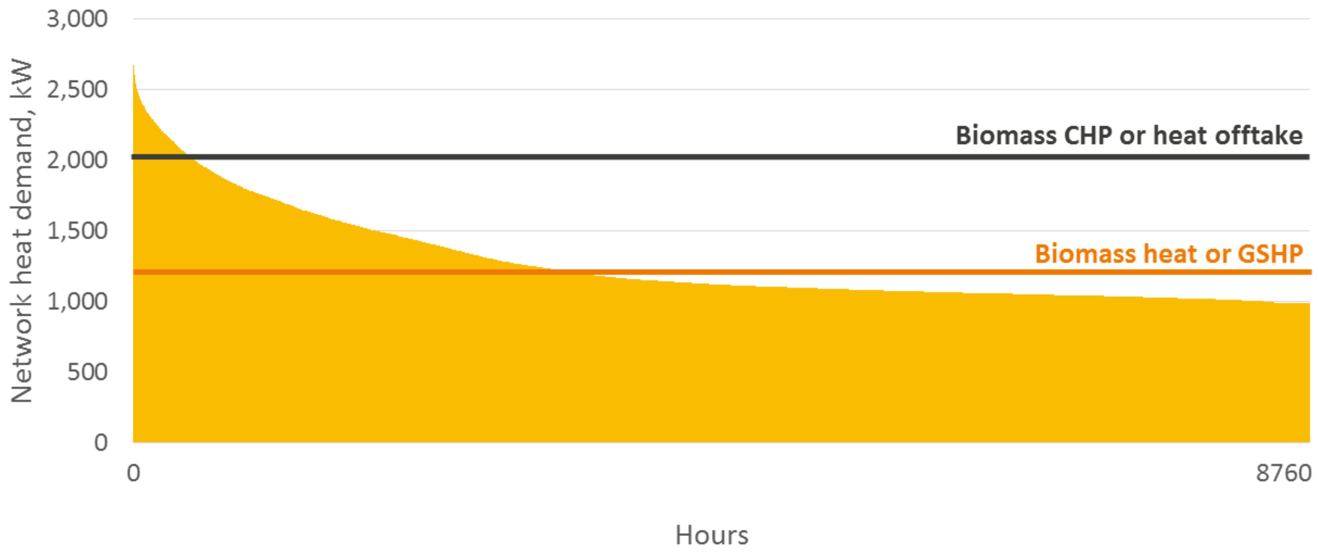


Figure 23: Load duration curve for Scenario 2 network

Operating conditions

Operating conditions assume that the network is a LTHW system. As the network supplies existing buildings as well as planned developments, target network distribution flow temperatures in peak demand periods are likely to be 85 °C and return temperatures may be optimised to a maximum of 55 °C (maintaining ΔT 30 °C), whereas summer demands could be met with reduced flow temperatures of 75 °C and average return temperatures of 45 °C. Design for the system network would be that seasonal heat losses to not exceed 10 % of the sum of the estimated annual heat consumption of all the buildings connected[10].

The existing buildings considered for connection incorporate secondary systems that may include calorifiers, AHUs and ChickMaster units (see Appendix 3 – Planned Developments) that will impact on the target flow and return temperatures. If this project is progressed to the feasibility stage then detailed plant room and building surveys should be conducted to assess these issues, highlight potential impacts upon network operation and make practical recommendations to minimise potential impacts (such as replacing calorifiers with plate heat exchangers). As buildings are modified to improve efficiency, network temperatures should be lowered.

Energy Centre

An energy centre and delivery area to accommodate either a 1.2 MW biomass boiler or a 2 MWth biomass CHP would require a land area of approximately 1,500 m^2. An energy centre to accommodate a 1.2 MW GSHP would require a land area of approximately 300m^2. For a vertical array, approximately 115 vertical boreholes would be required. It has been assumed that this would be located to the north of the heat map area adjacent to the planned Syn2gen biomass CHP within the Expel Oil Seed Processing Ltd planned development. It has been assumed that vertical boreholes for a GSHP could be located to the north east of the heat map area on the former airfield land.

High Level Financial Appraisal

The 25 year and 40 year high level financial cases for a biomass boiler, biomass CHP, GSHP or heat offtake from Syn2gen biomass CHP are shown in Table 16.

[9] CIBSE Heat Networks Code of Practice states that best practice would be for the primary low carbon heat source to deliver 75 to 80% of the annual heat demand

[10] The CIBSE/ADE Heat Networks Code of Practice states that the calculated annual heat loss from the network up to the point of connection to each building when fully built out is typically expected to be less than 10 %

Table 16: 25 and 40 year high level financial cases for the Scenario 2 network

		Biomass heat		Biomass CHP	
Financial case period		**25 years**	**40 years**	**25 years**	**40 years**
Low carbon technology heat output		1,200 kWth		2,050 kWth	
Number of units		1		1	
% network heat demand supplied by low carbon technology		>85 %		>90 %	
Annual electricity generated		-		2,396 MWh	
% generated electricity sold via private wire[11]		-		84 %	
Capital expenditure	**Energy source costs**	£1,377,000		£2,458,000	
	Network costs	£2,527,531		£3,099,675	
	Contingency	20 %		20 %	
	Total	£4,685,438		£6,669,210	
IRR		6.3 %	6.5 %	7.6 %	7.9 %
Net present value		£1,535,018	£2,070,773	£3,346,979	£4,681,298
Simple payback		12 years	13 years	11 years	12 years
Annual carbon saving		2,965 tonnes		4,058 tonnes	
		GSHP		**Heat offtake**	
Financial case period		**25 years**	**40 years**	**25 years**	**40 years**
Low carbon technology heat output		1,200 kWth		2,000 kWth	
Number of units		2		-	
% network heat demand supplied by low carbon technology		>85 %		>95 %	
Annual electricity generated		-		-	
% generated electricity sold via private wire		-		-	
Capital expenditure	**Energy source costs**	£3,161,775		£273,000	
	Network costs	£2,527,531		£2,527,531	
	Contingency	20 %		20 %	
	Total	£6,827,168		£3,360,638	
IRR		6.7 %	6.9 %	8.8 %	9.7 %
Net present value		£2,463,625	£3,377,201	£2,408,792	£4,170,906
Simple payback		12 years	13 years	11 years	11 years
Annual carbon saving		1,937 tonnes		3,275 tonnes	

Under the assumptions stated in Table 28 in Appendix 7 – Financial Viability Assessments, the network options shown in Table 16 are unlikely to reach the assumed hurdle rate for private sector investment (12 %).

Building connection costs have been included for existing buildings and varied based on heat, electricity and cooling demand. Building connection costs have not been included for planned developments as it has been assumed that developers would install HIU's in place of boilers. Trench costs have been varied in accordance with digging conditions with lower costs applied for trenches crossing development land as it has been assumed the heat and private wire network could be installed at the same time as the planned development is built out.

Key Network Risks and Considerations

The Scenario 2 is unlikely to be financially viable as it does not achieve the hurdle rate required for private sector development and investment (>12 %).

The key risks associated with developing this network include:

- Atherstone Airfield development connections reduce overall IRR and so will not be attractive to the private sector.
- Engagement with and between a diverse range of private sector stakeholders
- Identifying and agreeing a suitable land area for an energy centre within proximity to the network
- Engagement with Syn2gen/Expel Oil Seed Processing Ltd for heat offtake option

[11] Percentage of power generated by CHP plant supplied to network via private wire arrangements, the remainder of the power generated is exported to the grid

Until all key heat loads are engaged in the project, and either an energy centre location can be agreed or heat offtake from the Syn2gen biomass CHP can be secured, this scenario presents a high-risk opportunity. High level financial case sensitivity and risk for this option are further assessed in Chapter 4.

3.6 Atherstone Airfield development

The Scenario 3 network connects the Atherstone Airfield development and the 3 Wealmoor buildings. Initial network assessments established that the Scenario 3 network is unlikely to be financially viable based on the assumptions made in this study. The network option with the highest 25 year IRR was a network served by heat offtake from the Syn2gen biomass CHP with a high-level IRR of -1.9 %.

One of the key factors affecting the viability of this network option is the combined heat demand profile of the network connections. Figure 24 shows the hourly network heat demand, including network heat losses, for every hour of a year ordered from highest to lowest. The network has a low baseload during summer months, weekends and evenings with the network heat demand below 400 kW for more than 60 % of the year. The majority of this baseload arises from the cooling demand for the 3 Wealmoor buildings.

As the night time and summer demands are low the overall network demand is 'peaky' and less viable for renewable/low carbon technologies. Peak demands and low network demands (above the capacity and below the modulation limits of the renewable/low carbon technologies assessed) will need to be met by more expensive and carbon intensive fossil fuel boilers.

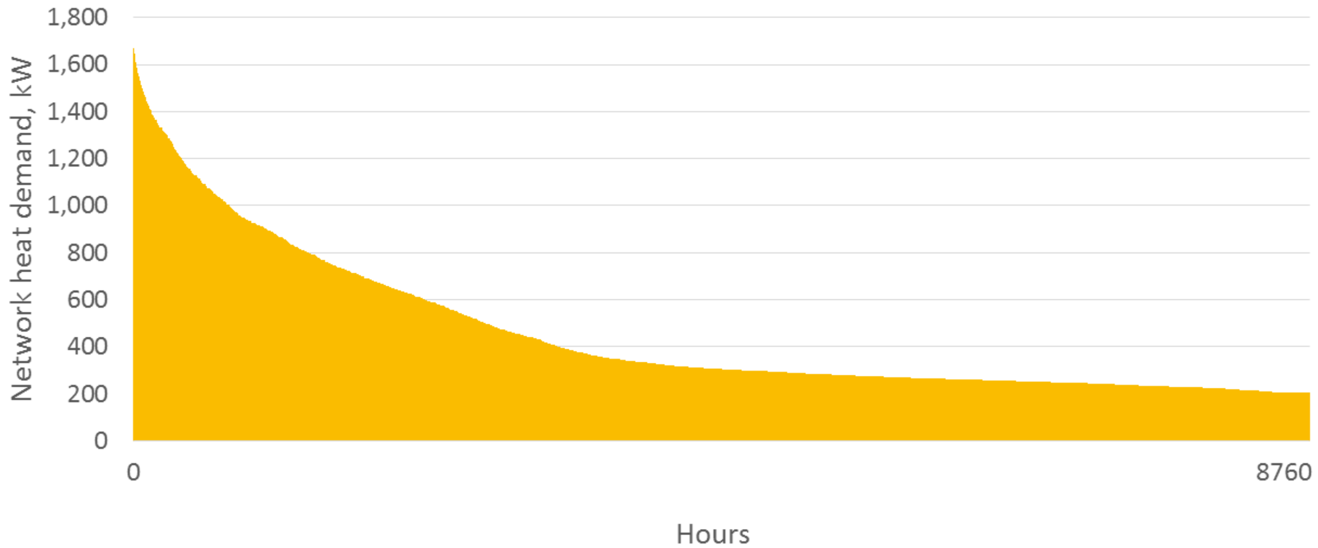


Figure 24: Load duration curve for Scenario 3 network

Figure 25 shows the load duration curve for Scenario 4. The Scenario 4 network connects the Atherstone Airfield development only without the existing or planned Wealmoor buildings. The heat demand profiles for the Atherstone Airfield development have been based on the building use, occupancy and operating hours of existing buildings within the Canal Quarter development area with low heat demand during the summer months and evenings and weekends. An increase in diversity of hourly head demand would increase the financial and technical viability of a network at Atherstone Airfield.

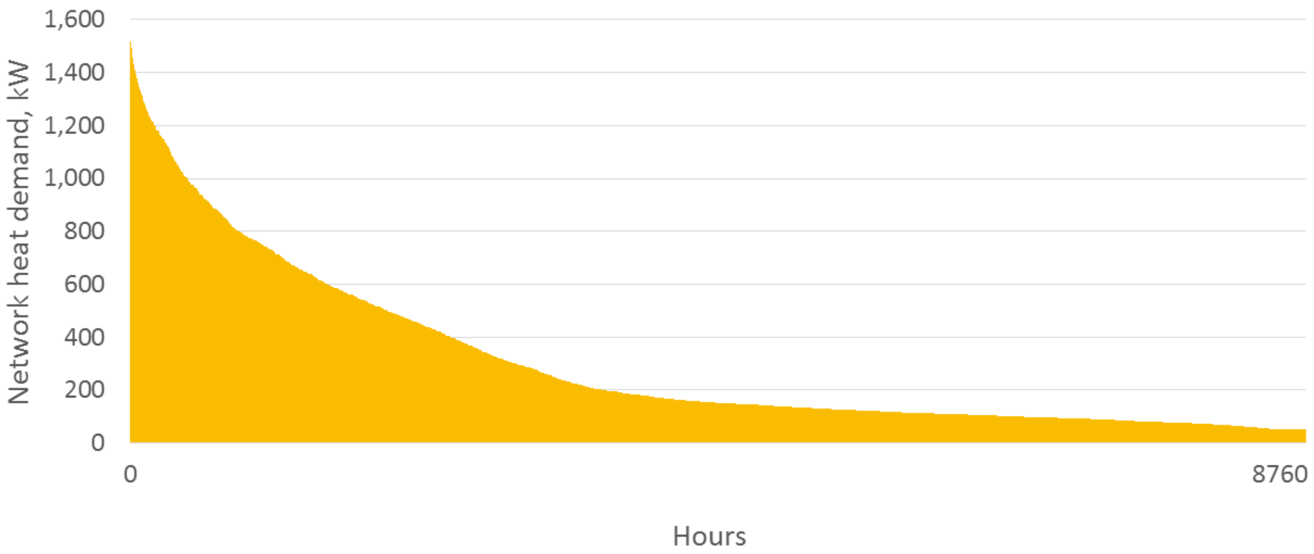


Figure 25: Load duration curve for Scenario 4 network

3.7 Summary

A summary of the network scenarios and options assessed is shown in Table 17. Two network opportunities have been identified within the Atherstone Airfield heat map area, namely:

- Scenario 1: Connecting all buildings within the heat map area (assume Syn2gen biomass CHP is not brought forward)
- Scenario 2: Connecting all buildings within the heat map area except for Camgrain, Expel Oil Seed Processing Ltd planning development and RMCA planned development (assumes Syn2gen biomass CHP is brought forward and supplies energy to Camgrain, Expel and RMCA only)

Scenario 1 is the most viable network opportunity with IRRs that are likely to meet private sector hurdle rates, however, as the Atherstone Airfield development connections reduce overall IRR they are unlikely to be attractive to the private sector. Scenario 2 has an IRR that would be likely to require grant funding, public sector investment or other further incentives to provide a viable financial case for private sector investment.

A network serving only the Atherstone Airfield planned development (not including the Wealmoor and RMCA planned developments) is not financially viable, based on the assumptions made in this study. However, if development plans were to change, or more heat intensive businesses (with higher summer heating or cooling demands) were attracted to the development, the financial viability of this network would increase. As the development of a network for the Atherstone Airfield site only is not financially viable, the site should not be allocated as a priority heat network area (unless heat intensive businesses with consistent heat demands are to locate at the site).

Additional key variables and the potential requirements for this network to become financially viable is discussed further in section 4.2.3.

Sensitivity analysis for potential network opportunities can be found in section 1.1. Sensitivity analysis for a network to serve the Atherstone Airfield development can be found in section 4.2.3. The associated risks and approach to engaging with developers are further assessed in sections 1.1 and chapter 5 respectively.

Table 17: Summary of network options

Scenario	Technology	Heat output of low carbon technology	Network trench length	Estimated CAPEX	Carbon savings	£/tCO_2	25 year financial case			40 year financial case		
							Simple payback	IRR	NPV	Simple payback	IRR	NPV
1	Biomass heat	5,000 kWth	1.9 km	£8,567,532	13,009 tpa	£659/tCO_2	6 years	20.7 %	£21,940,475	6 years	19.7 %	£25,568,134
	Biomass CHP	4,100 kWth		£9,078,953	14,666 tpa	£619/tCO_2	5 years	21.8 %	£29,167,434	6 years	21.2 %	£36,803,641
2	Biomass heat	1,200 kWth	1.7 km	£4,685,438	2,965 tpa	£1,175/tCO_2	12 years	6.3 %	£1,535,018	13 years	6.5 %	£2,070,773
	Biomass CHP	2,050 kWth		£6,669,210	4,058 tpa	£1,643/tCO_2	11 years	7.6 %	£3,346,979	12 years	7.9 %	£4,681,298
	GSHP	1,200 kWth		£6,827,168	1,937 tpa	£2,906/tCO_2	12 years	6.7 %	£2,463,625	13 years	6.9 %	£3,377,201
	Heat offtake from Syn2gen biomass CHP	2,000 kWth		£3,360,638	3,275 tpa	£660/tCO_2	11 years	8.8 %	£2,408,792	11 years	9.7 %	£4,170,906

4 ASSUMPTIONS, RISK AND SENSITIVITY ANALYSIS

4.1 Assumptions and Operating Parameters

Key operating parameters, financial values and assumptions used in this report are shown in Table 18 and Table 19. All proposals and assumptions are in line with available information the CIBSE/ADE Heat Networks: Code of Practice for the UK.

Table 18: Parameters used in financial assessments

Parameter	Value	Source of Data
Electricity price day for energy centre operation (p/kWh)	9.0	Average market value for local area
Electricity price night for energy centre operation (p/kWh)	6.0	
Electricity price export (p/kWh)	4.5	Current market rate
Cost for biomass fuel (p/kWh)	2.9	Conservative current market value for local area
Cost for oil for auxiliary fuel (p/kWh)	3.4	Average oil tariff for local area 2016
Efficiency of biomass boiler	80 %	Experience of operating plant
Efficiency of auxiliary oil boiler	85 %	Experience of operating plant
Efficiency of biomass CHP heat	16 %	Experience of operating plant
Efficiency of biomass CHP electricity	69 %	Experience of operating plant
Plant parasitic load (as % of Σ heat generated)	2 %	Experience of operating plant
RHI value	Proposed 2017 tariffs	Non-domestic RHI tariffs, Ofgem

Table 19: Heat and private wire electricity tariffs

Category	Price of heat sales, p/kWh	Private wire electricity day, p/kWh	Private wire electricity night, p/kWh
Wealmoor	5.40	9.50	6.00
Aviagen	6.08	9.50	6.00
Camgrain, Expel and RMCA	5.38	9.50	6.00
Atherstone Airfield development	4.03	9.50	6.00
Woodyard development	4.03	9.50	6.00

Table 20: Financial interest rate assumptions and sources of data

Financial interest rates	Value	Reference/Justification
Oil tariff	Varies annually	Department for Business, Energy and Industrial Strategy Fuel Price Projections – all electricity prices (private wire, export and grid) linked to the electricity services indexation All oil prices and heat tariffs linked to oil (services) indexation
Grid electricity tariff		
Electricity sales (private)		
Electricity sales (export)		
Value of heat sales		
Discount rate	3.5 %	Treasury Green Book
RPI	NA	Not used in this analysis. Prices are shown in real values

4.2 Sensitivity Analysis

The sensitivity of the high level financial cases for the network options presented in section 3.5 are shown below. Key parameters for analysis include capital cost, cost of woodfuel, cost of oil for auxiliary, heat sales income, private wire income, electricity export income and RHI income.

This sensitivity analysis will provide further insight into key risks (assessed in section 0) and inform the overall conclusions and recommendations of the study.

4.2.1 Heat Demand and Connection Risk

The figures below summarise the effect of a change in the total network heat demand on the financial viability of the network. A change in the network heat demand may arise if buildings do not connect to the network or future heat demand values differ from those used in this study. This is particularly likely for the Atherstone Airfield development as the heat demands have been based on high level development information. The figures below give an indication of how a decrease or increase in heat demands might affect the financial viability of networks. The figures show the total network heat demand required to achieve a 25 year IRR of 12 % as well as the total network heat demand broken down to show the demands from key network connections (grouped by building ownership/planned development).

Figure 26 shows the heat demand sensitivity analysis for the 25 year business case for Scenario 1. It can be seen that a significant decrease in total network heat demand would be required for the 25 year IRR to fall below 12 % if all other parameters remained the same. The key heat loads for this network are Camgrain and Expel, without this connection a network served by biomass heat or biomass CHP is unlikely to achieve an IRR of 12 % (as shown by Scenario 2).

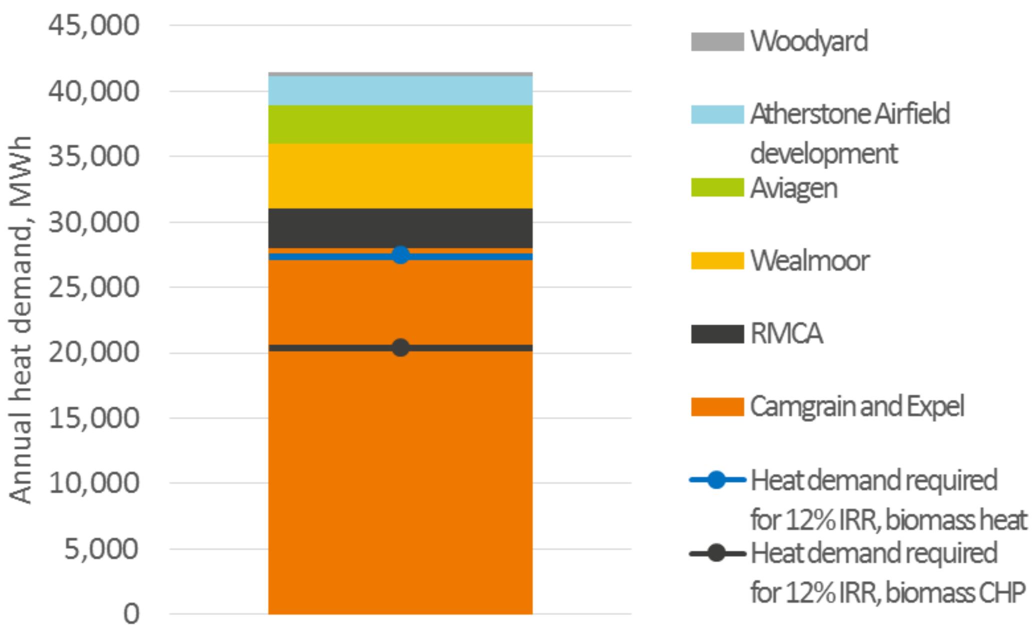


Figure 26: Sensitivity analysis for key heat demands for the Scenario 1 network

Figure 27 shows the heat demand sensitivity analysis for the 25 year business case for Scenario 2. It can be seen that a significant increase in total network heat demand would be required for the 25 year IRR to reach 12 % for a network served by a GSHP or biomass heat and a small increase in total network heat demand for a network served by biomass CHP or heat offtake. The key heat loads for this network are the 3 Wealmoor buildings.

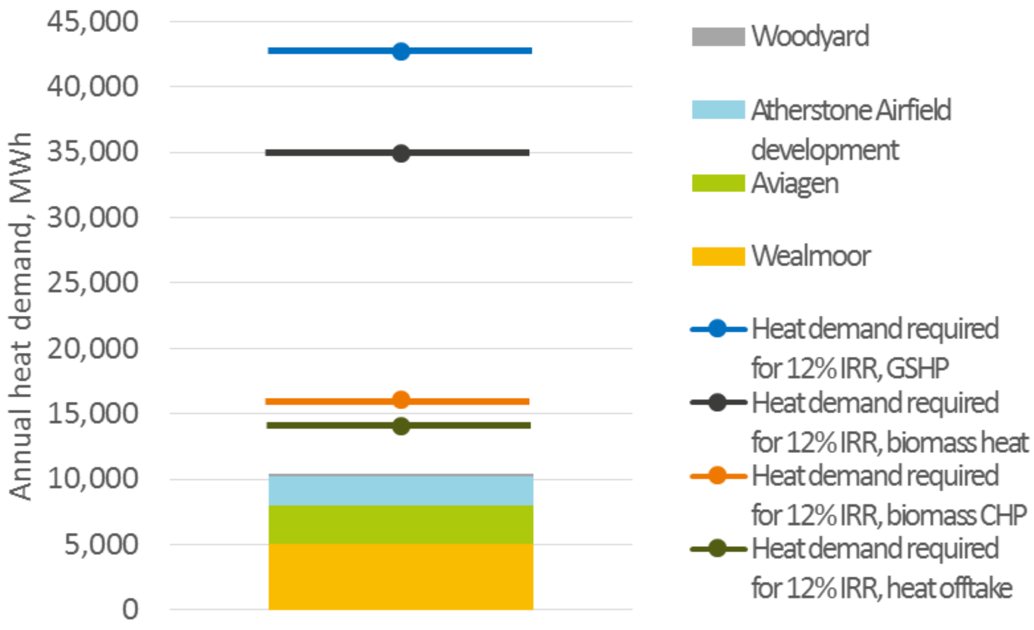


Figure 27: Sensitivity analysis for key heat demands for the Scenario 2 network

4.2.2 Identification of Key Variables for Potential Network Opportunities

This section considers the effect that key variables namely capital cost, cost of woodfuel, cost of oil for auxiliary, heat sales income, private wire income, electricity export income and RHI income have on the 25 year project IRR. A hurdle rate of 12 % IRR has been assumed for private sector investment.

Scenario 1

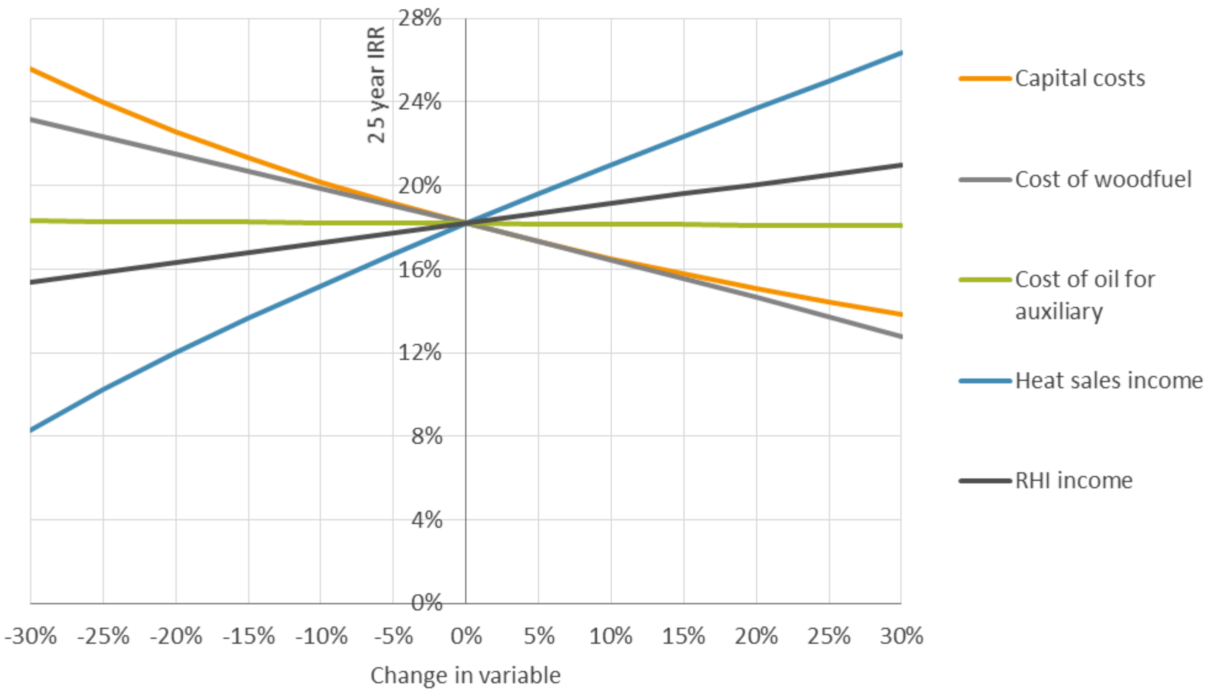


Figure 28: Scenario 1 network sensitivity analysis for biomass heat

Figure 28 shows the sensitivity analysis of the key variables for the Scenario 1 network served by a biomass boiler. Heat sales income, capital costs, cost of woodfuel and RHI income have the most significant effect on the financial case. For example, the high level 25 year IRR for the project has been assessed to be 18.2 %, if the heat sales income decreased by greater than 20 % the high level IRR for the project would decreased to below ~12 %. A decrease in heat sales income could arise by either a reduction in network heat demand or a reduction in heat sales tariff.

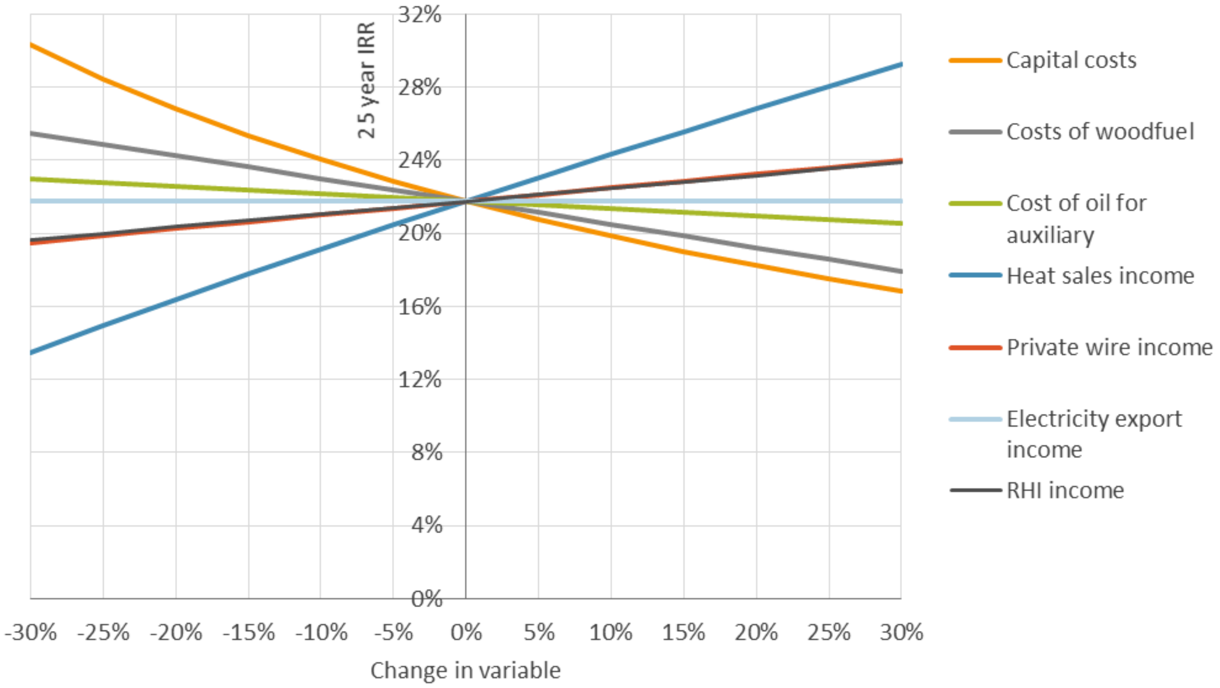


Figure 29: Scenario 1 network sensitivity analysis for biomass CHP

Figure 29 shows the sensitivity analysis of the key variables for the Scenario 1 network served by biomass CHP. Capital costs, heat sales income and cost of woodfuel have the most significant effect on the financial case. All key variables would require a variation of greater than 30 % for the high level 25 year IRR to be reduced to below the assumed hurdle rate of ~12 %.

Scenario 2

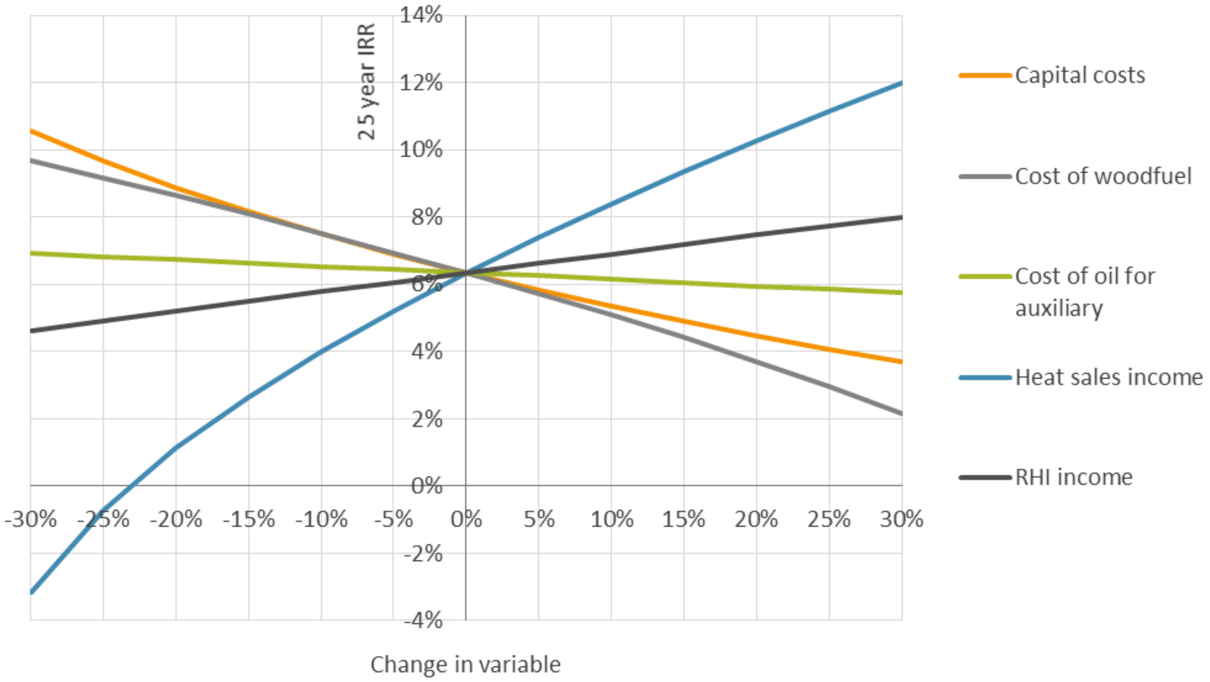


Figure 30: Scenario 2 network sensitivity analysis for biomass heat

Figure 30 shows the sensitivity analysis of the key variables for the Scenario 2 network served by a biomass boiler. Heat sales income, capital costs and costs of woodfuel have the most significant effect on the financial case. A 30 % increase in income from heat sales would be required to increase the high level 25 year IRR to above 12 %.

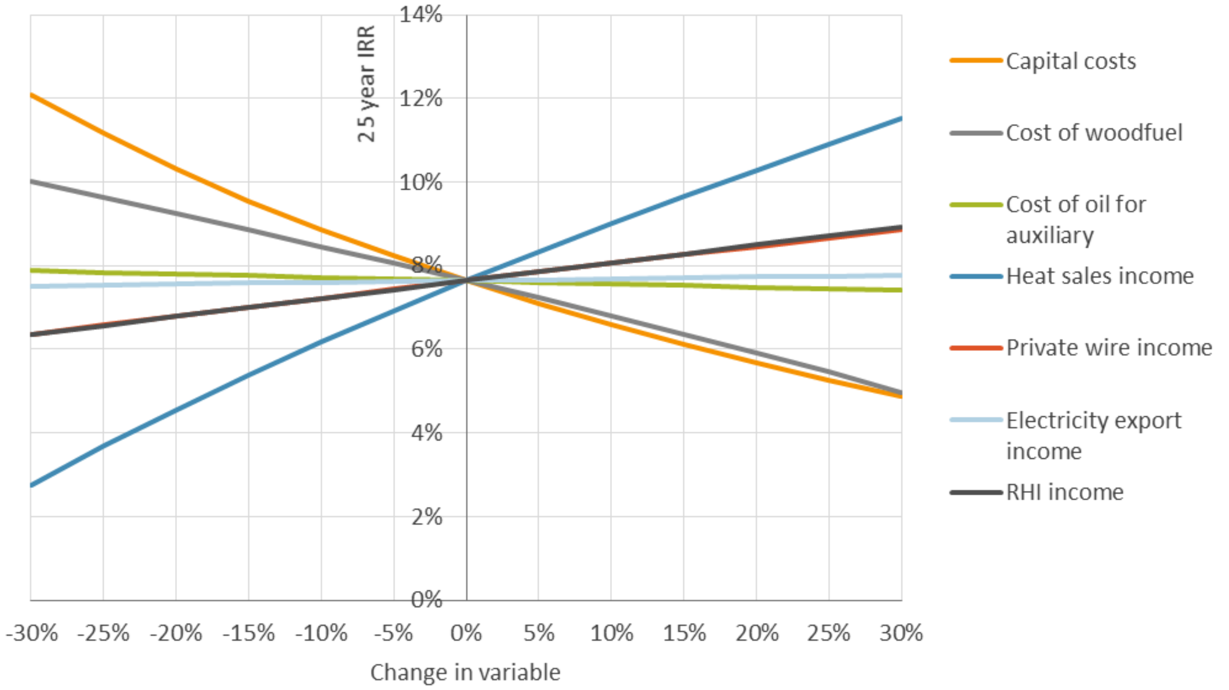


Figure 31: Scenario 2 network sensitivity analysis for biomass CHP

Figure 31 shows the sensitivity analysis of the key variables for the Scenario 2 network served by biomass CHP. Capital costs, cost of woodfuel, and heat sales income have the most significant effect on the financial case. A 30 % decrease in capital costs would increase the high level 25 year IRR to ~12 %.

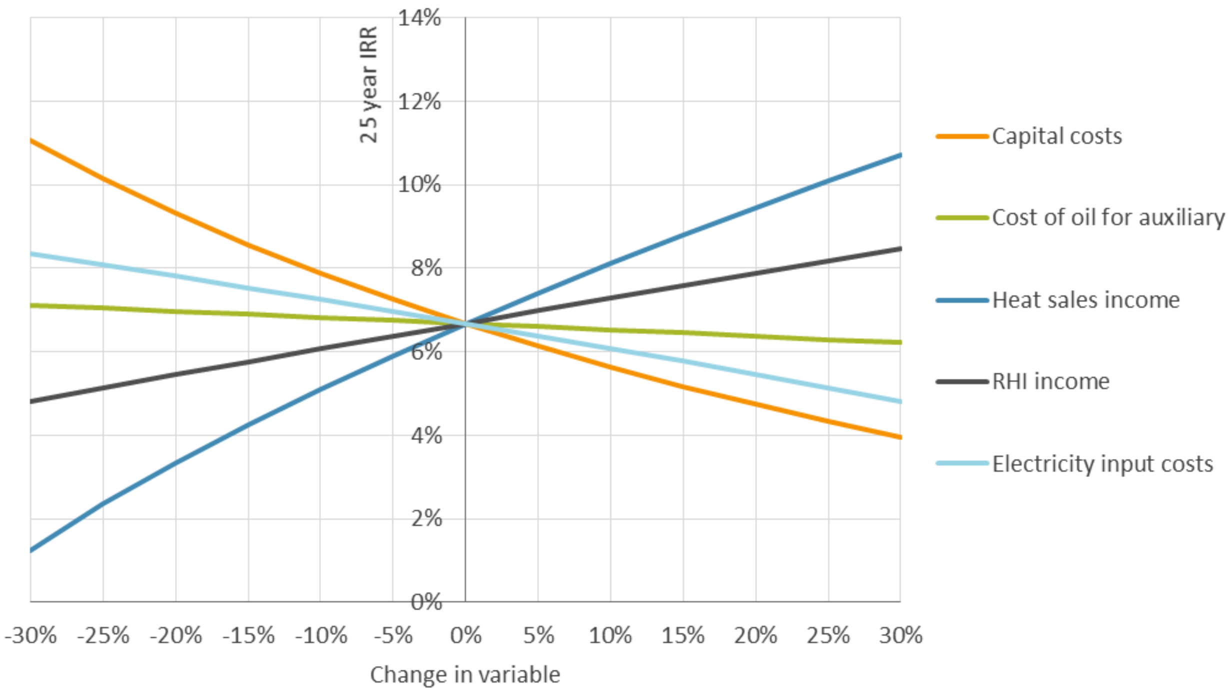


Figure 32: Scenario 2 network sensitivity analysis for GSHP

Figure 32 shows the sensitivity analysis of the key variables for the Scenario 2 network served by a GSHP. Heat sales income, capital costs, electricity input costs and RHI income have the most significant effect on the financial case. A increase in heat sales income or a reduction in capital costs by greater than 30 % would be required for the project to achieve a high level 25 year IRR of 12 %.

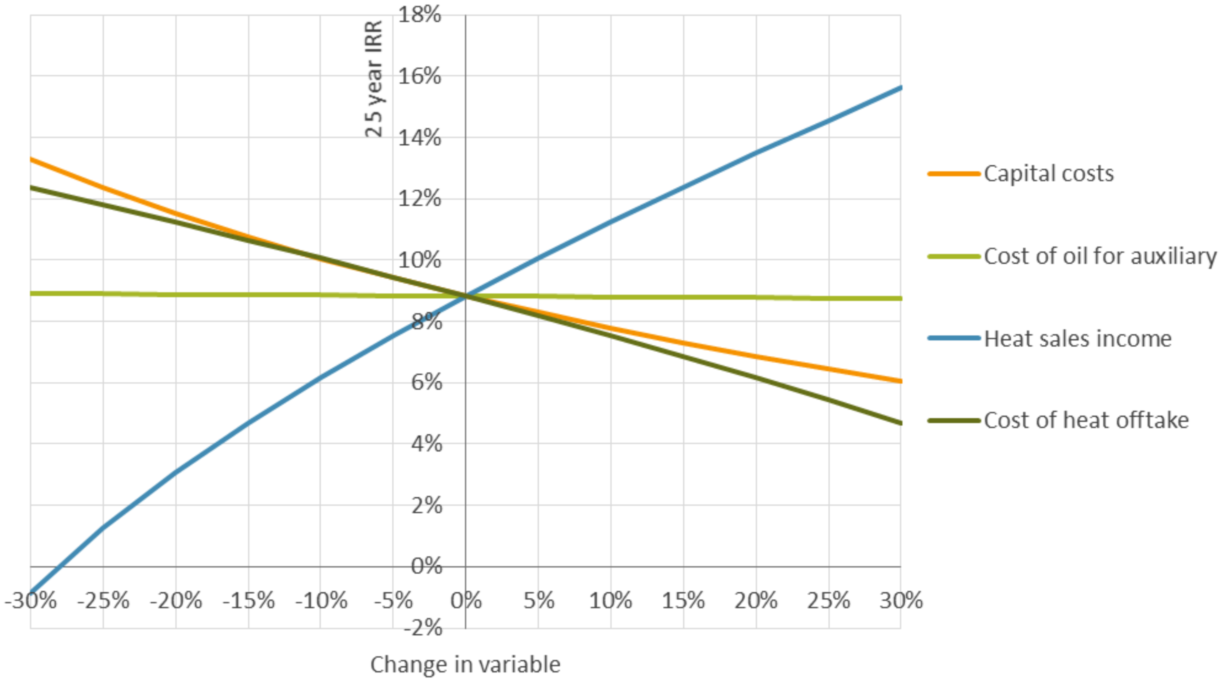


Figure 33: Scenario 2 network sensitivity analysis for heat offtake from Syn2gen biomass CHP

Figure 33 shows the sensitivity analysis of the key variables for the Scenario 2 network served by heat offtake from the Syn2gen biomass CHP. Heat sales income, cost of heat offtake and capital costs have the most significant effect on the financial case. A 13 % increase in heat sales income would be required to increase the high level 25 year IRR to 12 %. A 23 % decrease in capital costs or a 25 % decrease in the cost of heat offtake would reduce the IRR to 12 %.

4.2.3 Identification of Key Variables for Atherstone Airfield Development

The Scenario 3 network was assessed in section 3.4 and found to be unlikely to be financially viable. This network connects the Atherstone Airfield planned development and the 3 Wealmoor buildings. One of the most viable network options was found to be served by heat offtake from the Syn2gen biomass CHP with a high level 25 year IRR of -1.9 %. Sensitivity analysis has been undertaken to identify the key variables for this network option and to establish the potential requirements for it to become financially viable.

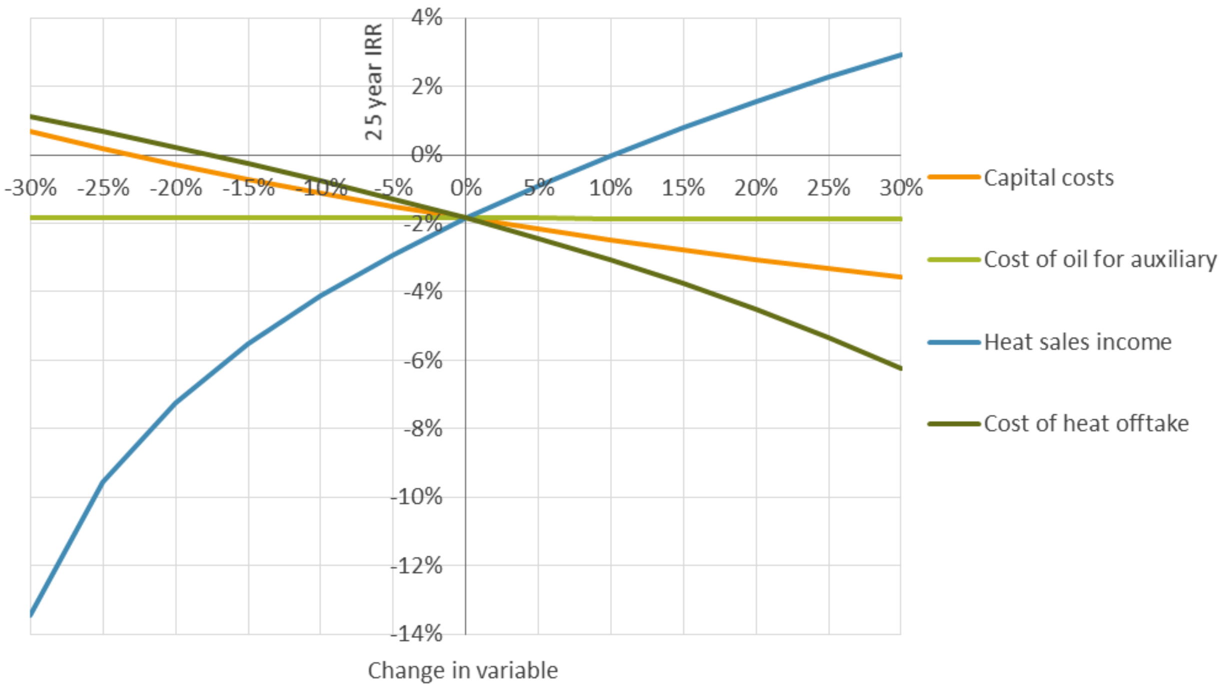


Figure 34: Scenario 3 network sensitivity analysis for heat offtake from Syn2gen biomass CHP

Figure 34 shows the sensitivity analysis of the key variables for the Scenario 3 network served by heat offtake from the Syn2gen biomass CHP. Heat sales income has a significant effect on the financial case. It can be seen that key variables would need to increase or decrease by greater than 30 % in order for this network option to become financially viable.

4.2.4 Summary

The key variables for the potentially viable networks are heat sales income, capital costs, cost of woodfuel (for biomass and biomass CHP options) and cost of heat offtake (for heat offtake options). Small changes in the cost of oil for auxiliary or the income from electricity export, RHI or private wire sales are less significant for the high level financial cases.

A variation in key variables of greater than 30 % would be required for the scenario 3 network to become financially viable. This scenario is unlikely to be financially viable without a significant change in development plans to increase heat demands and increase diversity in heat demand profiles.

The conclusions from the sensitivity analysis inform the key risks and issues examined in section 4.3.

4.3 Issues and Risks

The main barriers, issues and constraints to the implementation of district heating networks within the heat map areas were considered and risks assessed. Table 22 outlines potential risks and issues that apply to all networks. A key showing the level of risk is shown in Table 21.

Table 21: Risk level key

Low risk	
Medium risk	
High risk	

Table 22: Summary of risks and issues that apply to a network at Atherstone Airfield

	Risk/Issue	Risk level	Rationale	Mitigating measure/action
1	Where organisations were unresponsive, or not open to consultation, heat demands are verified using industry benchmarks.		For the existing potential heat loads where data was not available heat demands were developed from heat profile modelling verified using CIBSE benchmark data and data for similar buildings. Heat demand modelling of key heat loads was undertaken according to best practice and best available information. The hourly, daily and annual heat demand of the individual buildings was calculated and the distribution losses based on proposed pipe routes, specification and operating parameters to gauge heat demand identified.	CIBSE provide industry benchmarks that are widely used for heat demand modelling. However as they are derived from building energy data prior to 2008, there is a risk that they are less accurate for heat demands for modern buildings (due to more efficient thermal performance, increased use of electrical equipment etc.). 'Good practice' benchmark figures have been used (as opposed to 'typical practice') and a reduction of 10 % applied to demands for planning developments. The consultant team has a database of hundreds of hourly annual demand profiles for a wide range of building types and these were adapted to provide an indicative heat demand profile for each building and to verify the benchmark data used.
2	Changes to planned developments will change the modelled heat demand.		Heat demands for proposed developments were assessed according to latest knowledge, information and development plans including planning applications and consultation with planning officers from Stratford-on-Avon District Council, e.g. as the Atherstone Airfield development plans are currently at an early stage changes to the current development plans are likely.	If plans change, the impact upon the findings of this study should be assessed, e.g. as development plans are developed for the Atherstone Airfield development. Stratford-on-Avon District Council should undertake detailed consultation with all potential developers. The approach to engaging with developers and utilising the planning system is discussed in Chapter 5.
3	Complex strategic priorities for heat networks due to numerous and diverse stakeholders.		A wide range of strategic priorities were identified from various project partners and stakeholders. Key stakeholders include: - Stratford-on-Avon District Council - Alscot Estate - Syn2gen and Expel Oil Seed Processing Ltd	The consultant team has reviewed policy and strategic documentation and, wherever possible, undertaken consultation with project partners to review and discuss network priorities.
4	Network options presented do not allow			All future potential energy loads identified by Stratford-on-Avon District Council and land allocated for potential development in local

	Risk/Issue	Risk level	Rationale	Mitigating measure/action
	connection of key future developments.		Consideration should be given to future-proofing to ensure that the network has the capacity to serve potential future network phases.	plans have been considered in the heat-mapping and careful consideration is given to future proofing, whilst not at the expense of efficient operation in the short and medium term. No expansion opportunities were identified for any of the network options presented. This should be further considered if more detailed development information becomes available.
5	Physical barriers identified at master planning stage prevent implementation of scheme or lead to CAPEX increase and viability issues.		Potential barriers include key utilities infrastructure, main roads, hard digging conditions and land ownership.	The main physical barriers, issues and constraints within the study area have been considered and, where possible, avoided during the masterplanning process. GIS layers including Council owned land and main gas routes were reviewed and heat map area surveyed (on foot) for obvious barriers. At the feasibility stage, the client's representatives will also need to further liaise with local Highways, Environmental Health and Planning Departments and utilities companies.
6	Engagement with developers is not achieved or developers are not interested in network offer.		The viability of all network options is reliant upon planned developments. Key planned developments include Expel Oil Seed Processing Ltd, RMCA, and Wealmoor.	Effective early engagement with developers is essential and the benefits of connecting new buildings to a network need to be made clear. Discussions have been undertaken with the Alscot Estate and Syn2gen. The approach to engaging with developers and utilising the planning system is discussed in Chapter 5.
7	The capital costs for installation of scheme and network are higher than estimated within the high level financial viability assessment.		Sensitivity analysis indicates that the impact of higher capital costs would be significant for all network options. If the financial model does not provide a representative picture of the true cost of the network, and the likely financial benefits or the high level financial assessment does not provide sufficient information to secure funding, then the network plan will not progress.	Optimism bias[12] has been considered when deriving project costs and a contingency sum of 20 % of total CAPEX has been included in all financial assessment.

[12] All project costs are based on a combination of supplier quotes, industry costing tools and previous project experience. The consultant team hold a broad knowledge of the actual costs of installing a district heating scheme including costs for plant and equipment supply and installation, energy centre construction, distribution pipe work supply and installation, trench excavation and re-instatement.

	Risk/Issue	Risk level	Rationale	Mitigating measure/action
8	Heat sales tariffs significantly affect the high level financial case.		The income from heat sales is particularly significant for network options that are less financially viable. The high level financial assessment assumes that heat is sold to end users at tariffs bespoke to specific building categories. These values are calculated based on the current cost of heat to end users minus 5 %. The values are based on figures for current energy costs (taken from current quotes and tariffs paid by similar users in the area) for each of the consumer categories and include standing charges, efficiency losses, and maintenance and replacement costs.	If any projects are progressed to the feasibility stage, this should be updated. Heat sales tariffs are affected by oil costs that are based on current oil tariffs for similar categories of consumer and quotes for the Stratford-upon-Avon area.
9	Atherstone Airfield development connections reduce overall financial viability of projects.		Development plans indicate that the potential development at the Atherstone Airfield site will consist of B2/B8 units and will include some existing businesses from the Canal Quarter. These businesses are unlikely to operate heat/cooling intensive processes and will mainly require heat for space heating and domestic hot water with low night time and summer demands. Therefore, they are unlikely to provide viable network connection opportunities when considered in isolation. Private sector developers are unlikely to find these network connections attractive.	Unless heat/cooling intensive businesses, with consistent demands, can be attracted to the Atherstone Airfield development site, then it is unlikely to provide a viable opportunity.

5 PLANNING AND CORPORATE ACTIONS

The following short section summarises planning issues and corporate actions.

5.1 Planning Policy

5.1.1 Core Strategy

The Alscot Estate submitted a proposal for a development at Atherstone Airfield to Stratford-on-Avon District Council through the Call for Sites process in October 2014. Following this, Atherstone Airfield was included as a strategic site in the modified Core Strategy in July 2016 as site SUA.4. The Core Strategy proposes that the site will be used for the relocation of businesses from the Canal Quarter Regeneration Zone with Use Classes B1c, B2 or B8 or suitable sui generis uses. It is likely that the development could be brought forward as part of Core Strategy phase 2 (2016/17) and phase 4 (2030/31).

5.1.2 Planning Policy Recommendations

As the development of a network for the Atherstone Airfield site in isolation is not financially viable, the site will not be allocated as a priority heat network area (unless heat intensive businesses with consistent heat demands are to locate at the site).

If heat intensive businesses are to locate at the site, or the Council decide to encourage heat intensive businesses to the site, then this study could be referenced to demonstrate that connection to a district heat network may be technically and financially viable.

5.2 Corporate Actions

Stratford-on-Avon Council have several options to consider and these include doing nothing or playing a supporting and facilitating role for any network developments.

Due to the nature of the existing businesses and planned developments, it is unlikely that any of the schemes are suited to public sector ownership and would need to be private sector led.

As the Scenario 1 network has an IRR of over 12 % then it may provide a viable investment opportunity for the private sector and this is reflected in the initial (verbal) interest expressed by Syn2gen to further develop their proposed scheme to include the larger heat loads. However, as that the Atherstone Airfield development connections reduce overall financial viability they are unlikely to be attractive to the private sector.

As the other options considered are high risk propositions, and the high level financial cases for the presented schemes have IRRs of <12%, this would restrict financing opportunities and development opportunities. These networks are only likely to be a viable proposition if developed by, or with financial support from developers, with a grant, or with a mix of grant funding and public sector borrowing.

Stratford-on-Avon District Council may decide to undertake a series of corporate actions to promote and enable a scheme including:

- Facilitating engagement between key stakeholders namely Wealmoor, RCMA and Aviagen
- Engagement and support with planning consents and any highways activities for a proposed network
- Encouraging heat/cooling intensive businesses (potential key anchor loads) to locate at the site

6 CONCLUSIONS

This report details the results of the Atherstone Airfield Heat Mapping and Masterplanning Study. The district energy network options assessed have the potential to contribute to the regeneration of Atherstone Airfield, deliver low carbon developments for the area, improve energy security and reduce commercial carbon emissions.

Within the Atherstone Airfield heat map area, the largest heat and electricity demand both arise from the combined demand for Camgrain and the Expel Oil Seed Processing Ltd planned development. Significant existing cooling demands were identified at Wealmoor cold store and packaging warehouse and the Aviagen chick hatchery. A cooling demand was also included for the Wealmoor planned development.

The proposed anaerobic digesters and small biogas CHP adjacent to Whitehall Farm were ruled out as a potential energy source as the planning indicates that biogas will be mainly injected into the gas grid. The proposed Syn2gen biomass CHP plant, part of the Expel Oil Seed Processing Ltd planned development, may provide a potential energy source. High level plans for this scheme indicate that the biomass CHP plant developer intends to provide energy to the Camgrain site and the proposed Expel Oil Seed Processing Ltd planned development and is in early discussions with Wealmoor.

Potential site barriers for Atherstone Airfield include a small SSSI to the south-west of Wealmoor cold store and several local wildlife sites surrounding the area. No major site barriers were identified within the Atherstone Airfield heat map area.

Biomass heating, biomass CHP, GSHP and heat offtake were selected for further assessment for potential network options.

Table 23 and Table 24 summarise the high level financial assessment and key sensitivity parameters and risks for the Scenario 1 and Scenario 2 networks respectively.

Table 23: Scenario 1 network summary

Technology	Network trench length	Estimated CAPEX	Carbon savings	25 year financial case			40 year financial case		
				Simple payback	IRR	NPV	Simple payback	IRR	NPV
Biomass heat 5 MW	1.9 km	£9,767,532	13,009 tpa	6 years	18.2 %	£20,740,475	7 years	17.4 %	£24,368,134
Biomass CHP 4.1 MW		£10,278,953	14,666 tpa	5 years	21.8 %	£29,167,434	6 years	21.2 %	£36,803,641

Key sensitivity parameters	- Heat sales income - Cost of woodfuel - Capital costs	
Key opportunities	- Likely to be financially viable achieving the assumed hurdle rate required for private sector development and investment (>12 %) - Risk would be reduced if key stakeholders can be engaged - £659/tCO_2 (CAPEX per tonne of carbon saving) for biomass heat option - £619/tCO_2 for biomass CHP option	
Key risks and issues	- Scenario assumes that Syn2gen biomass CHP is not brought forward - Biomass heat revenue includes highest potential RHI tariff – scheme is currently under consultation and future of scheme likely to be clarified in March 2017 - Engagement with diverse range of private sector stakeholders including Camgrain and Expel, RMCA, Wealmoor, Aviagen and Woodyard and Atherstone Airfield developers - As the Atherstone Airfield development connections reduce overall financial viability they are unlikely to be attractive to a private sector developer - Attempts were made to obtain detailed information from Expel Oil Seed Processing Ltd, Wealmoor and Aviagen but the consultant team received limited feedback on their energy consumption/generation and future development plans - Private sector network developers may not be motivated to connect smaller, less viable heat demands such as the proposed Atherstone Airfield development without incentives - Presents a high-risk opportunity - Assessment based on high level plans for Atherstone Airfield development	**Risk Rating** (red)

As the Scenario 1 network has an IRR of over 12 % then it may provide a viable investment opportunity for the private sector and this is reflected in the initial (verbal) interest expressed by Syn2gen to further develop their proposed scheme to include the larger heat loads. However, as that the Atherstone Airfield development connections will reduce overall IRR they are unlikely to be attractive to the private sector.

Table 24: Scenario 2 network summary

Technology	Network trench length	Estimated CAPEX	Carbon savings	25 year financial case			40 year financial case		
				Simple payback	IRR	NPV	Simple payback	IRR	NPV
Biomass heat 1.2 MW	1.9 km	£4,685,438	2,965 tpa	12 years	6.3 %	£1,535,018	13 years	6.5 %	£2,070,773
Biomass CHP 2.1 MW		£6,669,210	4,058 tpa	11 years	7.6 %	£3,346,979	12 years	7.9 %	£4,681,298
GSHP 1.2 MW		£6,827,168	1,937 tpa	12 years	6.7 %	£2,463,625	13 years	6.9 %	£3,377,201
Heat offtake from Syn2gen biomass CHP		£3,360,638	3,275 tpa	11 years	8.8 %	£2,408,792	11 years	9.7 %	£4,170,906

Key sensitivity parameters	- Heat sales income - Capital costs - Cost of woodfuel for biomass heat and biomass CHP options - Cost of electricity input for GSHP option - Cost of heat offtake for heat offtake option	
Key opportunities	- Network options may be financially viable if grant funding or a longer term private sector investment model available - Risk would be reduced if key stakeholders can be engaged and RHI levels confirmed - £1,175/tCO_2 (CAPEX per tonne of carbon saving) for biomass heat option - £1,263/tCO_2 for biomass CHP option - £2,906/tCO_2 for GSHP option - £660/tCO_2 for heat offtake option	
Key risks and issues	- Engagement with diverse range of private sector stakeholders including Wealmoor, Aviagen and Woodyard and Atherstone Airfield developers (no stakeholders engaged at this stage - Biomass heat revenue includes highest potential RHI tariff – scheme is currently under consultation and future of scheme likely to be clarified in March 2017 - Initial contact was made with Syn2gen however no response was received to requests for detailed information - Atherstone Airfield development connections reduce overall financial viability - Assessment assumes Syn2gen plant has sufficient capacity to provide heat to wider network at an assumed competitive rate - Private sector network developers may not be motivated to connect smaller, less viable heat demands such as the proposed Atherstone Airfield development without incentives - Presents a high-risk opportunity - Assessment based on high level plans for Atherstone Airfield development	**Risk Rating**

The Scenario 2 network provides a high-risk proposition and the high level financial cases for the presented schemes have IRRs of <12%, this would restrict financing and development opportunities. This network is only likely to be a viable proposition if developed by, or with financial support from developers, with a grant, or with a mix of grant funding and public sector borrowing.

Atherstone Airfield development connections reduce overall financial viability of projects. Development plans indicate that the potential development at the Atherstone Airfield site will consist of B2/B8 units and will include some existing businesses from the Canal Quarter. These businesses are unlikely to operate heat/cooling intensive processes and will mainly require heat for space heating and domestic hot water with low night time and summer demands. Therefore, they are unlikely to provide viable network connection opportunities when considered in isolation. Unless heat/cooling intensive businesses, with consistent demands, can be attracted to the Atherstone Airfield development site, then it is unlikely to provide a viable opportunity.

As the development of a network at the Atherstone Airfield site in isolation is not financially viable, the site will not be allocated as a priority heat network area (unless heat intensive businesses with consistent heat demands are to locate at the site). If heat intensive businesses are to locate at the site, or the Council decide to encourage heat intensive businesses to the site, then this study could be referenced to demonstrate that connection to a district heat network may be technically and financially viable.

Due to the nature of the existing businesses and planned developments, it is unlikely that any of the schemes are suited to public sector ownership and would need to be private sector led.

Stratford-on-Avon Council have several options to consider and these include doing nothing or playing a supporting and facilitating role for any network developments. Stratford-on-Avon District Council may decide to undertake a series of corporate actions to promote and enable a scheme including:

- Facilitating engagement between key stakeholders namely Wealmoor, RCMA and Aviagen
- Engagement and support with planning consents and any highways activities for a proposed network
- Encouraging heat/cooling intensive businesses (potential key anchor loads) to locate at the site

Stratford-on-Avon District Council should consider the following next steps and recommendations. Table 25 summarises the recommendations made in this report.

Table 25: Table of recommendations

<table>
<tr><th>Recommendations</th><th>Indicative Timeline</th></tr>
<tr><td>1. Consider the findings of this study to decide how best to support district energy developments at Atherstone Airfield</td><td rowspan="3">Immediate</td></tr>
<tr><td>2. Engage with Syn2gen at senior level to establish their strategy for the site</td></tr>
<tr><td>3. Ensure effective early engagement and continue to work with Alscot Estate to further understand the nature of the development plans being brought forward</td></tr>
<tr><td>4. When the developments are brought forward and, more detailed information made available, if heat/cooling intensive businesses are to locate to the site then network options should be reassessed</td><td rowspan="4">Short and medium term</td></tr>
<tr><td>5. Engage with and support planning consents and highways activities</td></tr>
<tr><td>6. Ensure the technical and financial work undertaken in this study will provide an evidence base for planning policy</td></tr>
<tr><td>7. Encourage heat/cooling intensive businesses (potential key anchor loads) to locate at the site</td></tr>
</table>

APPENDIX 1 – KEY ORGANISATIONS CONTACTED

List of contacts of key organisations where owners were contacted by Sustainable Energy to request information.

Table 26: Key organisations contacted

Organisation	Site contact	Job Description	Contact Established
Alscot Estate	Robert Honan	Estates Director	Yes
Syn2gen	Kevin Ball	Director	Yes[13]
Camgrain	Philip Darke	Managing Director	No
Expel Oil Seed Processing Ltd	Andrew Hamilton	Director	No
RMCA Stratford Ltd	John Patching	Director	No
Wealmoor	Avnish Malde	Director	No
Aviagen	Graeme Dear	General Manager	No
Smiths Concrete	Mr C Eyre	Manager	No
Future Biogas Ltd	Daniel Purvis	Head of Operations	No

[13] Initial contact established, information not received

APPENDIX 2 – ENERGY DATA

Table 27: Key heat loads within the Atherstone Airfield heat map area

Building Name	Existing site / Planned development	Building Use	Ownership	Heat Demand, kWh	Electricity Demand, kWh	Cooling Demand, kWh	Energy data source for heat modelling and profiling
Camgrain and Expel development	Existing and planned development	Grain drying and storage, oil seed processing and solid biomass drying	Camgrain and Expel Oil Seed Processing Ltd	28,000,000	8,400,000	-	Energy statement attached to planning application (13/00952/FUL)
RMCA development	Planned development	Oil seed processing	RMCA	3,008,600	704,200	-	Estimated based on data for similar sized oil seed processing facility
Wealmoor cold store	Existing	Exotic fruit storage and distribution	Wealmoor	853,200	1,736,900	1,427,000	CIBSE TM46 – cold storage/refrigerated warehouse
Wealmoor packaging store	Existing	Exotic fruit packaging and distribution	Wealmoor	129,700	293,800	249,800	CIBSE TM46 – cold storage/refrigerated warehouse
Wealmoor development	Planned development	Exotic fruit storage and distribution	Wealmoor	312,500	643,300	563,900	CIBSE TM46 – cold storage/refrigerated warehouse
Smiths Concrete	Existing	Ready-mix concrete supplier	Smiths Concrete	-	15,500	-	Estimated based on data for similar sized facility
Aviagen	Existing	Chick hatchery	Aviagen	1,410,700	593,200	900,000	Estimated from ChickMaster datasheet attached to planning application (14/00629/FUL)
Woodyard, unit 1-4	Planned development	Small business units	Planned development	162,600	56,600	-	CIBSE Guide F – distribution warehouse
Woodyard, unit 5-7	Planned development	Small business units	Planned development	83,500	29,000	-	CIBSE Guide F – distribution warehouse
Atherstone Airfield 1	Planned development	Class B2/B8	Planned development	129,200	66,400	-	Based on data for existing buildings in Canal Quarter Regeneration Area 5% of floor area modelled as offices (CIBSE Guide F – offices, naturally ventilated, cellular)
Atherstone Airfield 2	Planned development	Class B2/B8	Planned development	258,600	132,700	-	
Atherstone Airfield 3	Planned development	Class B2/B8	Planned development	129,200	66,400	-	
Atherstone Airfield 4	Planned development	Class B2/B8	Planned development	129,200	66,400	-	
Atherstone Airfield 5	Planned development	Class B2/B8	Planned development	161,600	83,000	-	
Atherstone Airfield 6	Planned development	Class B2/B8	Planned development	323,100	165,900	-	
Atherstone Airfield 7	Planned development	Class B2/B8	Planned development	193,900	99,500	-	
Atherstone Airfield 8	Planned development	Class B2/B8	Planned development	193,900	99,500	-	
Atherstone Airfield 9	Planned development	Class B2/B8	Planned development	193,900	99,500	-	
Atherstone Airfield 10	Planned development	Class B2/B8	Planned development	155,100	79,600	-	
Atherstone Airfield 11	Planned development	Class B2/B8	Planned development	193,900	99,500	-	
Atherstone Airfield 12	Planned development	Class B2/B8	Planned development	129,200	66,400	-	
Atherstone Airfield 13	Planned development	Café	Planned development	45,500	91,500	-	CIBSE Guide F – high street agencies

APPENDIX 3 – PLANNED DEVELOPMENTS

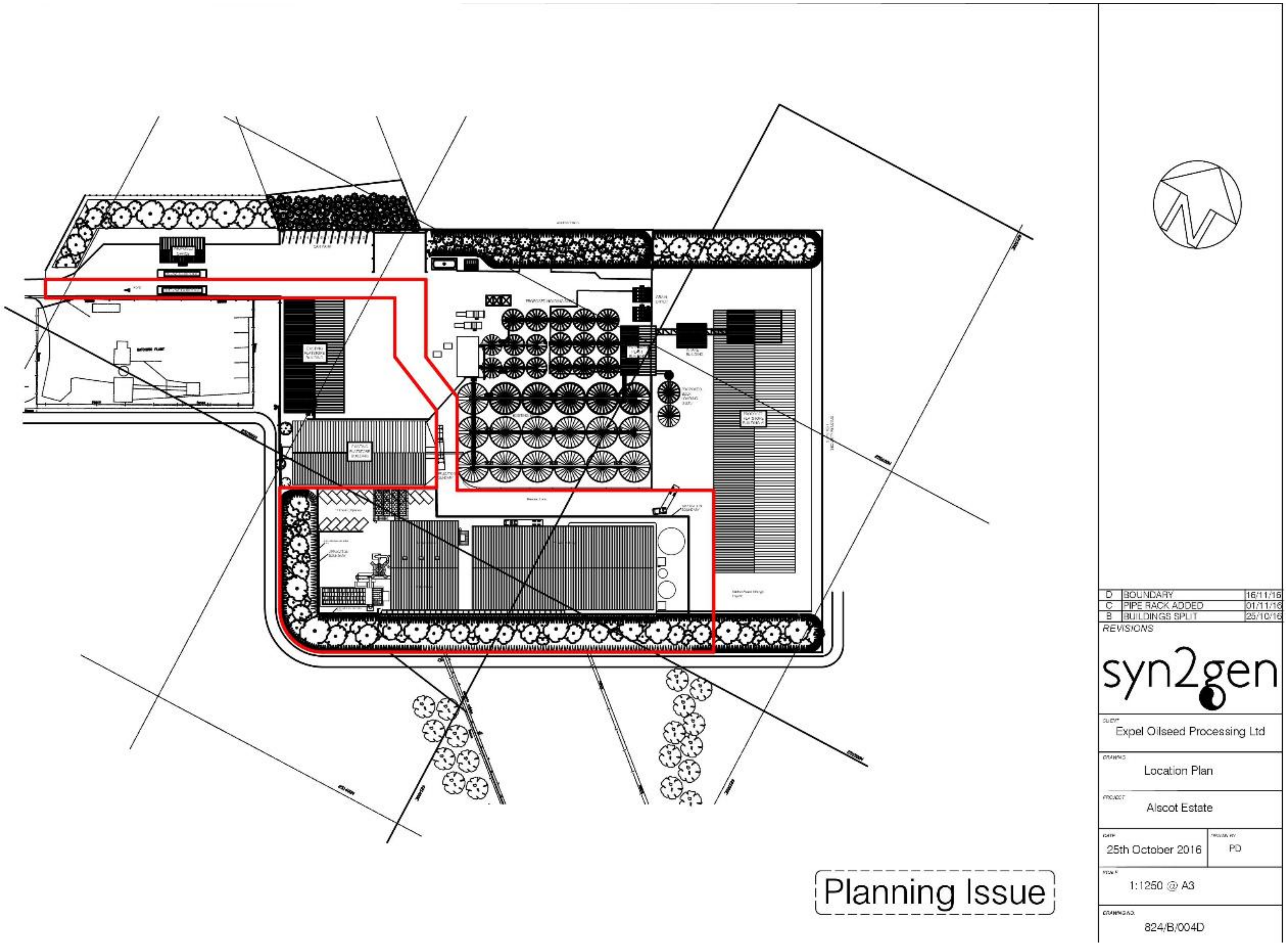


Figure 35: Expel Oil Seed Processing Ltd development site plan

Figure 36: Woodyard site development plan

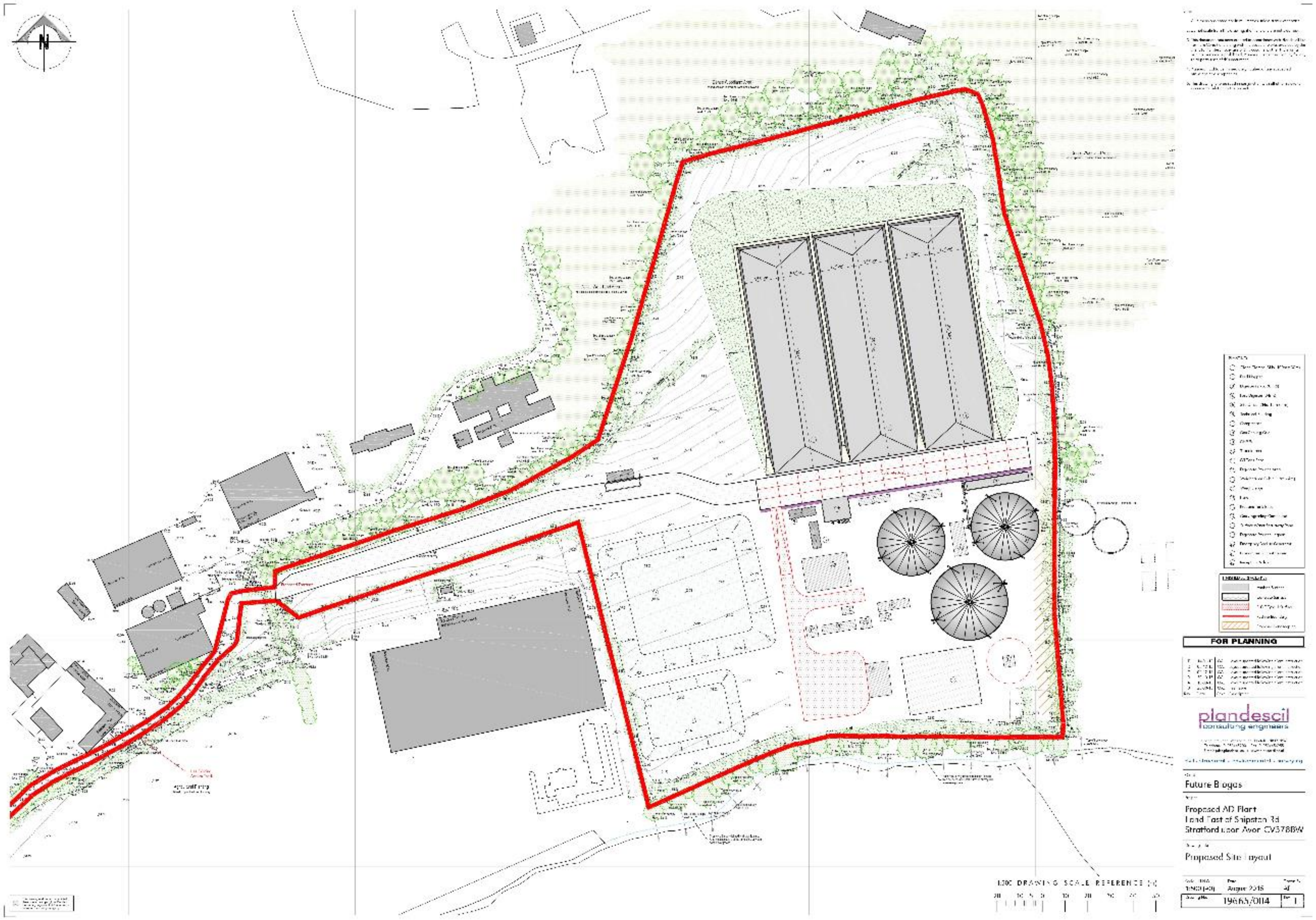


Figure 37: Future Biogas Ltd anaerobic digesters site development plan

CC3-GL
CLIMATE CONTROL SYSTEM

Product Specification

CC3-GL 14400HE

AIR HANDLING SYSTEMS

Setter, Hatcher and Egg Store Application - Eggs per week: **1,015,000**
Nominal (HR/Cooling Coil) Supply Fan Airflow: **6.8 m^3/s**
Maximum Supply Fan Airflow (including Option for Dry Air Cooling): **8.84 m^3/s**
Air Supply Maximum External Resistance: **500 Pa**
HR Coil Capacity (Heat Dissipation - Air on 1°C, Air off 25.9°C): **240 kW**
Cooling Coil Capacity (Air on 35°C 40% RH, Air off 17.9°C 50%RH): **198.49 kW**
Maximum Hot Water Heating Capacity (extreme weather condition): **376 kW**

CC3 AHU selection model No: **AH2300$-50-50WP**
Width: **2010mm**
Length: **6000mm**
Height: **2770mm**
Electrical compartment height: **2770mm**
Nominal Supply Fan - Motors are suitable for 415/3/50 OR 220/3/60hz: **22 kW**
Max. Supply Fan - Motors are suitable for 415/3/50 220/3/60Hz voltage: **22 kW**
Dry Air Cooling Supply Fan - Motors suitable for 415V/3Ph/50Hz: **7.5kW**
Chick Holding Cooling Requirement: **59.31 kW**
Egg Store Cooling Requirement: **28.86 kW**
Maximum Chiller Capacity (Incl. Egg Store & Chick Holding Room): **526.67 kW**
Maximum Boiler Capacity: **352.68 kW**
No. of Boilers: **8**

HYDRONIC PUMP SYSTEMS

Incubator/Ventilation Pumps @ 350kPa (M1 & M2): **23.099 l/s (15.00 kW)**
cooling/heating load 526.67 kW

Chiller Circulation Pumps @ 185kPa (M3 & M4): **27.719 l/s (11.00 kW)**
cooling/heating load 526.67 kW

Hot Water Circulation Pump @ 350kPa (M5 & M6): **4.640 l/s (5.5 kW)**
cooling/heating load 352.68 kW

ChickMaster
www.chickmaster.com

CC3-GL 14400HE

BASE TANK CAPACITY

Volume: **3,423 ltrs**
Capacity per Tank: **1,712 ltrs**
Length of Tank: **17.80m**
Base Manifold Length: **9.0m**

OVERALL UNIT DIMENSIONS

Width: **2,200mm**
Length: **9,250mm**
Total Height: **3,570mm**
Electrical Compartment Height: **2,770mm**
Base Manifold Length: **10.5mm**

ELECTRICAL DATA & REQUIREMENTS

Basic CC3 Unit: **54kW**
CC3 Unit + Dry Air Cooling Module: **76 kW**
Typical Average Running Power Consumption (with Dry Air Module): **45 kW**

Electrical Supply at 380V Three Phase 50Hz
380V 3 Phase 50Hz Maximum Current Loading (with Dry Air Cooler Module): **121 Amps**
Recommended Supply and Circuit Protection Capacity: **125 Amps**

Electrical Supply at 220V Three Phase 60Hz
220V 3 Phase 60Hz Maximum Current Loading (with Dry Air Cooler Module): **209 Amps**
Recommended Supply and Circuit Protection Capacity: **225 Amps**

GAS FIRED HOT WATER HEATERS - DATA & REQUIREMENTS*

Natural gas heaters - gas supply pressure: **20 mbar**
Lpg (propane) gas heaters - gas supply pressure: **37 mbar**
Gas consumption input at minimum output: **35 kW**
Gas consumption input at maximum output: **432 kW**

***Based on full boilers**

ChickMaster

www.chickmaster.com

ChickMaster International: 25 Rockwood Place, Suite 335, Englewood, New Jersey 07631, USA.
Tel:+1 (201) 871-8810, Fax:+1 (201) 871-8814, e-mail: sales@chickmaster.com
ChickMaster North American Sales Office: 327 Dahlonega Street, Suite 801, Cumming, GA 30040, USA.
Tel: +1 (678) 341-9047, Fax: +1 (678) 771-8867
ChickMaster UK: 1 The Leggar, Bridgwater, Somerset TA6 4AF, UK.
Tel:+44 (0)1278 411000, Fax:+44 (0)1278 451213, e-mail: sales@chickmasteruk.com

Figure 38: ChickMaster data sheet from Aviagen planning application

APPENDIX 5 - INTRODUCTION TO TECHNOLOGIES ASSESSED

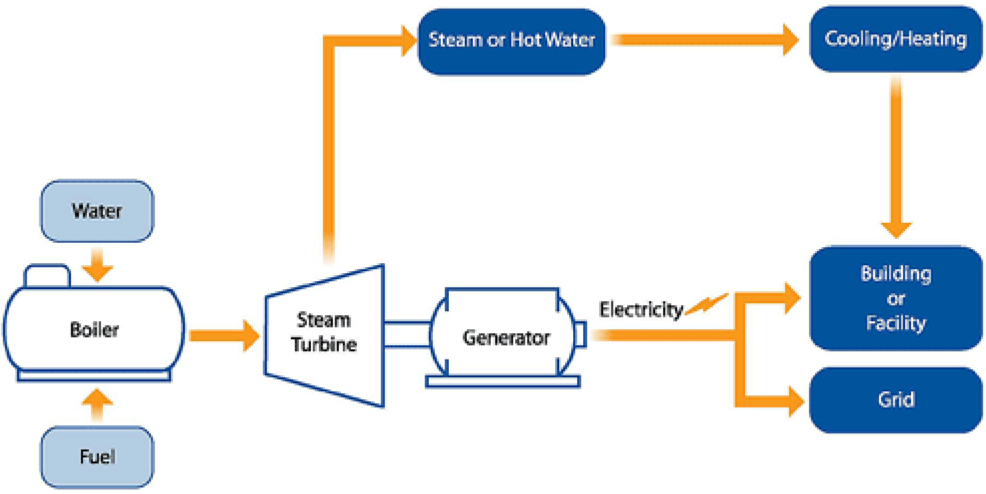
Biomass Boiler – a biomass boiler burns wood fuel in the form of wood pellets, chips or logs to provide heat in the form of low temperature, medium temperature hot water or steam. A biomass boiler comprises two main parts, the combustion chamber where wood fuel is combusted with unrestricted oxygen and the boiler tubes which transfer heat from the combustion chamber to the water or steam medium. The heated water or steam is then distributed around the heating system as required.

6MW Wood Chip Boiler at Sawmill Site in Mid-Wales, Photo Courtesy of Sustainable Energy Ltd

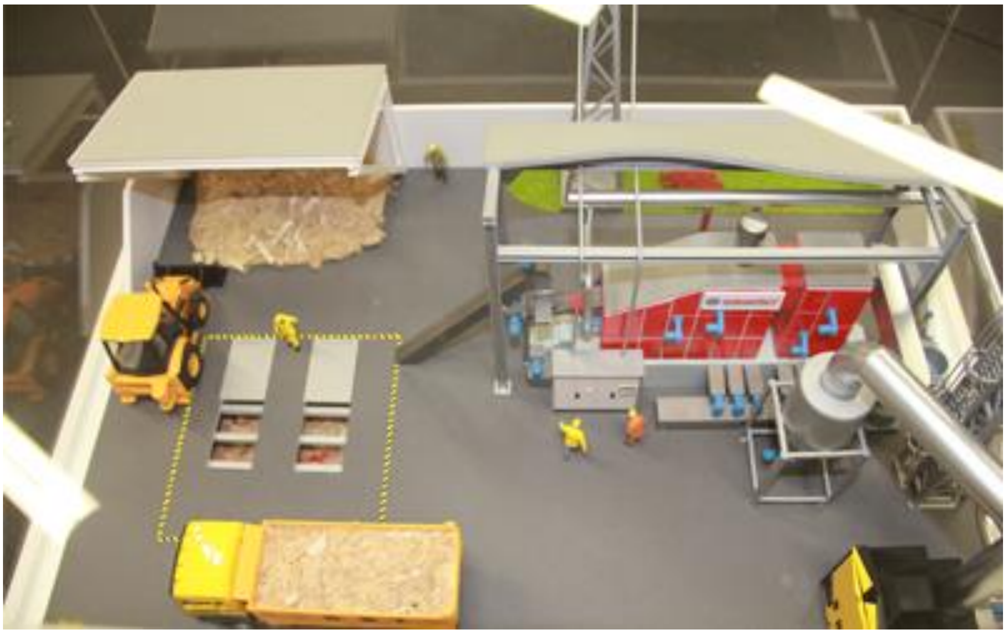
Wood Chip Delivery to Wood Chip Store for 6MW Biomass Boiler, Photo Courtesy of Sustainable Energy Ltd

Biofuels CHP - Cogeneration from biomass fuels can be achieved by three means, medium to large scale steam turbine systems; smaller scale ORC systems and advanced thermal conversion with gas engines systems.

Biomass Steam Turbine CHP – This utilises biomass in the form of wood chip, wood pellet or bio oils as a fuel source for a boiler which is then used to raise steam which drives a steam turbine to generate electricity, with heat recovered from the steam turbine's exhaust and cooling systems to provide useable heat.



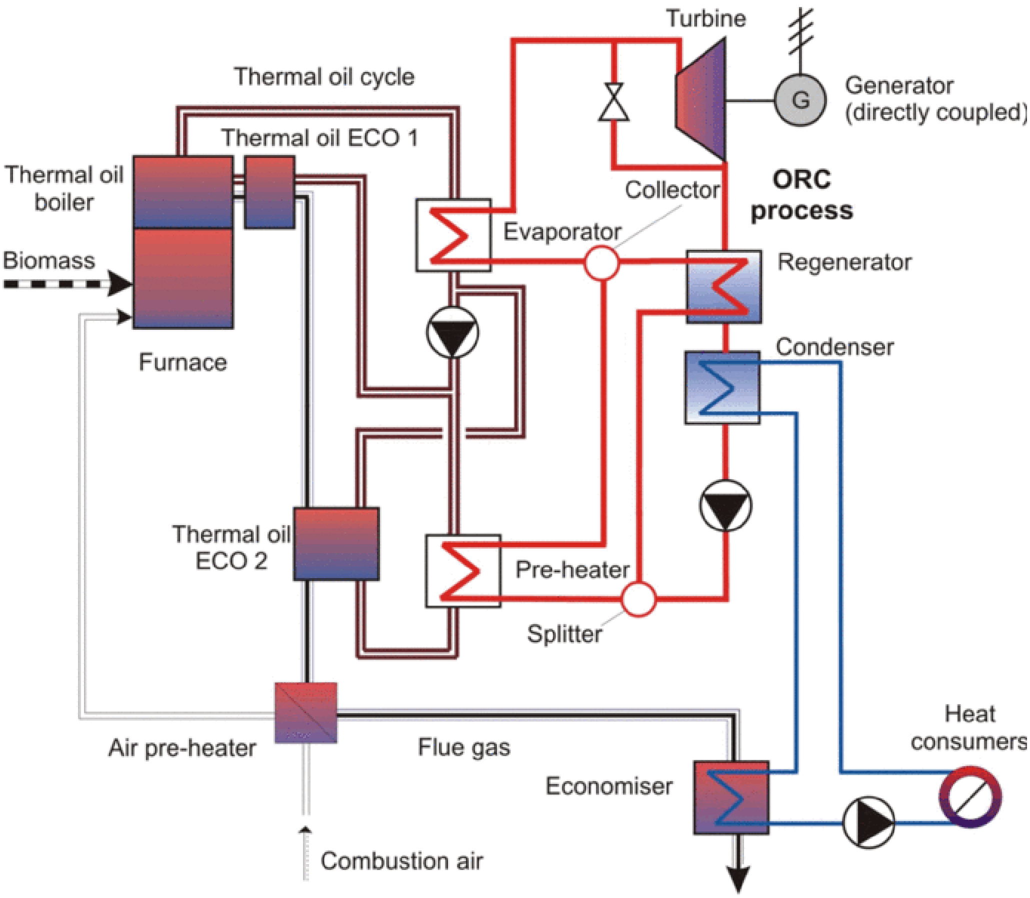
Picture courtesy of www.epa.gov



130kWe Biomass CHP Plant, Photo Courtesy of www.environltd.co.uk

Biomass Organic Rankine Cycle CHP (ORC) – Reciprocating steam engines and steam turbines use a thermodynamic process called the Rankine Cycle. At small scale, this is inefficient due to the high temperatures and pressures involved. However, it is possible to replace water as the working medium with an organic compound with a lower boiler point, such as a silicone oil or organic solvent. This allows the system to work at much lower temperatures, pressures and at smaller scale. The working medium is usually less corrosive than water to components such as turbine blades and the turbine can operate at a lower speed which can improve reliability. CHP systems where biomass fuel is used to produce heat in order to evaporate an organic compound to drive a turbine are known as Organic Rankine Cycle systems.

Picture courtesy of www.endswasteandbioenergy.com



Picture Courtesy of www.bios-bioenergy.at

Biomass Gasification CHP – For Biomass Gasification CHP, instead of wood fuel being combusted to raise steam to generate electricity via a steam turbine, the wood fuel is burned with restricted oxygen levels to produce a wood gas which is then combusted within an internal combustion engine. The engine is then used to generate electricity, with heat recovered from the engine's exhaust and cooling systems to provide useable heat.

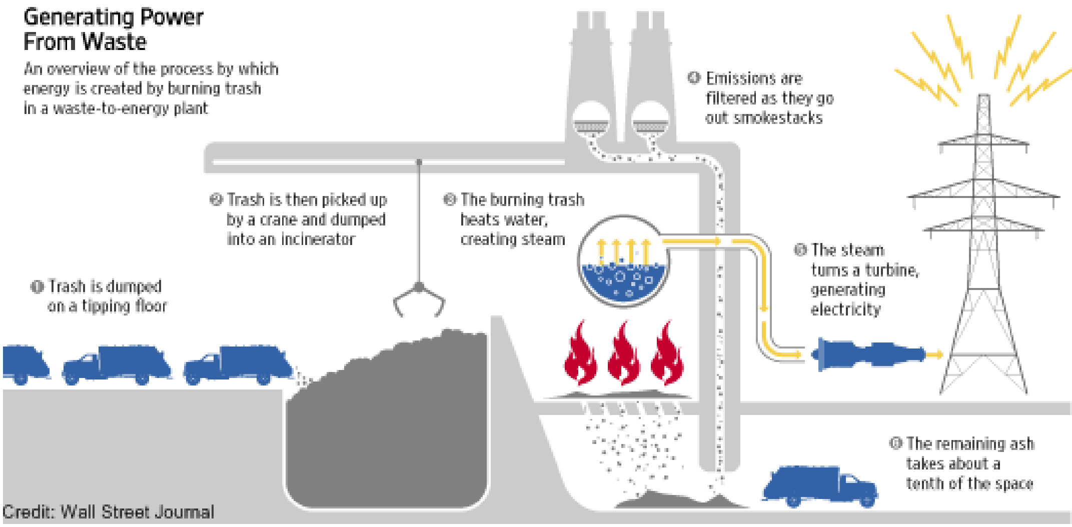
250kWe Wood Gasification System, Photo Courtesy of Sustainable Energy Ltd

The temperatures of the usable heat available from different CHP systems depends on the type of prime mover[14] used. Higher flow temperatures can be achieved from engines for gas CHP and biomass gasification CHP or ORC systems whereas fully condensing steam turbines will not generate temperatures suitable for district heat systems unless electrical efficiency is sacrificed to achieve higher flow temperatures. Indicative flow temperatures for different CHP technologies are shown below:

	Internal Combustion Engine	ORC	Steam turbine – full condensing
Flow Temperature	80°C to 90°C	80°C to 90°C	40°C to 50°C
Potential Thermal efficiency	55%	50% to 60%	60% to 70%
Use as LTHW	Yes	Yes	No

Energy from Waste – Energy from Waste plants burn waste to generate electricity via a prime mover such as steam turbine or engine. The waste normally combusted in such plants is the residual waste from Municipal Solid Waste which is left over after all recycling possible has been done. This waste is normally a mix of items made from oil such as plastics and items that are biodegradable such as paper, wood and food. The most common thermal treatment for waste is incineration; waste is incinerated and the heat produced is used to heat water to raise steam which then drives a turbine and generates electricity. Significant amounts of heat are generated in this process which are often dumped, but this could be used to provide a heat source for a district heating scheme by recovering the heat from the exhaust and cooling systems of the steam turbine. Advanced thermal conversion processes such as gasification and pyrolysis can also be used to generate electricity from waste; by converting the waste into a product such as oil or gas that can then be burnt directly in gas engines or turbines. Advanced thermal conversion systems are potentially more efficient but are technically difficult and relatively unproven at commercial scale.

[14] The CHP prime mover is the heart of the CHP system. It is a mechanical machine which drives the electricity generator or develops mechanical power for direct use



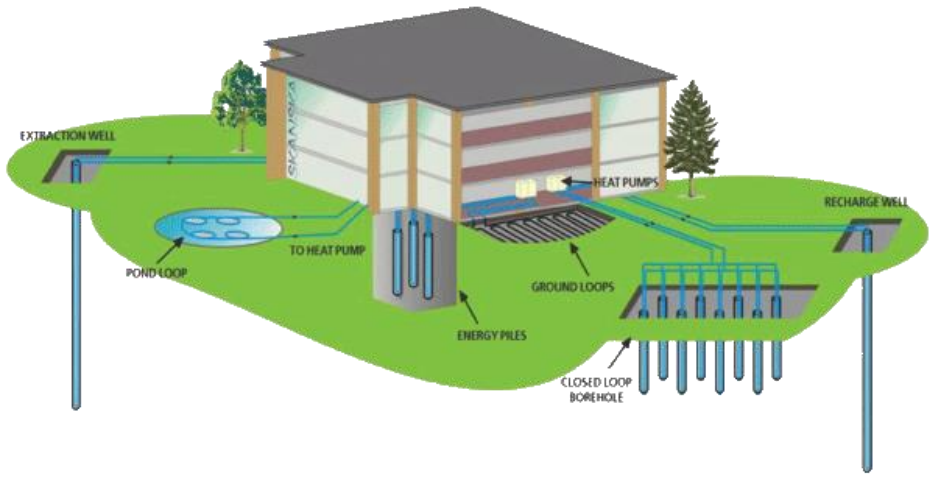
Picture courtesy of www.edouardstenger.com

Heat Pump Technologies[15] **-** Ground and Water Source Heat Pumps take heat from the ground or water and transfer it into buildings or a district heating system. The technology used is the same as that used in refrigerators. Just as a fridge extracts heat from the food and transfers it into the kitchen, so a ground source heat pump extracts heat from the earth and transfers it into a building. For every unit of electricity used to power the heat pump, approximately 3-4 units of heat are captured and distributed. At this efficiency level there will usually be less carbon dioxide emissions than for a gas boiler heating system.

A Ground or Water Source Heat Pump system comprises three basic elements - a ground loop / collector array, the heat pump itself and the heat distribution system. The ground loop is a pipe buried underground in a horizontal trench, in a vertical borehole or immersed in water.

Horizontal trenches can be dug >2 m below ground level and, although covering more land surface than a borehole, they are usually cheaper for smaller systems. Boreholes are drilled to a depth of between 15-150 m and benefit from higher ground temperatures than trenches. However, there are a variety of types of pipe (e.g. the coiled pipe known as a 'slinky') which can be used in a trench instead of a straight one, which increase the amount of heat absorbed from the ground and so enhance performance. The ground area required for trenches will vary with the location, the property and the heat output required. A water/anti-freeze mixture is circulated through the pipe where it absorbs heat from the surrounding medium. A heat exchanger then extracts the absorbed heat and transfers it to the heat pump.

The third basic element of a ground or water source heat pump, the heat distribution system, can be either low temperature radiators or, preferably, underfloor heating. If the heat pump is asked to produce higher temperatures, for a conventional radiator circuit, then its efficiency will significantly reduce.



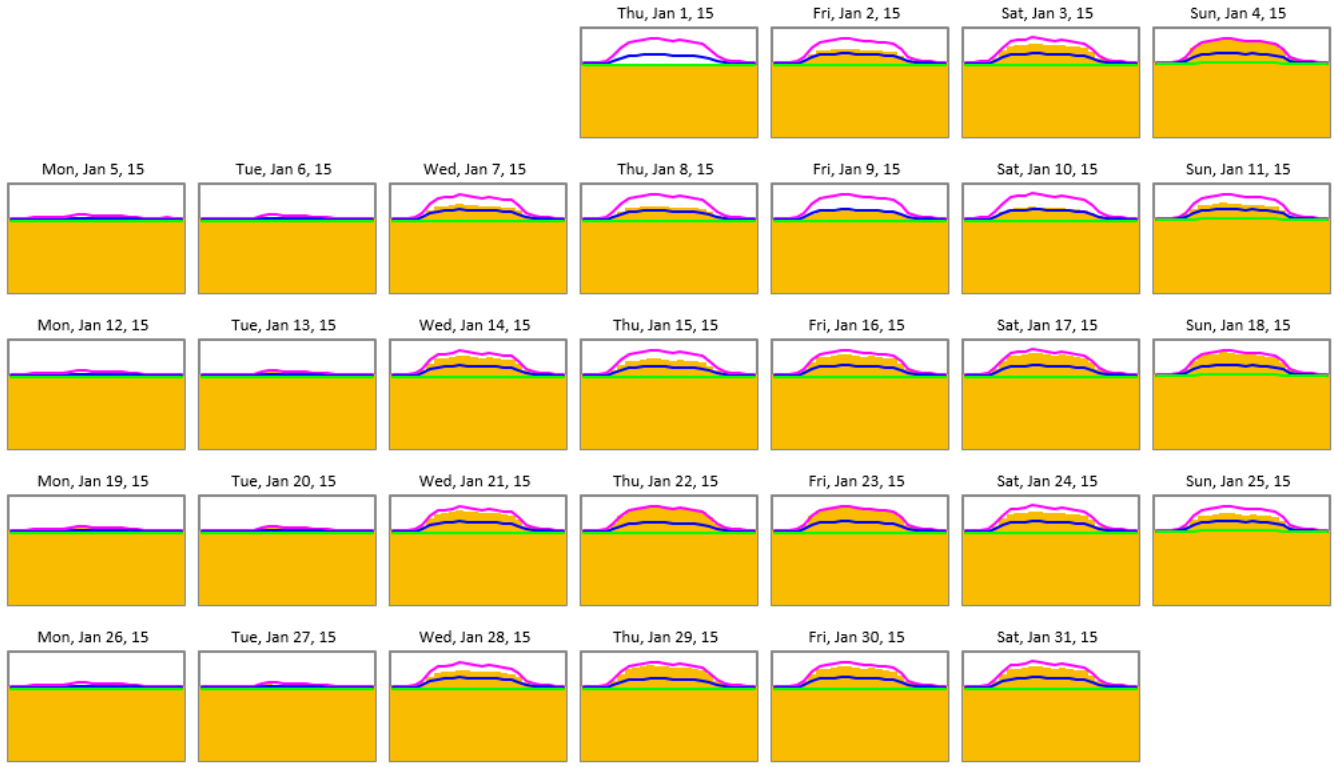
Picture courtesy of www.esru.strath.ac.uk

[15] Summarised from GSHP Association

APPENDIX 6 – HEAT DEMAND MODELLING

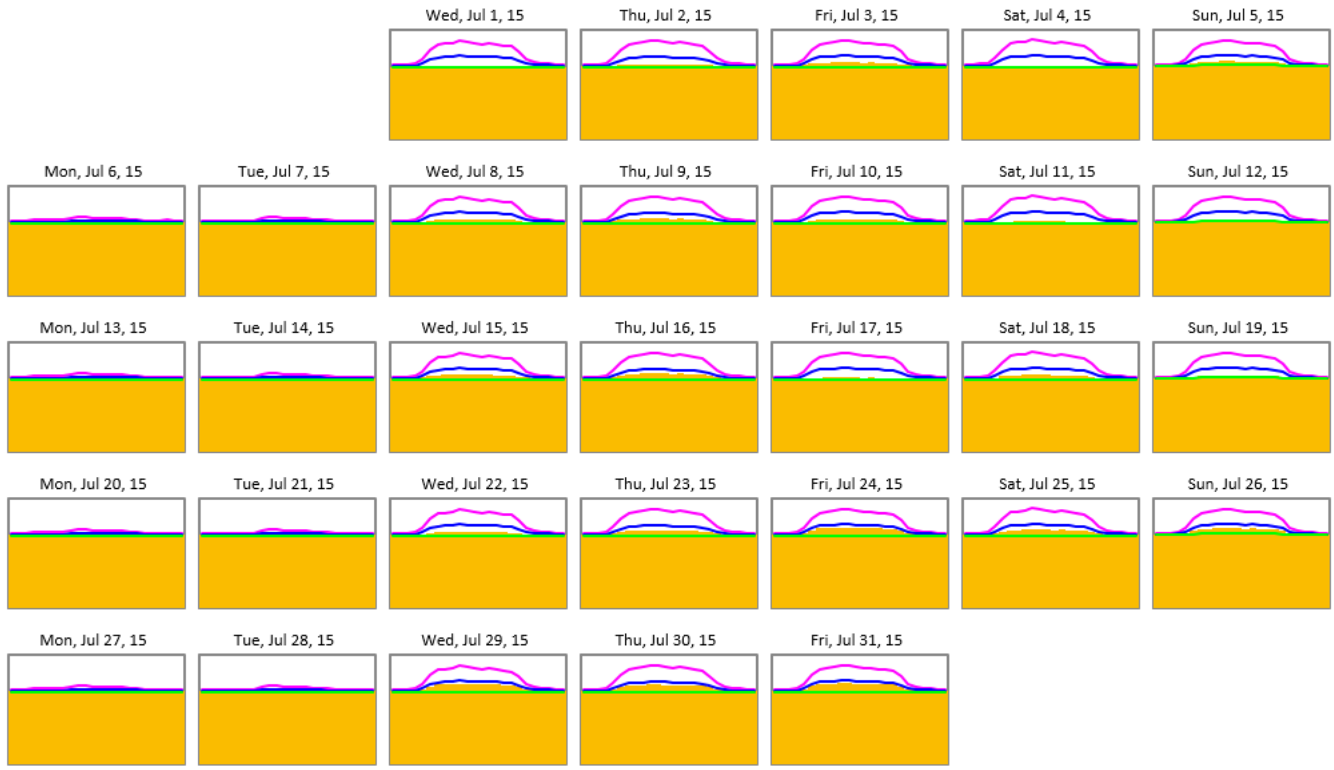
Seasonal Demand Profiles

The heat demand profiles for priority networks for each day of the week, for two separate months, are shown in the figures below. The pink, blue and green lines indicate minimum, average and maximum respectively. The yellow shaded area shows the heat demand profile for each specific day.



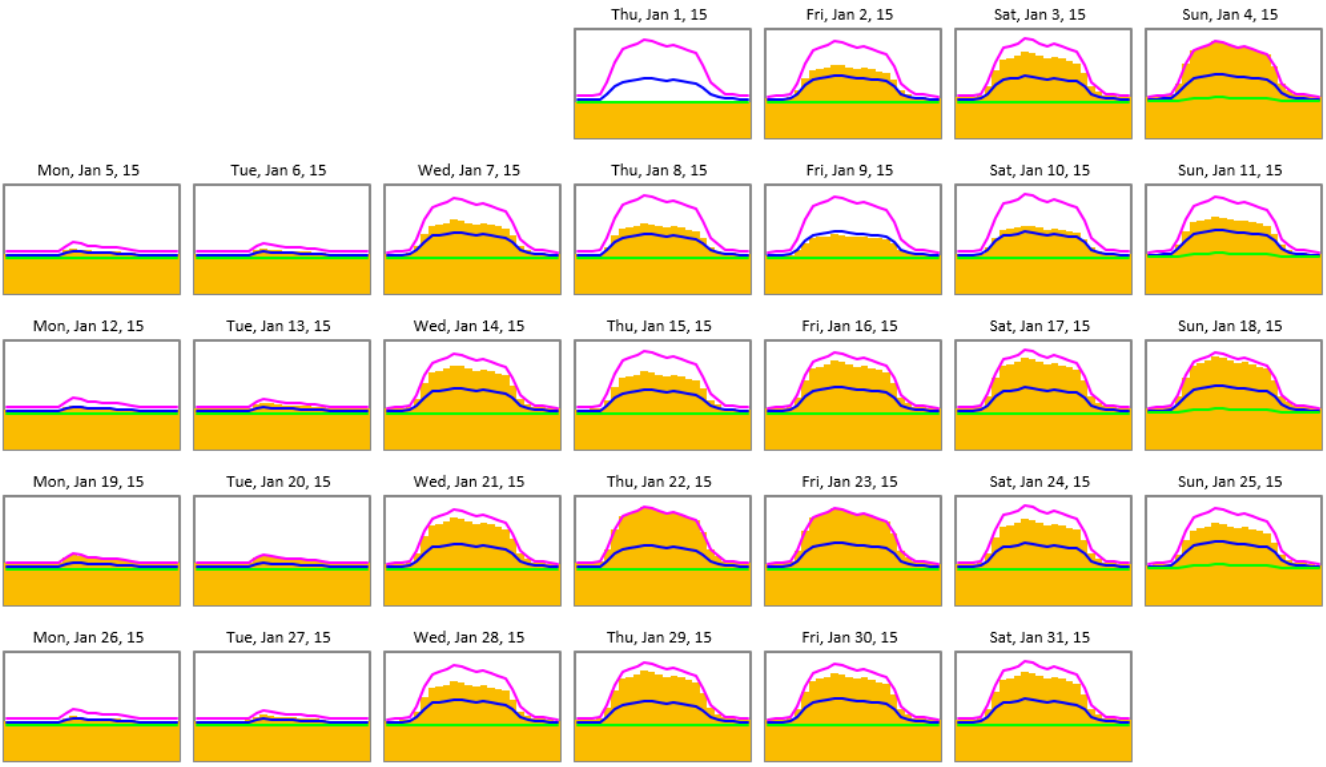
All chart scales run from 0 to 6,846.85 kW (average power over hour interval). Maximum, average, and minimum profiles are included for each day of the week.

Figure 39: Atherstone Airfield Scenario 1 network daily profiles - January



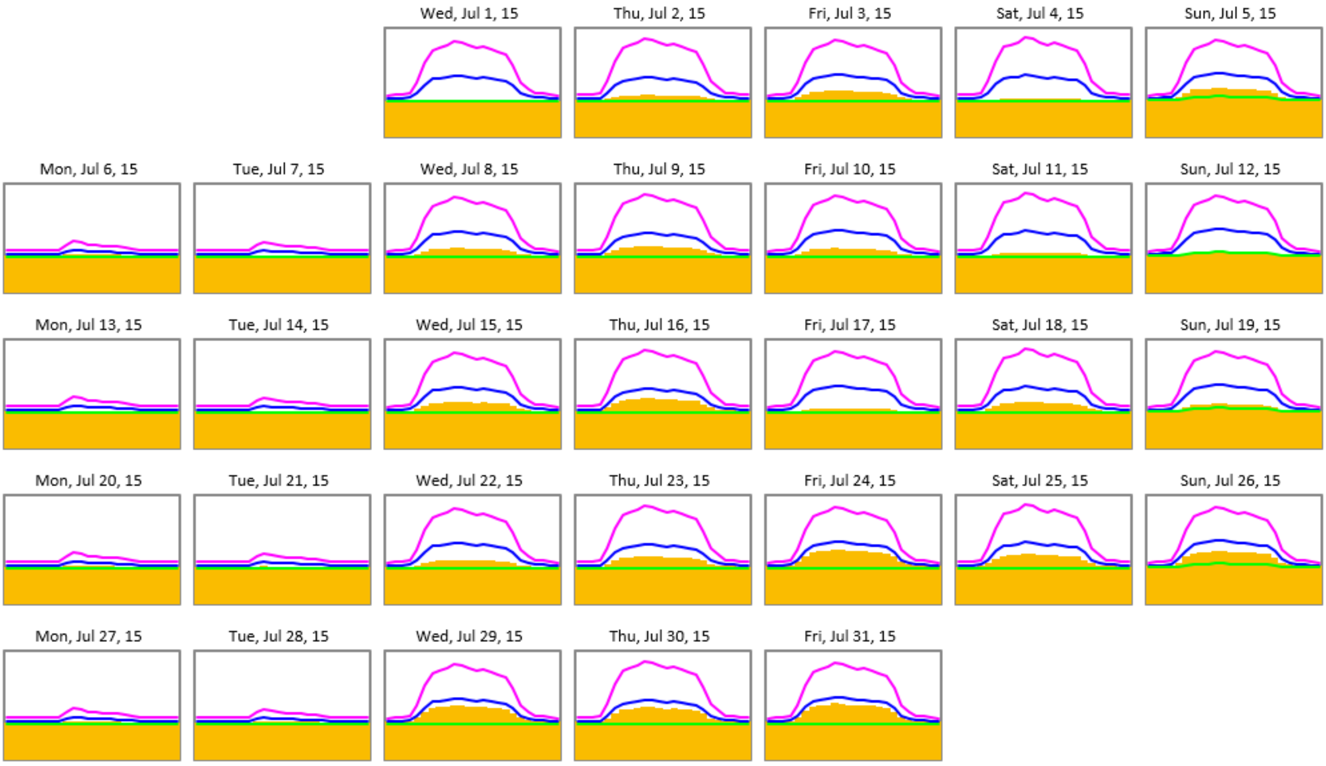
All chart scales run from 0 to 6,846.85 kW (average power over hour interval). Maximum, average, and minimum profiles are included for each day of the week.

Figure 40: Atherstone Airfield Scenario 1 Network daily profiles – July



All chart scales run from 0 to 2,928.98 kW (average power over hour interval). Maximum, average, and minimum profiles are included for each day of the week.

Figure 41: Atherstone Airfield Scenario 2 network daily profiles - January



All chart scales run from 0 to 2,928.98 kW (average power over hour interval). Maximum, average, and minimum profiles are included for each day of the week.

Figure 42: Atherstone Airfield Scenario 2 Network daily profiles - July

APPENDIX 7 – FINANCIAL VIABILITY ASSESSMENTS

Assumptions

Technology Efficiencies

Table 28 shows the assumed efficiencies used in technology assessments for peak and reserve oil boilers, biomass heat, biomass CHP and the average SPF used for a GSHP. Efficiencies for gas and biomass CHP technologies vary according to the size of the plant. These can be seen in the full business cases shown below for each network option.

Table 28: Technology details assumptions and sources of data

Technology details	Value	Reference/Justification
Peak and reserve oil boiler efficiency	85 %	Expected efficiency of new boiler
Biomass boiler efficiency	80 %	Previous experience for good practice
Average annual SPF for GSHP	3.5	Previous experience for good practice

Emissions Factors

Table 29 shows the emissions factors used to calculate carbon savings.

Table 29: Emissions factor assumptions and sources of data

Emissions factors	Value	Reference/Justification
Grid electricity	0.41205 $kgCO_2/kWh$	DEFRA 2016 Carbon factors
Kerosene (burning oil)	0.25838 $kgCO_2/kWh$	DEFRA 2016 Carbon factors
Woodchip	0.01307 $kgCO_2/kWh$	DEFRA 2016 Carbon factors
Wood pellet	0.01307 $kgCO_2/kWh$	DEFRA 2016 Carbon factors

Technology Replacement Costs

Technology replacement costs have been modelled on an annualised basis and take into account the expected lifetime of the technology, fractional repairs and the length of the business term.

Pipe Sizing and Specifications

All pipe specifications and costs are based on previous experience including a schedule of rates for a district heating project on Bristol for an installed network for which SEL acted as client's engineer. Pipe costs shown are the average (cost per meter of trench) for Scenario 1 network and include costs for pipe, insulation, trench excavation and backfill. These costs have been varied for a range of dig conditions (including concrete, tarmac, grass top and grass seed).

Table 30: Pipe sizes for Scenario 1 network

Pipe Size	Pipe Length, m
DN32	222
DN40	339
DN50	414
DN65	715
DN80	792
DN100	587
DN150	574
DN200	218

Table 31: Pipe specifications and heat loss

Pipe Size	Internal diameter, mm	Outer diameter, mm (including insulation)	Trench width, mm	Trench depth, mm	Heat loss, kW/m	Average cost per metre, £/m
DN32	33	160	820	960	17	229
DN40	41	160	820	960	19.0	250
DN50	53	180	860	980	20.6	278
DN65	68	200	900	1,000	23.1	306
DN80	78	225	950	1,025	24.4	348
DN100	102	280	1,080	1,080	25.3	534
DN150	154	355	1,210	1,155	31.1	580
DN200	203	450	1,400	1,250	32.4	638

Private Wire

It has been assumed that the private wire network for each network option will be installed in the heat network trench during network construction. Trenching costs have therefore not been included in private wire costs. A costs of £200/m has been included in financial assessment for the costs of the wire only. This figure is based on experience from previous projects.

Financial Viability Assessments – Potentially Viable Networks

Scenario 1 – Biomass Heat

Table 32: Estimated capital costs for Scenario 1 – biomass heat

Cost of biomass boiler (incl. controls, M&E, emissions abatement)	£4,600,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£651,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,751,610
Cost of building connections for existing buildings	£1,137,000
Contingency	20 %
Total cost of scheme	**£9,767,532**

Table 33: Financial assessment for Scenario 1 – biomass heat

Phase heat demand (MWh)	41,432
District heat network losses (MWh)	827
Total amount of heat generated (MWh)	42,258
Size of biomass boiler (kWth)	5,000
Biomass and thermal store modulation limit	0 %
Size of auxiliary (kW)	6,200
Heat generation biomass (MWh)	41,474
Heat generation auxiliary oil (MWh)	785
Value of heat sales	£2,215,464
Value of RHI	£958,822
Total Income	**£3,174,286**
Cost of woodfuel for biomass	£1,481,210
Cost of operation for biomass	£100,000
Biomass replacement costs for 25 year business case	£57,500
Biomass replacement costs for 40 year business case	£143,750
Cost of fuel for auxiliary (oil)	£31,290
Cost of operation for auxiliary	£2,354
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£2,354
Cost of energy centre operation	£68,842
Cost of network operation and maintenance	£8,316
Total costs of generation for 25 year business case	**£1,749,511**
Total costs of generation for 40 year business case	**£1,845,526**
Net income for 25 year business case	**£1,424,774**
Net income for 40 year business case	**£1,328,759**

Table 34: Scenario 1 – biomass heat 25 year financial case

Internal rate of return	18.2 %
Net present value	£20,740,475
Simple payback	6 years

Table 35: Scenario 1 – biomass heat 40 year financial case

Internal rate of return	17.4 %
Net present value	£24,368,134
Simple payback	7 years

Scenario 1 – Biomass CHP

Table 36: Estimated capital costs for Scenario 1 – biomass CHP

Cost of CHP plant (incl. controls, M&E, emissions abatement)	£4,370,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£651,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,751,610
Cost of building connections for existing buildings (heat network)	£1,137,000
Cost of private wire network	£386,184
Cost of building connections for existing buildings (private wire)	£270,000
Contingency	20 %
Total cost of scheme	**£10,278,953**

Table 37: Financial assessment for Scenario 1 – biomass CHP

Phase heat demand (MWh)	41,432
District heat network losses (MWh)	827
Total amount of heat generated (MWh)	42,258
Size of biomass CHP (kWth)	4,100
Size of biomass CHP (kWe)	950
Biomass CHP modulation limit	10 %
Size of auxiliary (kW)	6,200
Heat generation biomass CHP (MWh)	33,545
Heat generation auxiliary oil (MWh)	8,713
Biomass CHP electrical generation per annum (MWh)	7,767
Value of heat sales	£2,215,464
Electricity sales (private wire)	£658,593
Electricity sales (export)	-
RHI	£777,007
Total Income	**£3,651,064**
Cost of woodfuel for biomass CHP	£1,198,020
Cost of operation for biomass CHP	£168,750
Biomass CHP replacement costs for 25 year business case	£43,700
Biomass CHP replacement costs for 40 year business case	£109,250
Cost of fuel for auxiliary (oil)	£347,507
Cost of operation for auxiliary	£26,140
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£9,765
Cost of energy centre operation	£68,842
Cost of network operation and maintenance	£11,016
Total costs of generation for 25 year business case	**£1,863,975**
Total costs of generation for 40 year business case	**£1,939,290**
Net income for 25 year business case	**£1,787,090**
Net income for 40 year business case	**£1,711,775**

Table 38: Scenario 1 – biomass CHP 25 year financial case

Internal rate of return	21.8 %
Net present value	£29,167,434
Simple payback	5 years

Table 39: Scenario 1 – biomass CHP 40 year financial case

Internal rate of return	21.2 %
Net present value	£36,803,641
Simple payback	6 years

Scenario 2 – Biomass Heat

Table 40: Estimated capital costs for Scenario 2 – biomass heat

Cost of biomass boiler (incl. controls, M&E, emissions abatement)	£1,104,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£273,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,455,531
Cost of building connections for existing buildings	£1,072,000
Contingency	20 %
Total cost of scheme	**£4,685,438**

Table 41: Financial assessment for Scenario 2 – biomass heat

Phase heat demand (MWh)	10,423
District heat network losses (MWh)	674
Total amount of heat generated (MWh)	11,097
Size of biomass boiler (kWth)	1,200
Biomass and thermal store modulation limit	0 %
Size of auxiliary (kW)	2,600
Heat generation biomass (MWh)	9,871
Heat generation auxiliary oil (MWh)	1,226
Value of heat sales	£548,500
Value of RHI	£220,221
Total Income	**£768,721**
Cost of woodfuel for biomass	£352,524
Cost of operation for biomass	£40,000
Biomass replacement costs for 25 year business case	£13,800
Biomass replacement costs for 40 year business case	£34,500
Cost of fuel for auxiliary (oil)	£48,899
Cost of operation for auxiliary	£3,678
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£4,095
Cost of energy centre operation	£18,204
Cost of network operation and maintenance	£7,556
Total costs of generation for 25 year business case	**£484,662**
Total costs of generation for 40 year business case	**£509,457**
Net income for 25 year business case	**£284,059**
Net income for 40 year business case	**£259,264**

Table 42: Scenario 2 – biomass heat 25 year financial case

Internal rate of return	6.3 %
Net present value	£1,535,018
Simple payback	12 years

Table 43: Scenario 2 – biomass heat 40 year financial case

Internal rate of return	6.5 %
Net present value	£2,070,773
Simple payback	13 years

Scenario 2 – Biomass CHP

Table 44: Estimated capital costs for Scenario 2 – biomass CHP

Cost of CHP plant (incl. controls, M&E, emissions abatement)	£2,185,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£273,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,455,531
Cost of building connections for existing buildings (heat network)	£1,072,000
Cost of private wire network	£322,144
Cost of building connections for existing buildings (private wire)	£250,000
Contingency	20 %
Total cost of scheme	**£6,669,210**

Table 45: Financial assessment for Scenario 2 – biomass CHP

Phase heat demand (MWh)	10,423
District heat network losses (MWh)	674
Total amount of heat generated (MWh)	11,097
Size of biomass CHP (kWth)	2,050
Size of biomass CHP (kWe)	475
Biomass CHP modulation limit	10 %
Size of auxiliary (kW)	2,600
Heat generation biomass CHP (MWh)	10,348
Heat generation auxiliary oil (MWh)	766
Biomass CHP electrical generation per annum (MWh)	2,396
Value of heat sales	£548,500
Electricity sales (private wire)	£174,573
Electricity sales (export)	£17,378
RHI	£251,694
Total Income	**£992,144**
Cost of woodfuel for biomass CHP	£369,561
Cost of operation for biomass CHP	£84,375
Biomass CHP replacement costs for 25 year business case	£21,850
Biomass CHP replacement costs for 40 year business case	£54,625
Cost of fuel for auxiliary (oil)	£30,540
Cost of operation for auxiliary	£2,297
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£4,095
Cost of energy centre operation	£18,204
Cost of network operation and maintenance	£10,056
Total costs of generation for 25 year business case	**£536,883**
Total costs of generation for 40 year business case	**£573,753**
Net income for 25 year business case	**£455,261**
Net income for 40 year business case	**£418,391**

Table 46: Scenario 2 – biomass CHP 25 year financial case

Internal rate of return	7.6 %
Net present value	£3,346,979
Simple payback	11 years

Table 47: Scenario 2 – biomass CHP 40 year financial case

Internal rate of return	7.9 %
Net present value	£4,681,298
Simple payback	12 years

Scenario 2 - GSHP

Table 48: Estimated capital costs for Scenario 2 – GSHP

Cost of GSHP (incl. controls, M&E)	£1,224,000
Cost of borehole for GSHP	£1,664,775
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£273,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,455,531
Cost of building connections and conversion of existing heating systems	£1,072,000
Contingency	20 %
Total cost of scheme	**£6,827,168**

Table 49: Financial assessment for Scenario 2 - GSHP

Phase heat demand (MWh)	10,423
District heat network losses (MWh)	674
Total amount of heat generated (MWh)	11,097
Size of GSHP (kWth)	1,200
Size of auxiliary (kW)	2,600
Heat generation GSHP (MWh)	9,720
Heat generation auxiliary gas (MWh)	1,377
Value of heat sales	£548,500
Value of RHI	£342,794
Total Income	**£891,293**
Cost of electricity for GSHP	£226,266
Cost of operation for GSHP	£77,760
GSHP replacement costs for 25 year business case	£15,300
GSHP replacement costs for 40 year business case	£38,250
Cost of fuel for auxiliary (oil)	£54,909
Cost of operation for auxiliary	£4,130
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£4,095
Cost of energy centre operation	£18,204
Cost of heat network operation and maintenance	£7,556
Total costs of generation for 25 year business case	**£404,126**
Total costs of generation for 40 year business case	**£431,171**
Net income for 25 year business case	**£487,168**
Net income for 40 year business case	**£460,123**

Table 50: Scenario 2 – GSHP 25 year financial case

Internal rate of return	6.7 %
Net present value	£2,463,625
Simple payback	12 years

Table 51: Scenario 2 – GSHP 40 year financial case

Internal rate of return	6.9 %
Net present value	£3,377,201
Simple payback	13 years

Scenario 2 – Heat offtake from Syn2gen biomass CHP

Table 52: Estimated capital costs for Scenario 2 – heat offtake from Syn2gen biomass CHP

Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£273,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,455,531
Cost of building connections for existing buildings	£1,072,000
Contingency	20 %
Total cost of scheme	**£3,360,638**

Table 53: Financial assessment for Scenario 2 – heat offtake from Syn2gen biomass CHP

Phase heat demand (MWh)	10,423
District heat network losses (MWh)	674
Total amount of heat generated (MWh)	11,097
Heat offtake capacity (kWth)	2,000
Size of auxiliary (kW)	2,600
Total heat offtake (MWh)	10,948
Heat generation auxiliary oil (MWh)	148
Value of heat sales	£548,500
Total Income	**£548,500**
Cost of heat purchased from Syn2gen	£273,708
Cost of fuel for auxiliary (oil)	£5,920
Cost of operation for auxiliary	£445
Auxiliary replacement costs for 25 year business case	-
Auxiliary replacement costs for 40 year business case	£4,095
Cost of energy centre operation	£18,204
Cost of network operation and maintenance	£7,556
Total costs of generation for 25 year business case	**£305,833**
Total costs of generation for 40 year business case	**£309,928**
Net income for 25 year business case	**£242,666**
Net income for 40 year business case	**£238,571**

Table 54: Scenario 2 – heat offtake 25 year financial case

Internal rate of return	8.8 %
Net present value	£2,408,792
Simple payback	11 years

Table 55: Scenario 2 – heat offtake 40 year financial case

Internal rate of return	9.7 %
Net present value	£4,170,906
Simple payback	11 years

Financial Viability Assessments – Less Viable Networks

Scenario 3 – Biomass Heat

Table 56: Estimated capital costs for Scenario 3 – biomass heat

Cost of biomass boiler (incl. controls, M&E, emissions abatement)	£644,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£256,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,002,975
Cost of building connections for existing buildings	£1,042,000
Contingency	20 %
Total cost of scheme	**£3,533,969**

Table 57: Financial assessment for Scenario 3 – biomass heat

Phase heat demand (MWh)	3,489
District heat network losses (MWh)	529
Total amount of heat generated (MWh)	4,018
Size of biomass boiler (kWth)	700
Biomass and thermal store modulation limit	0 %
Size of auxiliary (kW)	1,600
Heat generation biomass (MWh)	3,586
Heat generation auxiliary oil (MWh)	432
Value of heat sales	£173,599
Value of RHI	£81,880
Total Income	**£255,479**
Cost of woodfuel for biomass	£128,078
Cost of operation for biomass	£53,793
Biomass replacement costs for 25 year business case	£8,050
Biomass replacement costs for 40 year business case	£20,125
Cost of fuel for auxiliary (oil)	£17,225
Cost of operation for auxiliary	£1,296
Auxiliary replacement costs for 25 year business case	£6,827
Auxiliary replacement costs for 40 year business case	£10,667
Cost of energy centre operation	£6,670
Cost of network operation and maintenance	£5,082
Total costs of generation for 25 year business case	**£227,020**
Total costs of generation for 40 year business case	**£242,935**
Net income for 25 year business case	**£28,459**
Net income for 40 year business case	**£12,544**

Table 58: Scenario 3 – biomass heat 25 year financial case

Internal rate of return	-8.6 %
Net present value	-£2,685,683
Simple payback	>25 years

Table 59: Scenario 3 – biomass heat 40 year financial case

Internal rate of return	No IRR
Net present value	-£3,077,904
Simple payback	>40 years

Scenario 3 – Biomass CHP

Table 60: Estimated capital costs for Scenario 3 – biomass CHP

Cost of CHP plant (incl. controls, M&E, emissions abatement)	£1,787,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£256,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,002,975
Cost of building connections for existing buildings (heat network)	£1,042,000
Cost of private wire network	£266,908
Contingency	20 %
Total cost of scheme	£5,225,859

Table 61: Financial assessment for Scenario 3 – biomass CHP

Phase heat demand (MWh)	3,489
District heat network losses (MWh)	529
Total amount of heat generated (MWh)	4,018
Size of biomass CHP (kWth)	720
Size of biomass CHP (kWe)	36
Biomass CHP modulation limit	30 %
Size of auxiliary (kW)	1,600
Heat generation biomass CHP (MWh)	3,632
Heat generation auxiliary oil (MWh)	402
Biomass CHP electrical generation per annum (MWh)	252
Value of heat sales	£173,599
Electricity sales (private wire)	£21,823
Electricity sales (export)	-
Value of RHI	£82,961
Total Income	**£278,383**
Cost of woodfuel for biomass CHP	£129,713
Cost of operation for biomass CHP	£20,000
Biomass CHP replacement costs for 25 year business case	£17,870
Biomass CHP replacement costs for 40 year business case	£44,675
Cost of fuel for auxiliary (oil)	£16,051
Cost of operation for auxiliary	£1,207
Auxiliary replacement costs for 25 year business case	£6,827
Auxiliary replacement costs for 40 year business case	£10,667
Cost of energy centre operation	£6,670
Cost of network operation and maintenance	£6,682
Total costs of generation for 25 year business case	**£205,021**
Total costs of generation for 40 year business case	**£235,666**
Net income for 25 year business case	**£73,362**
Net income for 40 year business case	**£42,717**

Table 62: Scenario 3 – biomass CHP 25 year financial case

Internal rate of return	-6.1 %
Net present value	-£3,679,478
Simple payback	>25 years

Table 63: Scenario 3 – biomass CHP 40 year financial case

Internal rate of return	-7.7 %
Net present value	-£4,162,572
Simple payback	>40 years

Scenario 3 - GSHP

Table 64: Estimated capital costs for Scenario 3 – GSHP

Cost of GSHP (incl. controls, M&E, boreholes, etc)	£1,953,999
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£256,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,002,975
Cost of building connections and conversion of existing heating systems	£1,042,000
Contingency	20 %
Total cost of scheme	**£5,105,968**

Table 65: Financial assessment for Scenario 3 - GSHP

Phase heat demand (MWh)	3,489
District heat network losses (MWh)	529
Total amount of heat generated (MWh)	4,018
Size of GSHP (kWth)	700
Size of auxiliary (kW)	1,600
Heat generation GSHP (MWh)	3,496
Heat generation auxiliary gas (MWh)	522
Value of heat sales	£173,599
Value of RHI	£138,818
Total Income	**£312,417**
Cost of electricity for GSHP	£82,453
Cost of operation for GSHP	£27,971
GSHP replacement costs for 25 year business case	£8,925
GSHP replacement costs for 40 year business case	£22,313
Cost of fuel for auxiliary (oil)	£20,806
Cost of operation for auxiliary	£1,565
Auxiliary replacement costs for 25 year business case	£6,827
Auxiliary replacement costs for 40 year business case	£10,667
Cost of energy centre operation	£6,670
Cost of heat network operation and maintenance	£5,082
Total costs of generation for 25 year business case	**£160,300**
Total costs of generation for 40 year business case	**£177,527**
Net income for 25 year business case	**£152,117**
Net income for 40 year business case	**£134,889**

Table 66: Scenario 3 – GSHP 25 year financial case

Internal rate of return	-2.0 %
Net present value	-£2,359,639
Simple payback	>25 years

Table 67: Scenario 3 – GSHP 40 year financial case

Internal rate of return	-1.3 %
Net present value	-£2,446,774
Simple payback	>40 years

Scenario 3 – Heat offtake from Syn2gen biomass CHP

Table 68: Estimated capital costs for Scenario 3 – heat offtake from Syn2gen biomass CHP

Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£256,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£1,002,975
Cost of building connections for existing buildings	£1,042,000
Contingency	20 %
Total cost of scheme	**£2,121,184**

Table 69: Financial assessment for Scenario 3 – heat offtake from Syn2gen biomass CHP

Phase heat demand (MWh)	3,489
District heat network losses (MWh)	529
Total amount of heat generated (MWh)	4,018
Heat offtake capacity (kWth)	1,500
Size of auxiliary (kW)	1,600
Total heat offtake (MWh)	4,000
Heat generation auxiliary oil (MWh)	18
Value of heat sales	£173,599
Value of RHI	£173,599
Total Income	**£99,990**
Cost of heat purchased from Syn2gen	£736
Cost of fuel for auxiliary (oil)	£55
Cost of operation for auxiliary	£6,827
Auxiliary replacement costs for 25 year business case	£10,667
Auxiliary replacement costs for 40 year business case	£6,670
Cost of energy centre operation	£5,082
Cost of network operation and maintenance	£119,361
Total costs of generation for 25 year business case	**£123,201**
Total costs of generation for 40 year business case	**£54,238**
Net income for 25 year business case	**£50,398**
Net income for 40 year business case	**3,489**

Table 70: Scenario 3 – heat offtake 25 year financial case

Internal rate of return	-1.9 %
Net present value	-£1,397,494
Simple payback	>25 years

Table 71: Scenario 3 – heat offtake 40 year financial case

Internal rate of return	0.9%
Net present value	-£1,038,004
Simple payback	34 years

Scenario 4 – Biomass Heat

Table 72: Estimated capital costs for Scenario 4 – biomass heat

Cost of biomass boiler (incl. controls, M&E, emissions abatement)	£552,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£240,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£862,699
Cost of building connections for existing buildings	-
Contingency	20 %
Total cost of scheme	**£1,985,639**

Table 73: Financial assessment for Scenario 4 – biomass heat

Phase heat demand (MWh)	2,236
District heat network losses (MWh)	443
Total amount of heat generated (MWh)	2,679
Size of biomass boiler (kWth)	600
Biomass modulation limit	0 %
Size of auxiliary (kW)	1,500
Heat generation biomass (MWh)	2,322
Heat generation auxiliary oil (MWh)	358
Value of heat sales	£90,105
Value of RHI	£55,341
Total Income	**£145,445**
Cost of woodfuel for biomass	£82,918
Cost of operation for biomass	£34,826
Biomass replacement costs for 25 year business case	£6,900
Biomass replacement costs for 40 year business case	£17,250
Cost of fuel for auxiliary (oil)	£14,267
Cost of operation for auxiliary	£1,073
Auxiliary replacement costs for 25 year business case	£6,400
Auxiliary replacement costs for 40 year business case	£10,000
Cost of energy centre operation	£4,495
Cost of network operation and maintenance	£4,117
Total costs of generation for 25 year business case	**£154,996**
Total costs of generation for 40 year business case	**£168,946**
Net income for 25 year business case	**-£9,550**
Net income for 40 year business case	**-£23,500**

Table 74: Scenario 4 – biomass heat 25 year financial case

Internal rate of return	No IRR
Net present value	-£2,080,873
Simple payback	>25 years

Table 75: Scenario 4 – biomass heat 40 year financial case

Internal rate of return	No IRR
Net present value	-£2,627,293
Simple payback	>40 years

Scenario 4 – Biomass CHP

Table 76: Estimated capital costs for Scenario 4 – biomass CHP

Cost of CHP plant (incl. controls, M&E, emissions abatement)	£1,787,000
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£240,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£862,699
Cost of private wire network	£213,908
Contingency	20 %
Total cost of scheme	**£3,724,328**

Table 77: Financial assessment for Scenario 4 – biomass CHP

Phase heat demand (MWh)	2,236
District heat network losses (MWh)	443
Total amount of heat generated (MWh)	2,679
Size of biomass CHP (kWth)	720
Size of biomass CHP (kWe)	36
Biomass CHP modulation limit	30%
Size of auxiliary (kW)	1,500
Heat generation biomass CHP (MWh)	2,473
Heat generation auxiliary oil (MWh)	224
Biomass CHP electrical generation per annum (MWh)	172
Value of heat sales	£90,105
Electricity sales (private wire)	£15,008
Electricity sales (export)	-
Value of RHI	£59,468
Total Income	**£164,580**
Cost of oil for biomass CHP	£88,316
Cost of operation for biomass CHP	£20,000
Biomass CHP replacement costs for 25 year business case	£17,870
Biomass CHP replacement costs for 40 year business case	£44,675
Cost of fuel for auxiliary (oil)	£8,930
Cost of operation for auxiliary	£672
Auxiliary replacement costs for 25 year business case	£6,400
Auxiliary replacement costs for 40 year business case	£10,000
Cost of energy centre operation	£4,495
Cost of network operation and maintenance	£5,417
Total costs of generation for 25 year business case	**£152,100**
Total costs of generation for 40 year business case	**£182,505**
Net income for 25 year business case	**£12,481**
Net income for 40 year business case	**-£17,924**

Table 78: Scenario 4 – biomass CHP 25 year financial case

Internal rate of return	No IRR
Net present value	-£3,373,264
Simple payback	>25 years

Table 79: Scenario 4 – biomass CHP 40 year financial case

Internal rate of return	No IRR
Net present value	-£4,150,567
Simple payback	>40 years

Scenario 4 - GSHP

Table 80: Estimated capital costs for Scenario 4 – GSHP

Cost of GSHP (incl. controls, M&E, boreholes, etc)	£1,515,043
Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£240,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£862,699
Contingency	20 %
Total cost of scheme	**£3,141,291**

Table 81: Financial assessment for Scenario 4 - GSHP

Phase heat demand (MWh)	2,236
District heat network losses (MWh)	443
Total amount of heat generated (MWh)	2,679
Size of GSHP (kWth)	600
Size of auxiliary (kW)	1,500
Heat generation GSHP (MWh)	1,823
Heat generation auxiliary gas (MWh)	856
Value of heat sales	£90,105
Value of RHI	£90,142
Total Income	**£180,246**
Cost of electricity for GSHP	£44,029
Cost of operation for GSHP	£14,586
GSHP replacement costs for 25 year business case	£7,650
GSHP replacement costs for 40 year business case	£19,125
Cost of fuel for auxiliary (oil)	£34,146
Cost of operation for auxiliary	£2,568
Auxiliary replacement costs for 25 year business case	£6,400
Auxiliary replacement costs for 40 year business case	£10,000
Cost of energy centre operation	£4,495
Cost of heat network operation and maintenance	£4,117
Total costs of generation for 25 year business case	**£117,992**
Total costs of generation for 40 year business case	**£133,067**
Net income for 25 year business case	**£62,255**
Net income for 40 year business case	**£47,180**

Table 82: Scenario 4 – GSHP 25 year financial case

Internal rate of return	-8.0%
Net present value	-£2,207,855
Simple payback	>25 years

Table 83: Scenario 4 – GSHP 40 year financial case

Internal rate of return	No IRR
Net present value	-£2,619,476
Simple payback	>40 years

Scenario 4 – Heat offtake from Syn2gen biomass CHP

Table 84: Estimated capital costs for Scenario 4 – heat offtake from Syn2gen biomass CHP

Cost of auxiliary & plant equipment (incl. thermal store, energy centre, M&E)	£240,000
Cost of DH network (incl. trenching costs, project management, designs and surveys)	£862,699
Contingency	20 %
Total cost of scheme	**£1,323,239**

Table 85: Financial assessment for Scenario 4 – heat offtake from Syn2gen biomass CHP

Phase heat demand (MWh)	2,236
District heat network losses (MWh)	443
Total amount of heat generated (MWh)	2,679
Heat offtake capacity (kWth)	2,000
Size of auxiliary (kW)	1,500
Total heat offtake (MWh)	2,672
Heat generation auxiliary oil (MWh)	7
Value of heat sales	£90,105
Total Income	**£90,105**
Cost of heat purchased from Syn2gen	£66,811
Cost of fuel for auxiliary (oil)	£278
Cost of operation for auxiliary	£21
Auxiliary replacement costs for 25 year business case	£6,400
Auxiliary replacement costs for 40 year business case	£10,000
Cost of energy centre operation	£4,495
Cost of network operation and maintenance	£4,117
Total costs of generation for 25 year business case	**£82,122**
Total costs of generation for 40 year business case	**£85,722**
Net income for 25 year business case	**£7,982**
Net income for 40 year business case	**£4,382**

Table 86: Scenario 4 – heat offtake 25 year financial case

Internal rate of return	-7.1 %
Net present value	-£1,057,006
Simple payback	>25 years

Table 87: Scenario 4 – heat offtake 40 year financial case

Internal rate of return	-3.6 %
Net present value	-£1,043,972
Simple payback	>40 years