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TANYGRISIAU GWYNEDD COMMUNITY HEAT NETWORK

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GLOSSARY OF TERMS, ABBREVIATIONS AND ACRONYMS

ASHP	Air Source Heat Pump
BAU	Business as Usual
CAPEX	Capital Expenditure
CoP	Coefficient of Performance
DEC	Display Energy Certificate
DH	District Heating
DHN	District Heating Network
EC	Energy Centre
EPC	Energy Performance Certificate
FAST	Flexible, Appropriate, Structured and Transparent
LTHW	Low Temperature Hot Water
No.	Number of
NPV	Net Present Value
OPEX	Operational Expenditure
REPEX	Replacement Expenditure
TS	Thermal Store
WP	Work Package
WSHP	Water Source Heat Pump

EXECUTIVE SUMMARY

1.1 Background

Ramboll has been appointed under the DESNZ Framework LOT 1 to undertake the design and specification of a community heat network in the village of Tanygrisiau, Gwynedd on behalf of Cygnor Gwynedd.

The heat network scheme is part of a wider Innovate UK funded project to create a new business model that delivers heat and electricity by utilising local energy sources and local energy markets. The key collaborators on the client side for this project are:

- Gwynedd Council, who provides steer and input
- Energy Local (EL), who develop local energy markets and provides regulatory, technical and economic inputs.

The project is split into two separate work packages.

- **Work Package 1 (WP1): Heat Network Specification and design.**
This work package delivers a detailed design of the heat network including the network piping route, energy centre design, thermal storage needs and customer connection design.
- **Work Package 2 (WP2): Retrofit Strategy - Fabric Improvement and Heat Demand Reduction.**
This work package assesses the current housing stock to determine the most cost-effective methods of reducing energy demand within the customer premises and how much can be achieved compared to a business as usual base case.

The objective of the two work packages above is to provide inputs to inform a wider business case with detailed financial and operational data. The project aims to secure capital funding and begin the local planning application.

1.2 Summary of Analysis

Within work package 2, the effect of the fabric improvement on the houses in Tanygrisiau showed to reduce space heating demands by an average of 35%. This reduced heating demand value was then used in the work package 1 within the demand assessment to understand the requirement of the heat network. Rehaus is the largest load requiring over half of the total peak of 1.8MW.

To supply the network, the reservoir in Tanygrisiau has been chosen as a suitable source for a water source heat pump. Through analysis and optimisation, it was found that 1MW of heat pump, alongside 1MW of electric boiler for peaking and 150m³ of thermal store will supply the network effectively.

As well as a water source heat pump, an air source heat pump (ASHP) option was also considered as an alternative / fall-back option. ASHPs require less secondary equipment, however, performance of ASHPs can be less efficient than WSHPs due to the variability in air temperature. Where the utilisation of the heat pump is high, the higher operating efficiency of WSHPs tends to lead to better project economics despite the higher capital costs.

The energy centre is assumed to be located close to the reservoir with the peaking plant assumed to be located at the Rehaus facility. High level hydraulic analysis was undertaken using our in-house GIS based hydraulic model District One. The network length is 5.1km with the largest internal pipe diameter of 125mm.

Once the energy centre equipment and network sizing analysis was completed, CAPEX and OPEX (not including energy import) costs were estimated through benchmarks, previous project data and supplier quotes.

1.3 Key Findings

Table 1 below summarises the key results of modelling and costing the WSHP and ASHP network options.

Table 1: Summary of key results for chosen network options

Variable	Units	WSHP	ASHP
Total Heat Generation	MWh/yr	4,930	4,930
Percentage of Heat Produced by Heat Pumps	%	90.4	90.4
Electricity Consumption	MWh/yr	1,791	2,263
Total CAPEX	M£	8.42	7.91
Total OPEX	M£	0.083	0.067

As expected, the estimated capital and maintenance costs of an ASHP are lower than a WSHP system, but the electrical consumption increases for ASHPs due to their lower COPs. Therefore, if the fuel costs had been taken into consideration, it is likely that the Whole Life Cost for the WSHPs will be overall lower than that for the ASHPs (although this was outside of this study's scope).

1.4 Recommendations and Next Steps

It is recommended that the outlined overall network scheme identified and developed through Work Packages 1 and 2 of this project is progressed to a further Project Development stage to include technical, financial and commercial elements.

Key considerations and limitations of the study are as follows:

1. The findings of this study are primarily based on the assumed annual heating profiles of the proposed connections. The economic viability of the scheme is sensitive to heat demand and securing connections from the key stakeholders. Therefore, further engagement and direct monitoring is recommended to reduce design risks.
2. The design and construction capital costs need more detailed analysis to reduce the risk associated with this. This is particularly relevant to the distribution network element of the DH scheme.
3. The planning process can create unintended barriers that increase development costs and extends delivery schedules.

Given the ambitions of the council to tackle the local fuel poverty and the carbon emission targets set by the local authority and the UK government, this heat pump led DHN scheme would significantly aid the Council and region to achieve their goals.

Some recommended actions are below:

- Contact heat pump manufacturers and arrange site visits to better understand the risks and potential costs of any suggested solutions.
- Engage with Rehau to understand the feasibility of placing any peaking plant within their premises.
- Engage with the local electricity DNO, SPEN and align with local strategies in electrical grid infrastructure upgrades.
- Engage with heat network developer ESCo(s) to further inform the procurement case.
- Engage with a specialist DH network design and installation contractor to further understand civil costs and potential implications and timescales if a crossing of an infrastructure is required.

2. INTRODUCTION

2.1 Background

Ramboll has been appointed under the DESNZ Framework LOT 1 to undertake the design and specification of a community heat network in the village of Tanygrisiau, Gwynedd on behalf of Cygnor Gwynedd.

The heat network scheme is part of a wider Innovate UK funded project to create a new business model that delivers heat and electricity by utilising local energy sources and local energy markets. The key collaborators on the client side for this project are:

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The project is split into two separate work packages.

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This work package assesses the current housing stock to determine the most cost effective methods of reducing energy demand within the customer premises and how much can be achieved compared to a business as usual base case.

The objective of the two work packages above is to provide inputs to inform a wider business case with detailed financial and operational data. The project aims to secure capital funding and begin the local planning application.

2.2 Work Package 1 Heat Network Specification and Design Objectives

The objectives of WP1, as defined in the project specification, were as follows:

1. Conduct an assessment of previous the feasibility studies carried out under Pioneer places, flag key risks and missing data. Refer to previous reports as appropriate.
2. Create a strategic plan, confirm the district heating plan and heat source is 'fit for purpose', confirm baseline profiles of current heat demand and the effect of high demand customers (use data available from studies to date) With data from **work package 2** estimate reduction in heat demand possible.
3. Define the electrical and thermal storage strategy and how this can be used to smooth the generation profile of the local hydro-electric plants and balance heat demand with electricity supply. Take into account network studies carried out under SP Energy Network lead NIA project.
4. Identify, development timelines, key dependencies, constraints, and strategic risks, alternative heat source if water source heat pump is not possible.
5. Confirm compliance with the latest industry standards, such as the CIBSE/ADE Heat Networks Code of Practice.
6. Technical Design of the heat network including, energy centre location and design, heat pipe routing, backup and contingency options.
7. Estimation of all capital costs involved in rolling out the heat network.
8. Estimation of operating costs involved in the day to day running of the heat network for a defined period of time i.e. 25, 30, 40 yrs.

2.3 Work Package 2 Retrofit Strategy Objectives

The objectives of WP2, as defined in the project specification, were as follows:

1. Using information gathered to date, assess the current heat load from domestic and industrial users to create a base line demand curve.

2. Assessment of options available to improve the housing stock's thermal efficiency to a high standard – ideally EPC A.
3. Capital costs associated with rolling out the preferred option from 2 above.
4. Creation of new heat demand models given preferred option from 2 above and reduction in heat demand.
5. Assessment of timeline of heat network rollout vs RSLs legal obligations to improve the EPC ratings of their housing stock
6. Creation of project plan for roll out.

2.4 Final Outputs Required

The scope of works above aimed to build upon the feasibility work already completed. The included the 'Tanygrisiau community heat network feasibility study' completed by Prospus, which proposed network routes, an energy centre location and high-level costs associated with heat network roll out. The work also builds upon the 'Braking Barriers to Bethesda and Blaenau becoming Net Zero' stage one report by Pioneer Places, which studied the heat demand reduction following retrofit measures and outlined a Community Energy Supply Company (CESCo) model for delivery of the scheme.

The outputs from this work will feed into the wider business case which is being developed by Energy Local and other Public Private (PP) consortium members. It will be used to create a robust a business plan to secure funding and initiate the local planning process.

The items below are required by the PP consortium to move to the next stage of the project.

1. Technical design of the heat network up to RIBA Stage 2 'Concept Design'
 - o Network Design – Piping used, estimates of lengths, diameters, river/road crossings
 - o Energy Centre Design including storage and back up strategy
 - o Typical Customer Connection Points and Measurement
 - o It will also cover all design optimisation work undertaken
2. Estimates of OpEx & CapEx for the project broken down in to
 - o CapEx - Energy Centre
 - o CapEx - Heat Network Infrastructure including Customer Connection
 - o CapEx for Retrofit Strategy
 - o OpEx – NOT including energy import costs
3. Produce Data to enable Energy Import/Local Use Estimates
 - o Production of a Domestic Heat Demand curve for Tanygrisiau housing
 - o Effect of Retrofit on above Heat Demand curve
 - o Match use of Hydro resource to Heat demand to estimate annual electricity import requirements.
4. Any supplementary designs, drawings and maps created throughout the project.
5. Produce a 1-page summary for residents: Explaining what a heat network is and what it means for the household (connection charge if any, works/disruption, tariff, HIU vs. boiler etc.)

This report has been structured in line with these scope items.

3. DESCRIPTION OF THE STUDY AREA

3.1 Overview

Tanygrisiau is small village and area neighbouring the semi-urban area of Blaenau Ffestiniog in the community of Ffestiniog and the county of Gwynedd in north-west Wales. The geographic area is rural and the village sits along the southern side of the Moelwyn mountain range at the upper end of the Vale of Ffestiniog.

The village sits on the northernmost point of Tanygrisiau reservoir, which alongside Llyn Stwlan, forms a 360 MW pumped storage hydroelectricity scheme. The scheme generates power through Ffestiniog Power Station and is operated by First Hydro, a joint venture between Engie Energy International PLC and Mitsui & Co.

Historically a major centre for slate mining, today the village hosts a population of approximately 350 and features around 216 houses, a school, a church, and an industrial site – Rehau. The majority of buildings in the area are located between Afon Barlwyd and the narrow gauge railway, with most of the remaining domestic properties located on Cwmorthin Road.

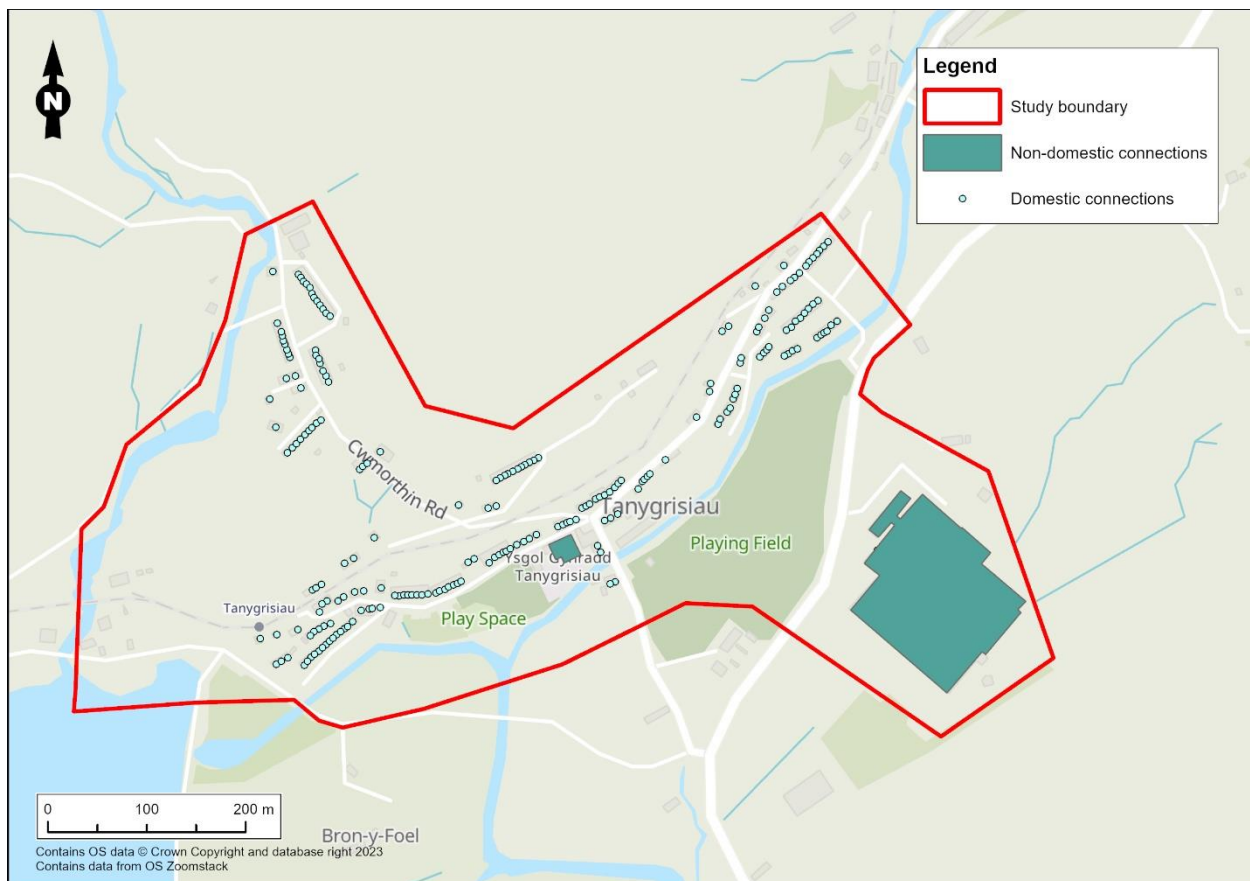


Figure 1: Location of Tanygrisiau

4. ENERGY DEMAND ASSESSMENT

4.1 Overview

This section is a summary of the energy demand data of the buildings within the study area considered. This data provided the design basis taken forward through subsequent stages of the project. As part of this study, previous master planning and feasibility studies were reviewed and updated to incorporate the latest Energy Performance Certificates (EPCs) and metered data.

The preferred scheme configuration includes 217 houses, 1 school and 1 industrial stakeholder, Rehau.

4.2 Stakeholder Engagement

Energy Local was supplied with Request for Information (RFI) templates to gather data and information required for buildings with potentially significant heat demand. RFI responses included a breakdown of demands and profiles for a typical house, the local school and the Rehau industrial load. Energy local also provided the data used in previous stages of their work such as the electrical output of the local hydro plants.

To help facilitate stakeholder engagement, Ramboll participated in a call with Rehau to discuss the project further and what it would mean for them as a connection. Rehau provided further details on how the plant is currently heated and showed substantial interest in connecting to the network.

4.3 Property Profile

The majority of the houses were constructed in the late 1800s with some further properties built in the mid-1900s. The property age is reflected in the build type, with the properties either having solid stone built walls - 70%, (EPC - Granite, Whinstone, Limestone or Sandstone), or cavity walls - 30%. Further detail on insulation and construction type can be found in Section 4.4.

4.4 Heat Demand Assessment Assumptions

The source data for the assessment of the annual heat demands used was the EPC database ([Energy Performance of Buildings Data England and Wales](#)). EPCs are required to be produced when a house is sold or rented out, hence over time more of the housing stock will have an EPC. EPCs are still only an estimate of the heat demands as although they consider the levels of insulation for each house, the ultimate demands are significantly influenced by the residents' heating behaviours (e.g. how warm they choose to heat the property and for how much of the day the property is heated).

The EPC data includes information on the estimated heat use for space heating, DHW (Domestic Hot Water), construction type, heating type and other energy efficiency measures. Excluding null or not applicable (N/A) values, there were 181 viable entries in the EPC database for Tanygrisiau.

Figure 2 shows the key characteristics of the buildings indicated within the EPC data.

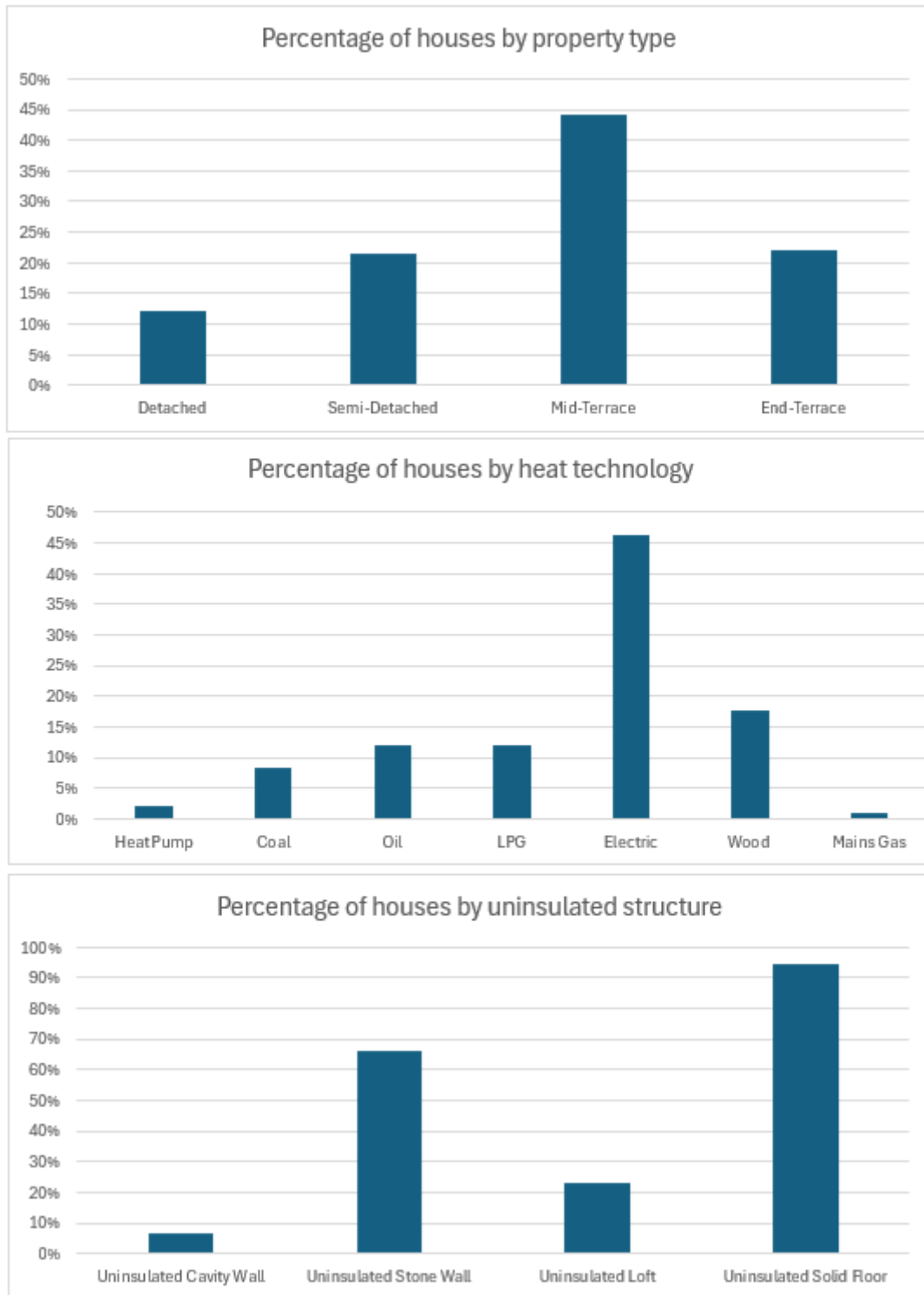


Figure 2: Categorisation of EPC data for the houses assessed in Tanygrisiau

In summary the data shows:

- 33% of houses heated with oil, LPG, or coal, 46% with electricity, and 18% through wood or similar materials. The EPC data set suggests 4 properties have an installed heat pump system however this has been excluded from further analysis due to lack of data certainty.

- The stock is predominantly terraced housing (66%), with detached and semi-detached houses accounting for 34% of the total property count.
- There is a high level of uninsulated properties with 73% of properties requiring wall insulation, 23% requiring loft insulation, and 94% requiring floor insulation.
- The proportion of these wall types and space heat demands were then increased pro-rata up to the number of houses included in the heat network feasibility.
- The houses with poor insulation / higher annual heat demands have typically a longer heating season (i.e. space heating required at higher ambient temperatures) than the better insulated houses. The domestic hot water (DHW) demand for the houses was modelled separately. Benchmarks were used depending on the size of the house and for Tanygrisiau an average annual DHW consumption of **2,370 kWh** per year was found.

To model the heat demands, the housing stock was categorised into archetypes designed to represent the diversity of the building stock as shown in Table 2, whilst minimising the number of options considered by the model.

4.4.1 Retrofit measures assumed

Retrofit measures were applied following the categorisation of the properties based on wall type, and the level of insulation in lofts and on floors. Double glazing was applied for all properties with an assumption made that all existing glazing will be upgraded.

The EPC total floor area was used to estimate wall areas, and property type used to estimate the total window count and area. These estimates were used to calculate the required amounts of insulation, and their associated costs. The heat demand reduction following application of retrofit measures was used to guide the selection of heat demand benchmarks per property type.

Table 2: Number of properties by property type that require identified retrofit measures

	No. of Detached	No. of Semi-detached	No. of Mid-terrace	No. of End-terrace	Total
Cavity wall insulation	0	2	8	6	15
Exterior wall insulation	17	10	73	45	144
Loft insulation	2	3	36	8	50
Solid floor insulation	25	27	99	53	205
Double glazing	25	34	102	56	217

4.4.2 Residential Heat Demand Assessment Updated inc. Retrofit

The above retrofit measures were estimated to result in a space heating demand reduction of above 35%, broken down into different house types. **Table 3** shows the chosen 219 stakeholders suitable for connection and how their demand altered with the incorporation of retrofit measurements.

By adding the hot water demand element which is unaffected by the retrofit measures the overall heat demand reduction (heating and domestic hot water) is estimated at 28% as an average, as seen in Table 4.

Table 3: Impact of retrofit measures on annual space heating demand

Average Annual Space Heating Demand if all retrofit measures were implemented (kWh)			
Typology	Pre-Retrofit	Post-Retrofit	Percentage of Reduction (%)
Mid-Terrace	6,664	3,880	41%
Semi-Detached	8,406	5,459	35%
End-Terrace	8,434	5,477	35%
Detached	11,645	8,030	31%

Table 4: Heat demand (Space heating and domestic hot water) Schedule of the preferred stakeholders pre and post retrofits.

Ref	Name	Before Retrofit (kWh/year)	After Retrofit (kWh/year)
1	Rehau	2,794	No change as no retrofits assumed
2	Ysgol Tanygrisiau	69	No change as no retrofits assumed
-	Residential (217 Houses)	2,263	1,619 (circa 28% reduction)

Figure 3 shows the location of the chosen stakeholders

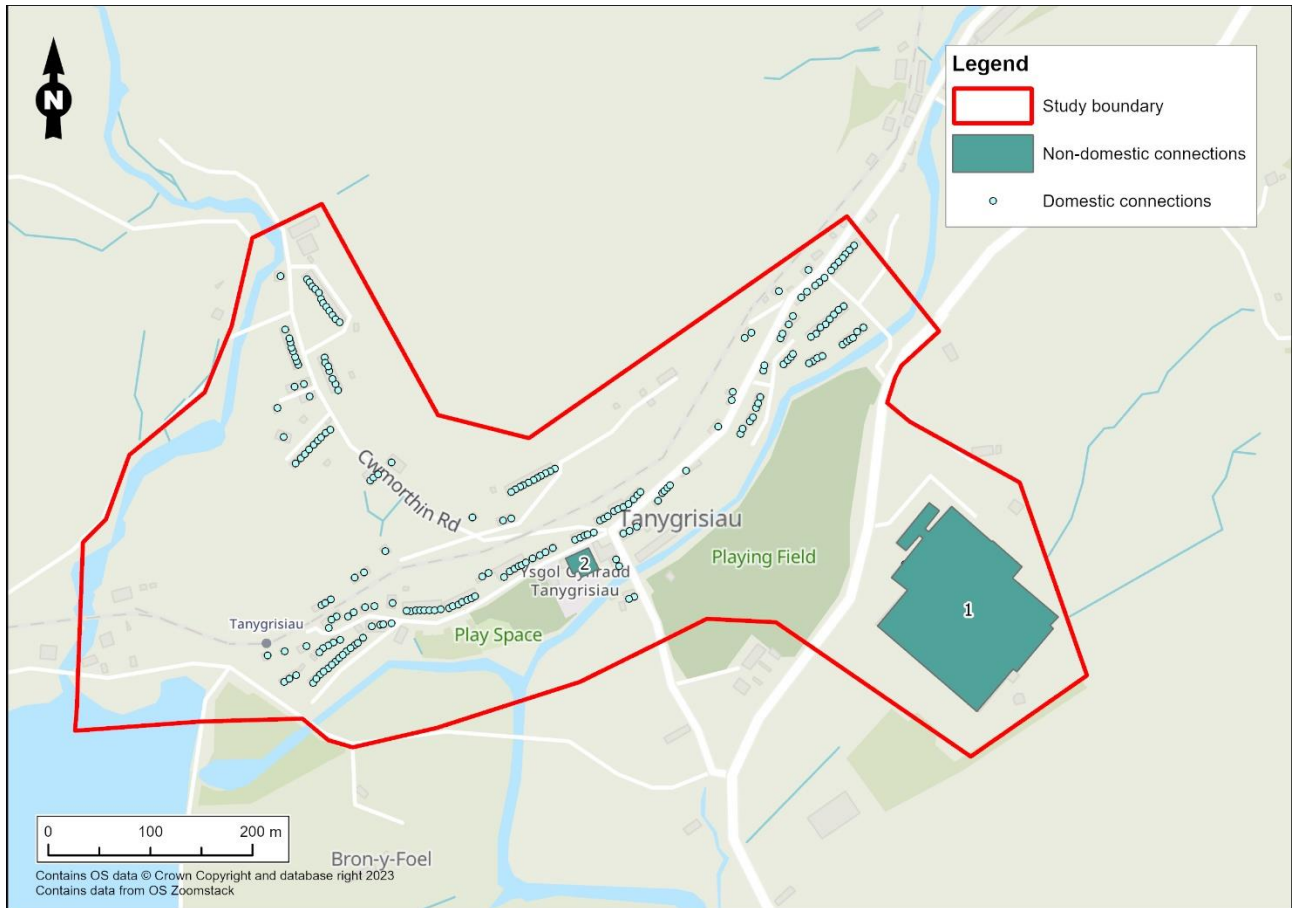


Figure 3: Chosen stakeholders

4.4.3 Heat Demand Profiles

Figure 4 below shows the demand profile of Rehau, the key anchor load in the project, showing a heat peak of around **1.1 MW**.

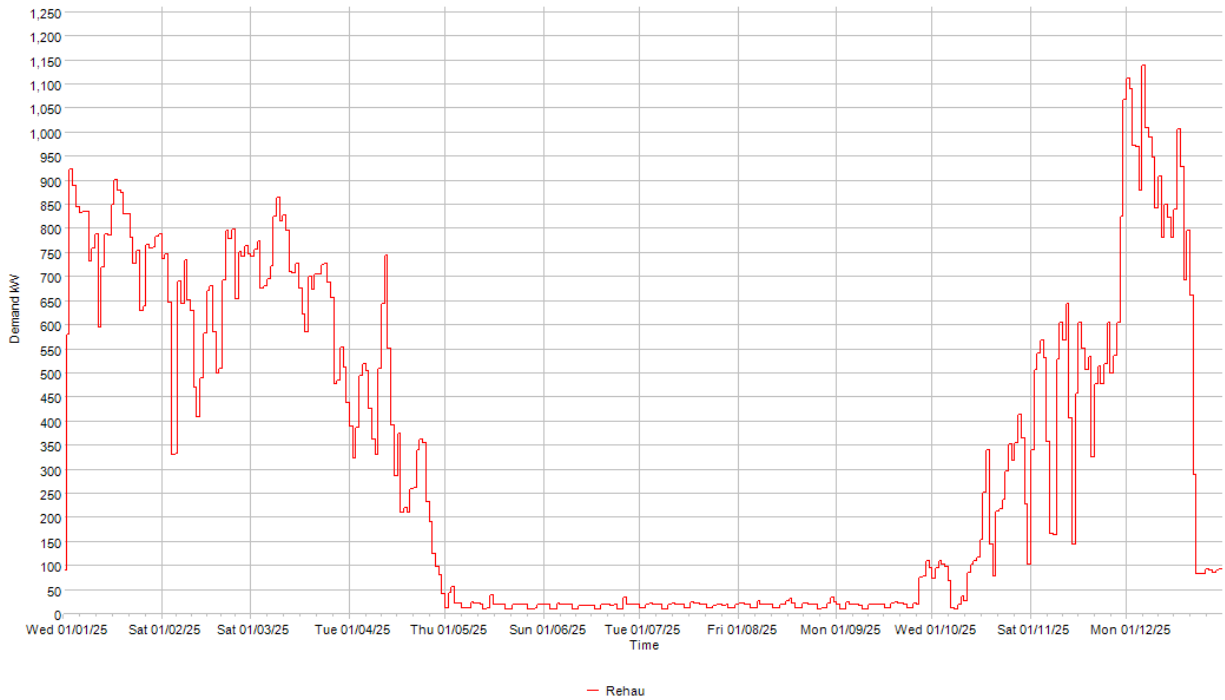


Figure 4: Demand profile of Rehaus

The total demand profile for all houses is shown in **Figure 5**. This profile has been taken from RFI data and accounts for diversification which reduces the overall peak demand by considering the simultaneity of the use of heating and hot water of the different users in the network. This results in a total diversified peak of roughly **700 kW** for all houses considered.

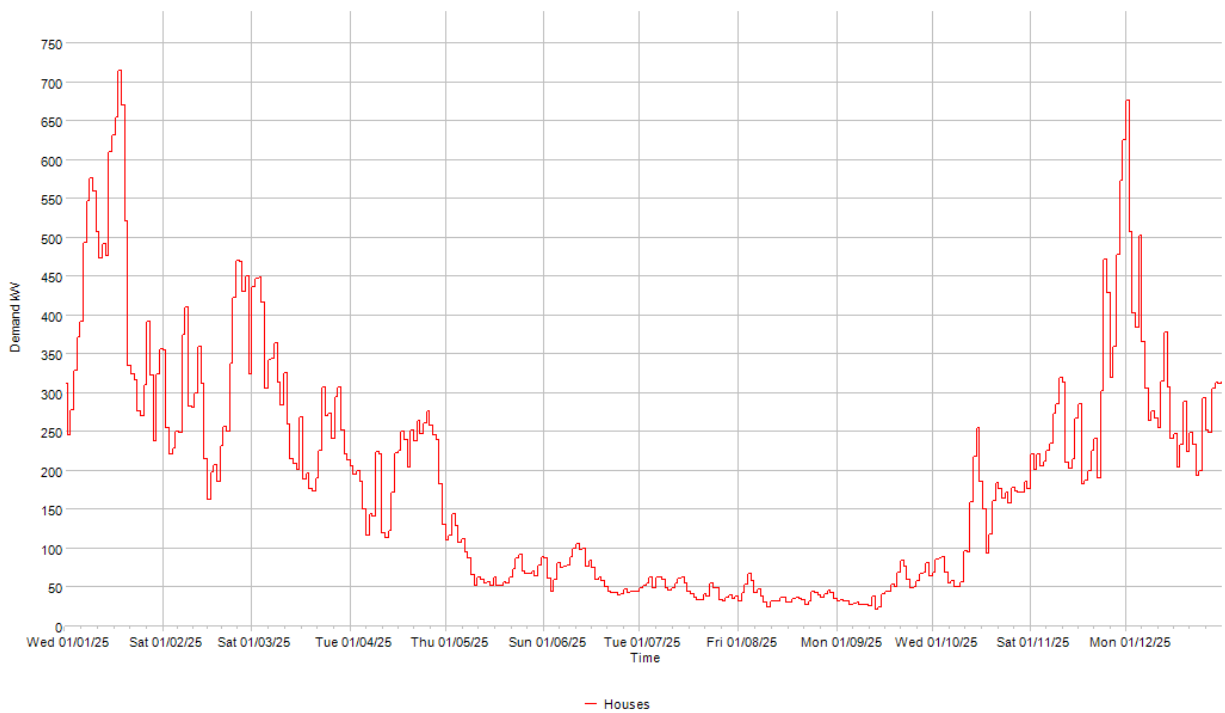


Figure 5: Total demand profile of all houses considered for connection.

The total annual heat demand for all chosen stakeholders is **4,480 MWh**. The yearly profile of this demand is shown below in **Figure 6** and with a heat peak of circa **1.8 MW**.

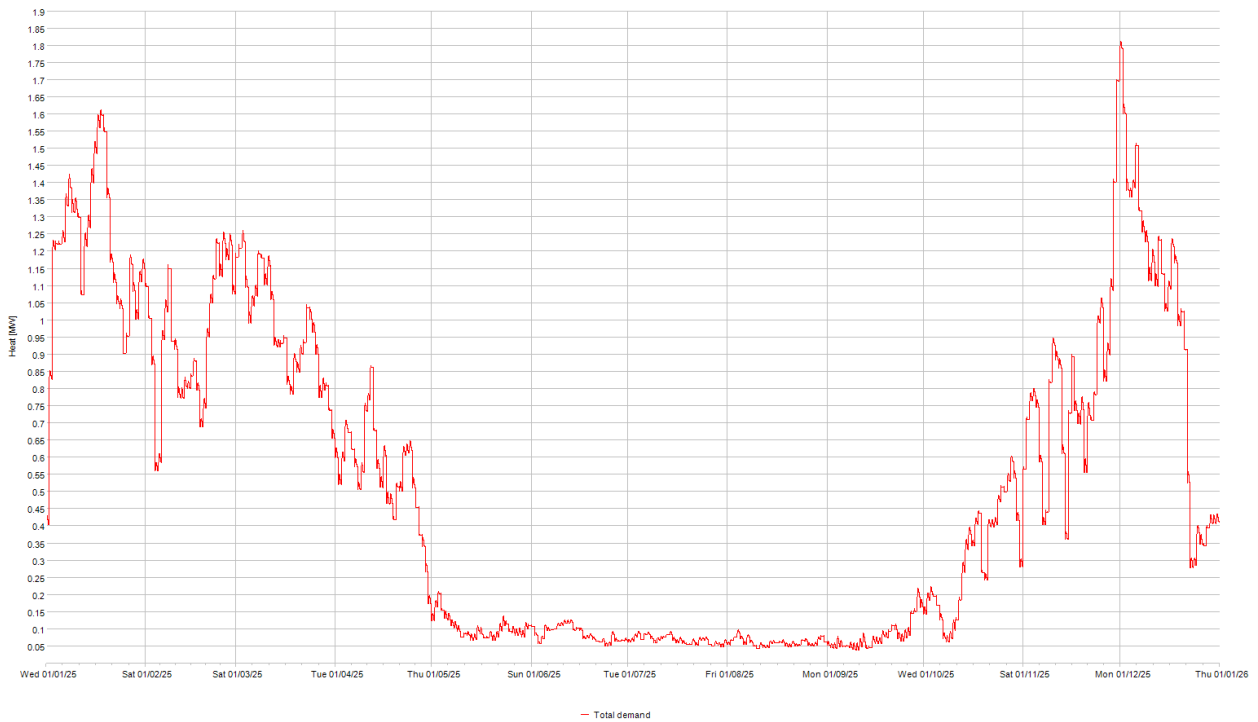


Figure 6: Total demand profile of chosen stakeholders

4.4.4 Summary of Heat Demand

Table 5 gives the summarised heat demand for the whole site used in the energy modelling and scheme design going forward.

Table 5: Heat Demand Assessment Summary

Name	Total Annual Heat Demand (MWh / year)	Total Peak Demand (MWth)
Rehau	2,793.5	1.14
Ysgol Tanygrisiau	69.4	0.04
Residential (217 Houses)	1,619.0	0.71
Total	4,481.9	1.80

5. ENERGY SUPPLY ASSESSMENT & OPTIMISATION

5.1 Low carbon heat source selection

The ambition is to utilise low carbon heat sources, supplied by locally generated electricity in the nearby hydro plants to provide heat for the heat network.

The appropriate renewable heat options shortlisted for this study are:

- open loop water source heat pumps;
- closed loop water source heat pumps;
- individual air source heat pumps.

Each of these are commented on below. Other renewable technologies such as biomass CHP and anaerobic digestion were not studied due to lack of proven technical solutions at this scale (biomass CHP) and lack of awareness of local resource for feedstock (anaerobic digestion).

5.2 Heat Pumps

Heat pumps take low temperature heat through the medium of water and use electricity to produce higher temperature heat. The output water can then be used to supply space heating and potentially hot water depending on the temperature achieved by the heat pump. The categorisation of heat pumps is through the heat source used (air, water or ground). The warmer the heat source the more efficient the heat pump can operate. Higher efficiency (also called Coefficient of Performance (COP)) results in lower operating costs and greater carbon savings.

Surface water source – e.g. drawing heat from river, lake or the sea.

In the case of water source heat pumps, a water source is passed through a heat pump to increase its temperature.

In Tanygrisiau, the nearest potential heat source is the reservoir, which is around 400 m to the centre of Tanygrisiau and the river (shown in Figure 7). Whilst initially the river was investigated as a potential heat source, it was disregarded due to limitations when using heat pumps with seasonally fluctuating water levels.

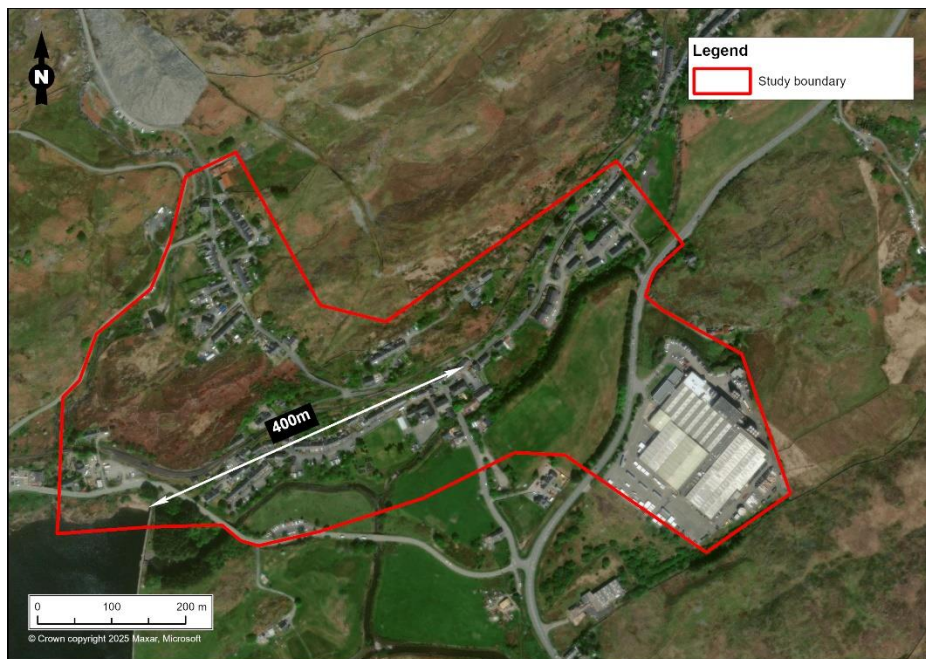


Figure 7: Location of reservoir in Tanygrisiau

From reviewing data provided in previous studies, temperatures of the reservoir ranged from around 16°C in August 2023 to 3°C in January 2024¹. Two technologies are available to extract heat from a water source: open loop and closed loop.

Open loop

Water is drawn from the source at its natural temperature and passed through a heat pump, where thermal energy is extracted. After the heat energy has been transferred to the heat pump, the water is then returned to its original source at a slightly reduced temperature, typically with a difference of around 3°C. The source water does not mix with any other substance during the process and there is no issue with contamination or pollution. However, due to the requirement for water extraction and reinjection, appropriate licenses must be secured from **Natural Resources Wales (NRW)**.

Figure 8 below shows a simple schematic of how an open loop system is configured.

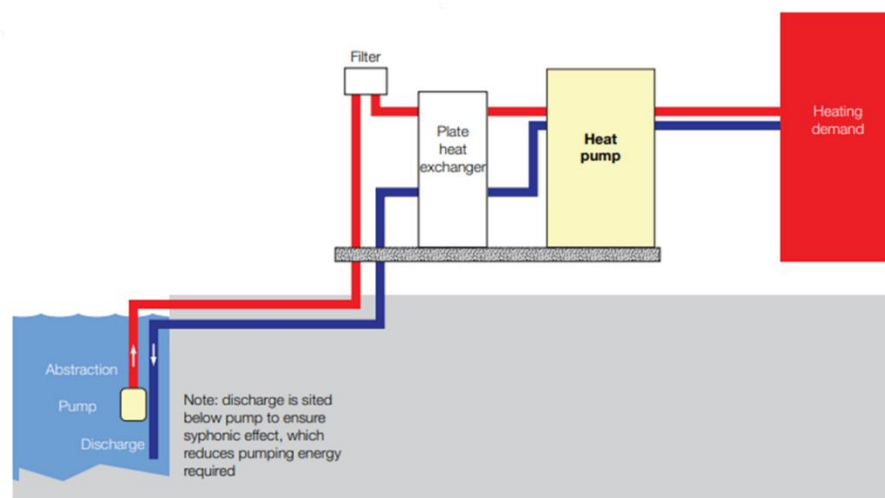


Figure 8: Simple Open Loop Heat Pump Schematic – Courtesy of CIBSE

It is recommended to use an intermediate heat exchanger in an open loop system for hydraulic separation between the water source and main circuit. This helps minimise the risk of contamination to the water source by keeping the two circuits separate and protects the components in the unit from the risk of corrosion.

Open-loop systems require filtration and regular maintenance to ensure no debris or living organisms enter the system. This will need to be selected based on the environmental parameters and local biodiversity of the area.

Another key consideration is how the water will be discharged back into the source. If the abstraction and discharge points are too close, the cooler discharged water may be immediately re-abstracted, reducing the heat pump system's efficiency due to an insufficient temperature differential for effective heating. Therefore, a water source temperature dispersion modelling is recommended at a later stage of this project to ensure correct separation is applied between abstract and discharge points.

Closed loop

In closed-loop systems, water is not extracted from the source. Instead, pipes are placed into the water in loops (slinkies) or pond mats (solution offered by Kensa), and refrigerant is circulated through these pipes to draw heat from the source. This approach of extracting heat from a static water source lowers

¹ 2460134-R01 (03) Tanygrisiau Reservoir Outflow Q1 2024

the efficiency of heat transfer. The lower heat transfer is evident when estimating the length of slinky required.

Slinkys tend to be used on smaller schemes; as a rule of thumb, 10 m of pipe (slinky) is needed per kW of heat pump capacity. For a heat pump of the size required for this project, the required pipe would be over 10 km.

Closed loop systems are more expensive to install and there is more environmental disruption risk due to the potential leakage of the refrigerant from splits or breaks in the slinky. However, there is less scope for problems associated with direct use of water which may be important in some cases where water sources cannot be disrupted.

Air source (ASHP) – taking heat from the air. This is inherently a less efficient application of heat pumps as the heat demands are higher in the winter when the air is colder than ground or water heat sources. The benefit of air source heat pumps is the lower capital cost. For the Tanygrisiau village, where the utilisation of the heat pump is high, the higher operating efficiency of water heat source heat pumps tends to lead to better economics despite the higher capital costs. For this reason, ASHP is considered only as an alternative / fall-back option.

5.3 Heat Source Selected

Based on the above factors two options were selected for evaluation. The open loop water source heat pump and the centralised air source heat pump.

These two options have the following characteristics:

Table 6: Comparison of heat technologies selected

Item	Water Source Heat Pump	Air Source Heat Pump
Capital costs	Higher – water source heat pump costs higher due to the extraction / discharge element.	Lower
Fuel costs	Lower due to the better COPs	Higher
Fuel supply process	Simple	Simple
Requirement for day-to-day management of energy centre	Low	Low
Energy centre size	Similar. Heat pump itself can be larger but extraction / discharge part can be placed within water source.	Similar. Heat pump itself can be smaller but there is a need of placing evaporators (if split units) or the heat pumps on the roof duplicating footprint.
Carbon Saving	Slightly higher due to better COPs.	Slightly lower
Local pollution	Low depending on refrigerant	Low depending on refrigerant
Keep Investment in local community	High if fuel costs can be spent locally i.e. through a PPA	High if fuel costs can be spent locally i.e. through a PPA
Technology maturity	Mature	Mature

Operating Costs – sensitivity to heat network operating temperatures	If low DH temperatures are not achieved the plant efficiency will be lower	If low DH temperatures are not achieved the plant efficiency will be lower
Key risks	Uncertain heat supply yield, biodiversity risks, low operating temperatures of DH network required, work required in houses to achieve low operating temperatures	Air Source 'island' effect that can further reduced their COP/ efficiency, low operating temperatures of DH network required, work required in houses to achieve low operating temperatures. Roof Space taken by Evaporators limits available space for PV panels. Noise emission from evaporators.
Predominant Operating Costs	Electricity	Electricity

Following discussions with water source heat pump suppliers, there is an indication that the majority of water source heat pumps utilising ambient water sources currently in operation in the UK use open source heat pumps for larger schemes (>= 1MWth). An example of such a project is Queens Quay development in Clydebank Town Centre.

The reliability of an open source system can be high, if an appropriate infiltration design is tailored to the local ecosystem and a water source temperature dispersion modelling exercise is undertaken to identify the potential yield.

5.3.1 Coefficients of Performance

During the study, a number of suppliers were contacted for further detail on existing WSHP systems and estimated coefficients of performance (COP). Data was received for both ammonia and CO₂ heat pumps, where COPs ranged from 3 to 3.5 depending on the source temperature as seen in Table 7 below.

Table 7: COPs received from suppliers

Supplier	Heat Pump Refrigerant	Source Temperatures (°C)	Network Temperatures (°C)	COP
STAR	Ammonia	5-2	65-35	3.3
			70-40	3.2
			75-45	3.1
FENAGY	CO ₂	7-2		3.0
		12-7	70-40	3.4
		15-10		3.5

As seen above, the type of refrigerant used can change what COPs are available. Refrigerant choice is based on the temperatures required for the secondary network.

Assuming an inlet temperature of 12°C, a COP of 3.4 was estimated for a CO₂ WSHP. This value has been used in this project as an average estimate of the WSHP's annual performance.

ASHPs typically have lower COPs because air temperatures are less stable, and air has lower thermal conductivity compared to water. From previous project experience it is assumed that the ASHP system will have a COP of 2.5.

5.4 Back-up and Thermal Storage

The proposed designs include the provision of back up electric boilers, as well as the retention of the gas boilers in the Rehau site at least for the initial stage of the project and until the end of their useful life. This strategy will mainly ensure security of supply, whilst also achieving the below:

- 1) A significant reduction in size of primary plant, whilst still allowing a high proportion of annual heat supplied from the primary heat source. Without a backup boiler the primary heat plant and or thermal store would have to be sized significantly larger to meet the rare points in the year when peak heat demand is reached.
- 2) The back-up plant ensures reliability of heat supply. In case the heat pump trips off or in scheduled maintenance the back-up will take over and there is less requirement for 24/7 instant response to faults. Fixing faults during the working week is much cheaper than undertaking such work outside of normal working hours.
- 3) In the event of failure to electricity supply, the retained gas boilers in Rehau could take over.
- 4) In the case of a power outage, a small generator of only a few kW would be required to run the Heat Network pumps and boilers and therefore guarantee security of supply. Electric boilers are cheap in the context of the whole scheme and their actual use should be small.

Thermal Storage

The thermal store is designed to enable the energy centre to maximise the heat output of low carbon heat technologies, in this case WSHP. A thermal store is a large hot water tank. The store allows a small plant to supply large peak heat demands. When demand is low the renewable heat source heats the store and when the demands are higher than the renewable plant output heat is drawn from the store to meet the peak. The smaller plant reduces the capital costs and the store allows the plant to run at a steady output over long time periods which enables the plant to operate efficiently. Therefore, thermal storage is crucial to maximising running hours of low carbon plant.

Thermal storage also enables intelligent operating strategies that take advantage of cheap nighttime electricity market prices. For example, charging overnight in higher temperatures and dispatching in the morning to alleviate demand peaks.

Several thermal store volumes had been modelled in energy pro against the core solution. A cost benefit analysis compared the increase in thermal store capex to the monetised energy savings over 25 years of full developed operation.

A **150 m³** thermal store able to store **4.95 MWh** of heat at a delta T of 30 °C has been picked as the optimal solution, as it is therefore able to **meet the demand peak (2MW) for 2 hours** in emergency situations.

Figure 9 shows two graphs; the heat consumption and its supply from the equipment (i.e. WSHPs, Electric Boilers and TS, and the corresponding TS content as it assists in meeting this demand.

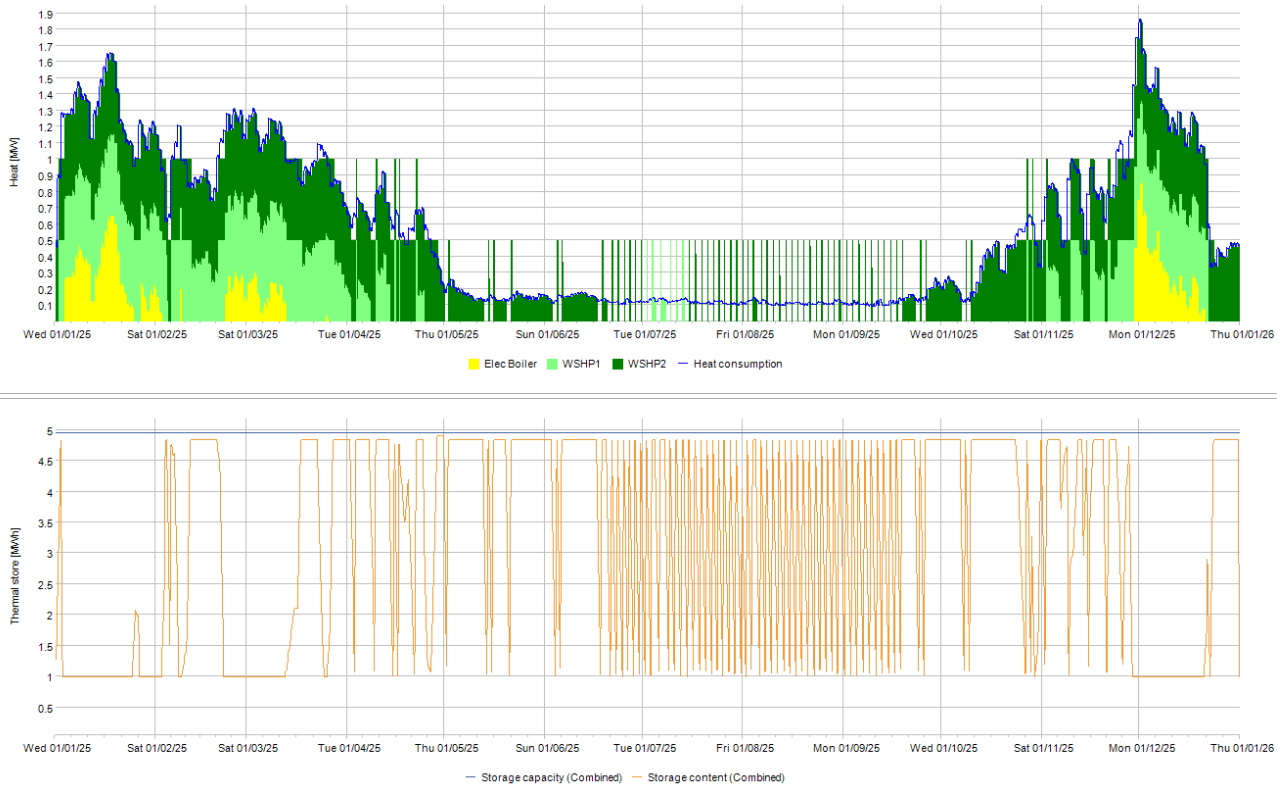


Figure 9: Typical Profile of Heat Consumption vs Production, alongside the thermal store charging / discharging profile

The profile chosen highlights the demand reaching its peak of 2MW, and how the equipment is used to meet this load.

Points in the above graph where the consumption curve is not directly met by the equipment can be seen to be met by the TS discharging, shown by the lower curve dropping below its capacity line (shown in blue at a maximum of 4.95MWh).

Conversely, points where the supply appears to be greater than the demand indicate charging periods for the Thermal Store.

5.5 Energy Modelling

Using energyPRO techno economic modelling software, we have evaluated the two recommended heat sources and economically optimised the plant and thermal store sizes. The results are summarised below:

Table 8: Proposed Energy Supply for WSHPs

Technology	Production Role	Size	Lifetime	Assumptions
Water Source Heat Pumps	Primary heat production, using water from the reservoir and electricity supplied by the hydro plants	2 X 500kW	20 years	High priority energy source Turndown: 25%
Thermal Storage	Storage	150 m3	60 years	Utilisation at 95% Charged only from WSHPs
Electric boilers	Peak heating plant and back up	1 X 1MW	20 years	Efficiency: 100%

Table 9: Proposed Energy Supply for ASHPs

Technology	Production Role	Size	Lifetime	Assumptions
Air Source Heat Pumps	Primary heat production, using electricity supplied by the hydro plants	1 X 1MW	20 years	High priority energy source Turndown: 25%
Thermal Storage	Storage	150 m3	60 years	Utilisation at 95% Charged only from ASHP
Electric boilers	Peak heating plant and back up	1 X 1MW	20 years	Efficiency: 100%

The results show that the heat pumps supply the majority of the heat demand, while the boilers are only engaged in times of exceptionally high demand. The heat pumps produce 90% of the total heat generation each year.

Table 10: Energy modelling results

Result	Units	Option 1 WSHPs	Option 2 ASHP
Total Heat Generation	MWh/yr	4,930	4,930
Heat Produced by Heat Pumps	MWh/yr	4,458	4,458
Heat Produced by Electric Boilers	MWh/yr	480	480
Percentage of Heat Produced by Heat Pumps	%	90.4	90.4
Percentage of Heat Produced by Electricity Boilers	%	9.6	9.6
Electricity Consumption	MWh/yr	1,791	2,263

The results seen above show the main benefit of using WSHPs is the reduced electric consumption required due to the larger COPs shown in section **5.3.1**.

Figure 10 below shows the duration curve for when all loads are connected for the WSHP option.

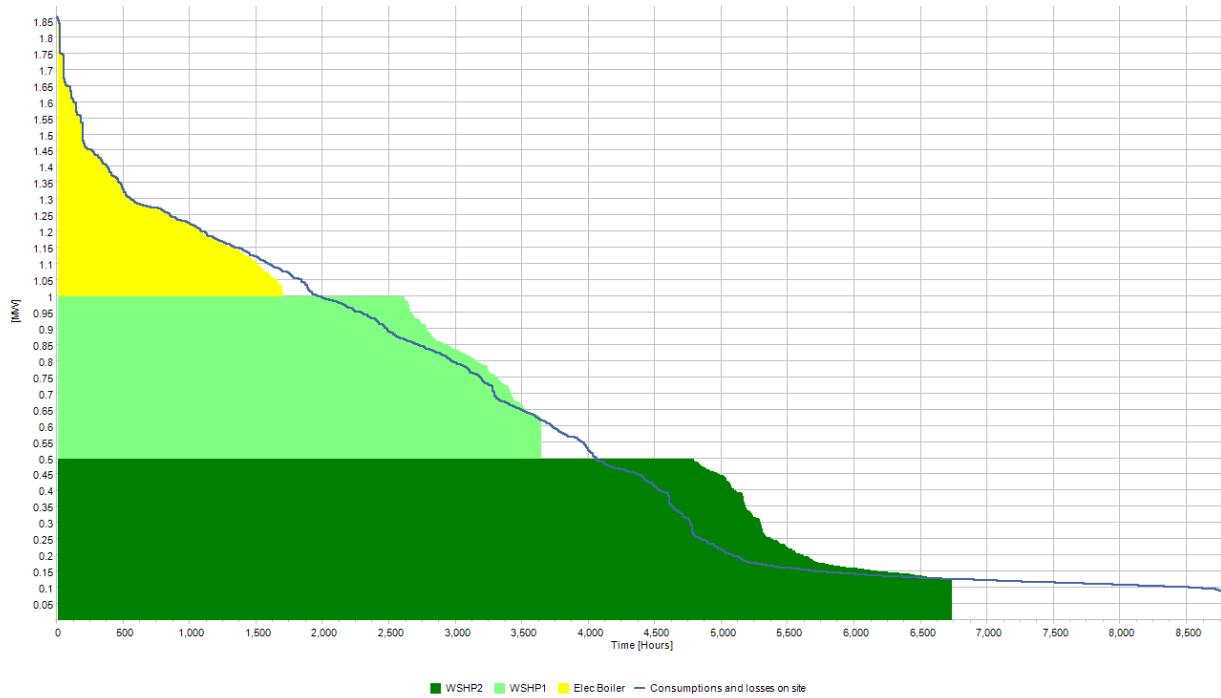


Figure 10: Demand Duration Curve for WSHP option

5.6 Hydro resource supply profile vs heat demand profile

There is potential for the Cwmorthin and Festiniog Hydro plant to contribute to the electricity required to supply the energy plant via a Power Purchase Agreement (PPA).

During the RFI stage the total electrical output profile from these hydro sites were used alongside the energy modelling to understand how much electricity can be met by the hydro plants exported electricity and how much will be required to be imported from the electricity grid. Figure 11 below shows the electrical consumption of the WSHP system alongside the generation of the hydro plant.

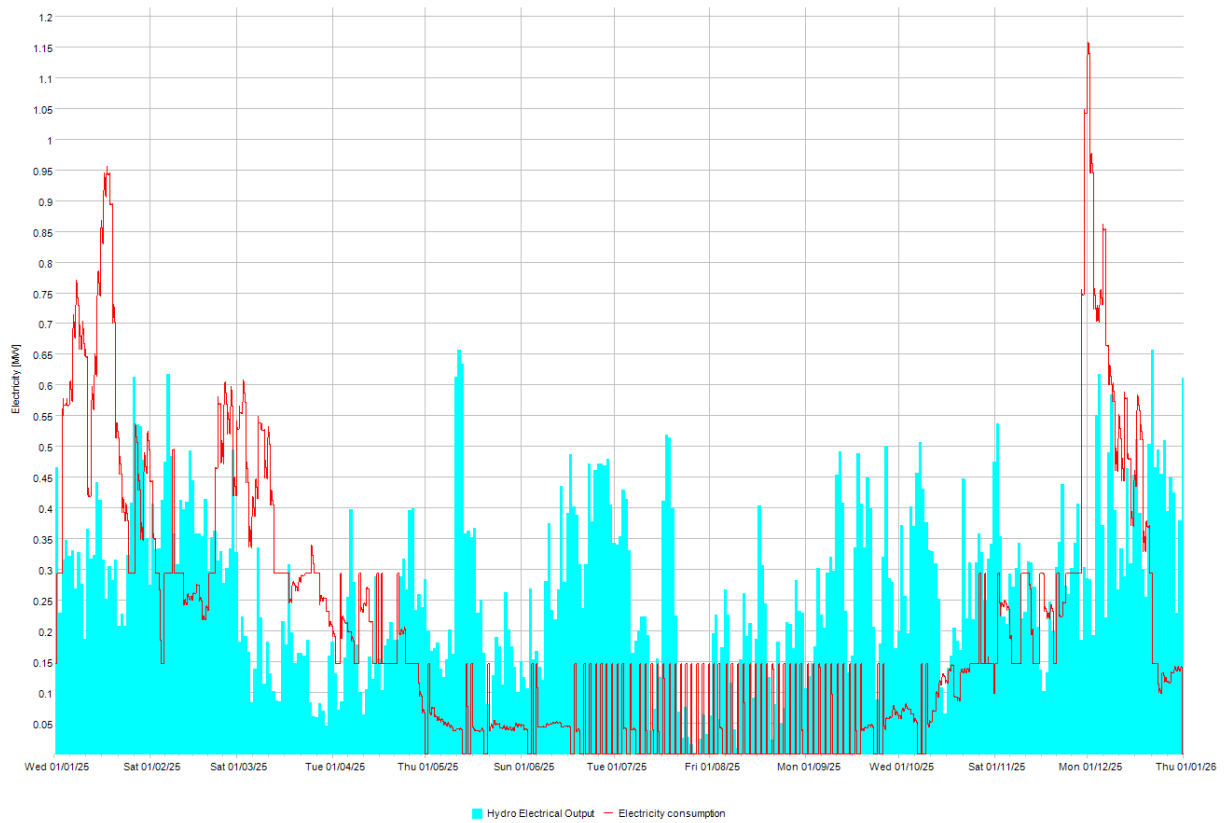


Figure 11: Electrical consumption with hydro electrical output

Even though the hydro produces around 2.4 GWh of electricity in the year, which is more than the estimated electricity consumption for the energy supply system (1.8 GWh), there may be peaks particularly in winter months where more electrical input from the grid may be required, as shown in the profile comparison graph (Figure 11).

6. ENERGY CENTRE

6.1 Energy Centre Location

When looking into selecting a suitable Energy centre location, the following criteria formed the basis of identification:

- Property/land under council ownership if possible
- Location to be in close proximity to the water heat source i.e. Reservoir.
- Area large enough to be able to accommodate the required plant to supply the scheme
- Close to anchor loads where possible.
- With good transport / fuel delivery / access for maintenance potential.
- With good access to utilities i.e. grid connections as required.
- The potential for future-proofing the site and building for additional primary plant / changes of peaking plant i.e. future replacement of gas boilers within Rehau with electric boilers to benefit from electrical grid decarbonisation.
- Flue emissions and air quality impact, visual impact, noise disturbance issues and flood risk.

During our project progress meetings, we discussed the project scope, structure and potential outcomes with Energy Local and the Council. It was agreed at this time that the project would look to include as much of the village as possible, as well as Rehau with a view to engage with local residents and stakeholders early on as the feasibility of any heat network depends on the buy in and commitment from households.

A site survey was conducted by Energy Local to inform our conversations and identify a suitable area for the location of the energy centre close to the reservoir. During the site walkover they explored potential energy centre locations and possible pipe routes based on the initial desktop analysis.

Figure 12 shows the identified area adjacent to the reservoir.



Figure 12: Proposed Energy centre location

The WSHP energy centre will house all main equipment for the network, including:

- WSHPs
- Space for pumps, piping and electrical equipment
- The electric peaking plant and thermal storage it assumed to be housed within the Rehau facility.

The anticipated footprint of an Energy Centre is of a key importance when assessing the viability of available plots. Therefore, a high-level estimation was conducted for both the required area for the energy centre primary plant (WSHPs) and the future-proofed peaking plant (electric boilers). The estimated available area in the identified plot next to the reservoir is sufficient to place the primary plant (330 m²). The peaking plant is estimated to require 210 m² of space within or alongside the Rehau facility.

The estimated height required for the primary plant will be 4m with the tallest equipment being the expansion vessels with a height of a 3.5m. When ASHPs are considered, an air cooler array will be needed on the roof, this will add an extra 3.2 metres to the height of the primary plant, accounting for the array and acoustic barriers. The peaking plant contains the thermal stores which have an estimated height of 11.2m. These can be placed inside in a room within a height of 12m or can be placed outside to reduce the height required for the peaking plant to be 6m allowing for the height of the electric boilers.

6.1.1 Energy Centre Layout

An indicative layout drawing, and schematic of the energy centre were produced and are shown below. A drawing for the primary plant layout has been created for both the WSHP and ASHP options. Alongside this is a drawing of the peaking plant required. All energy centre drawings are available in **Appendix A**.

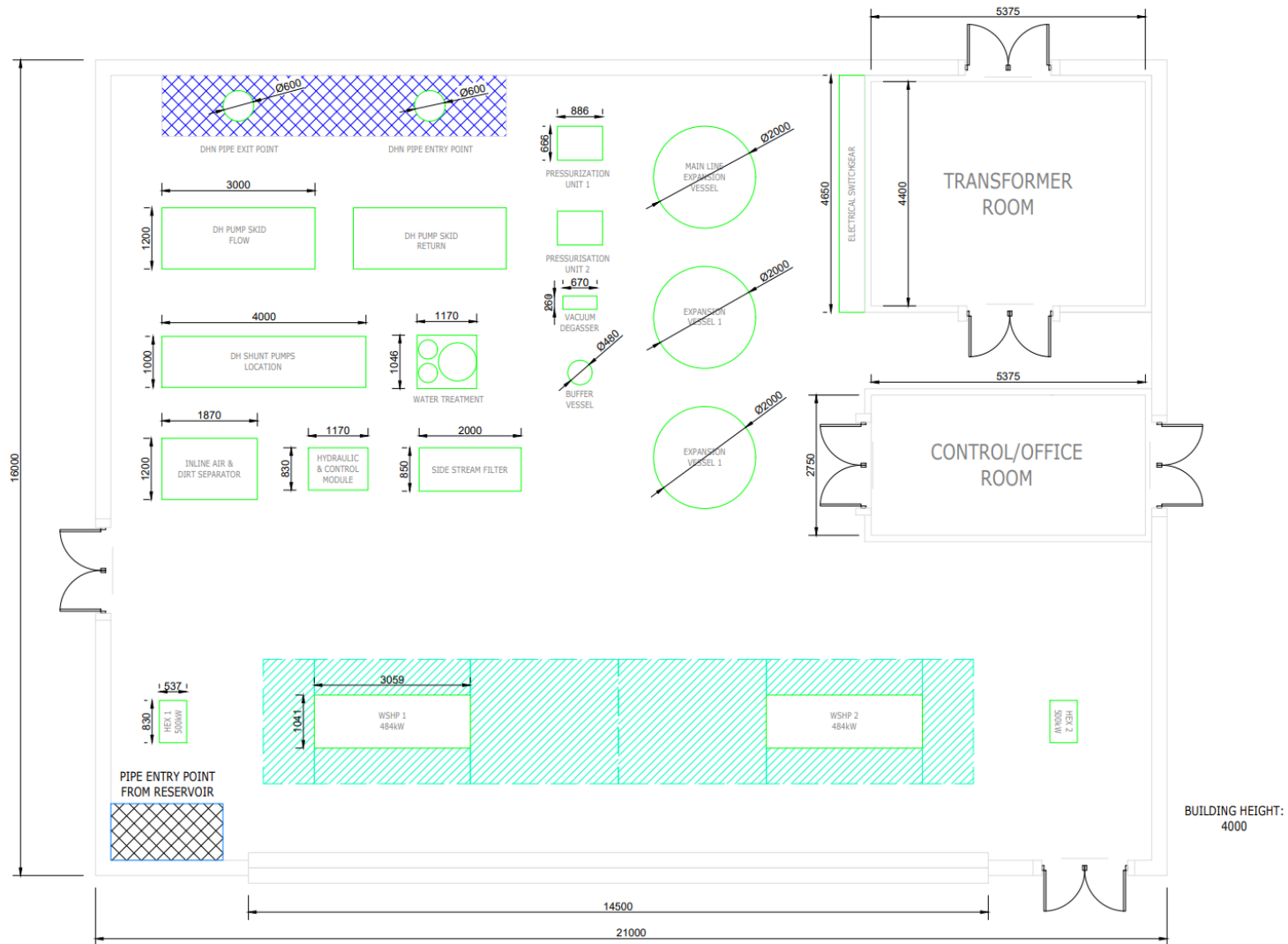


Figure 13: Energy centre layout - WSHP

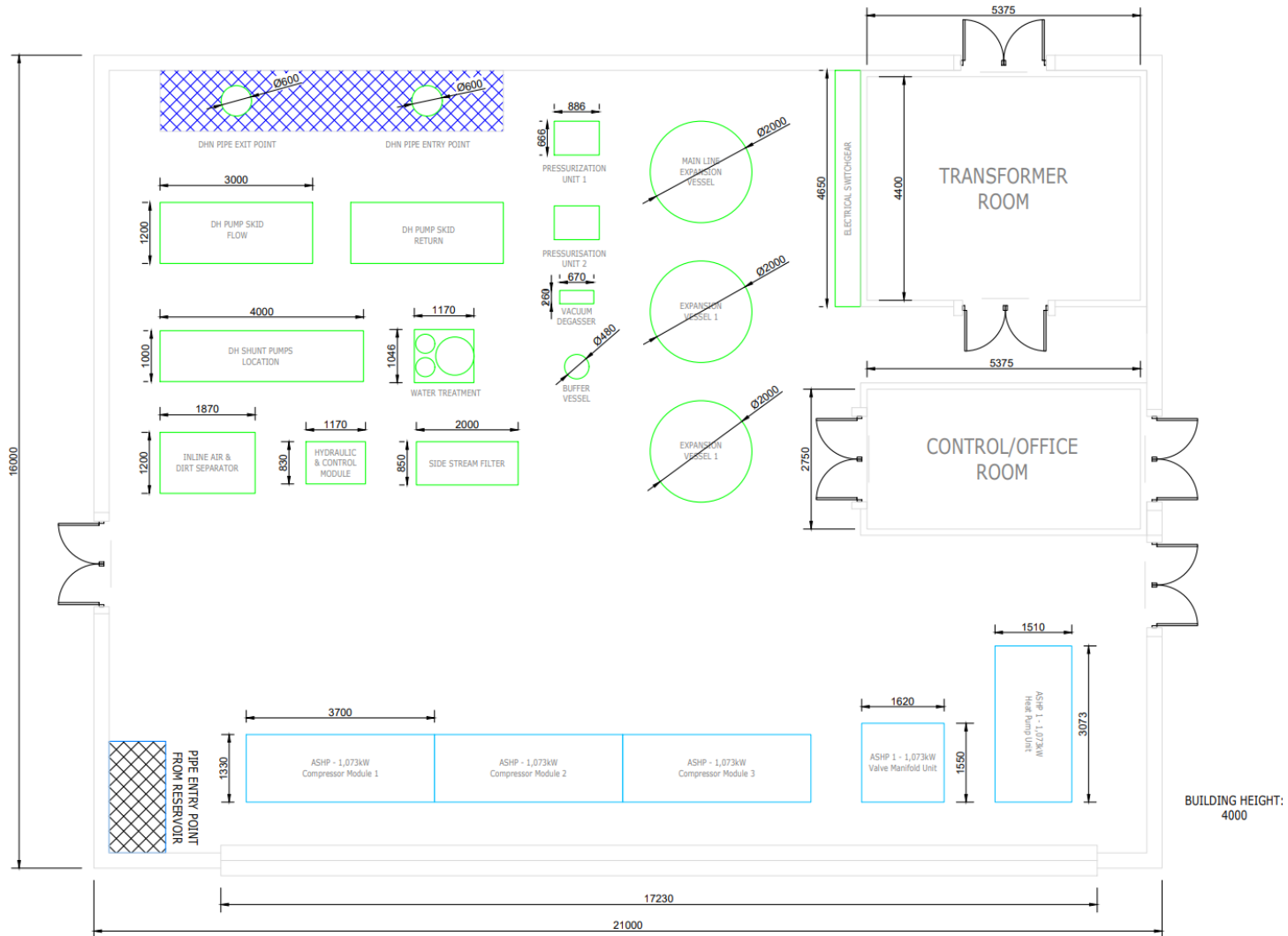


Figure 14: Energy centre layout – ASHP

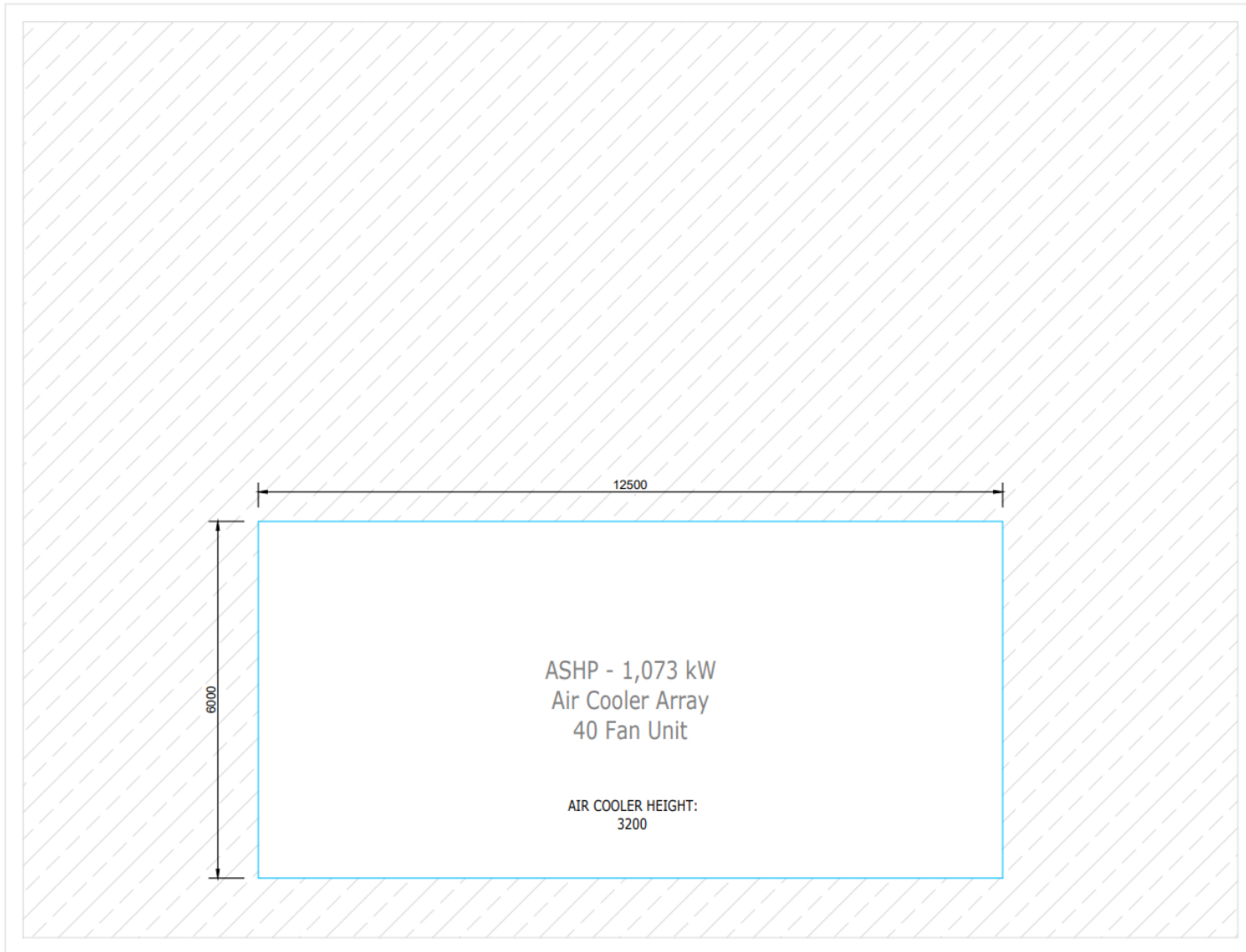


Figure 15: Energy centre roof layout – ASHP

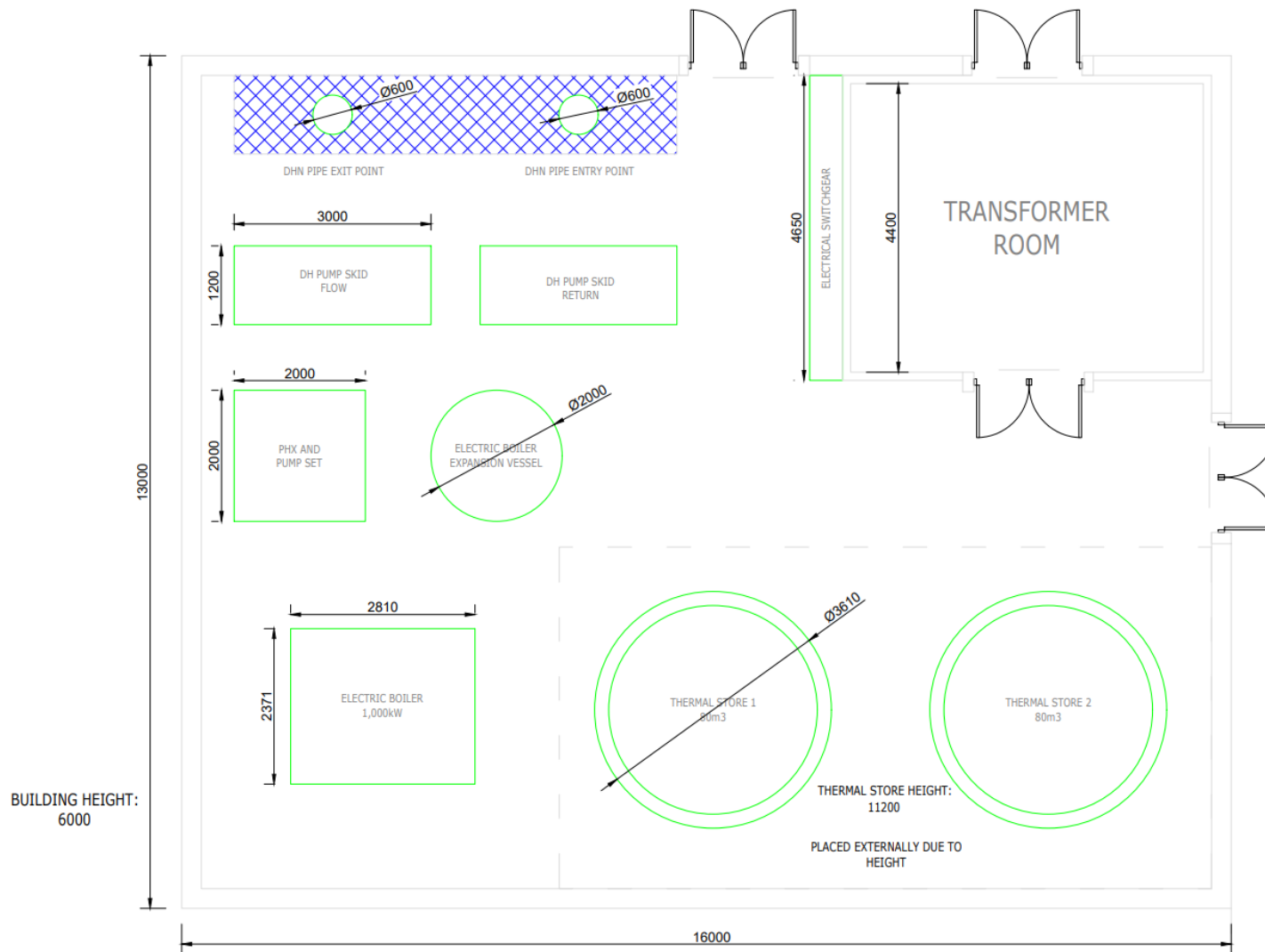


Figure 16: Peaking plant layout

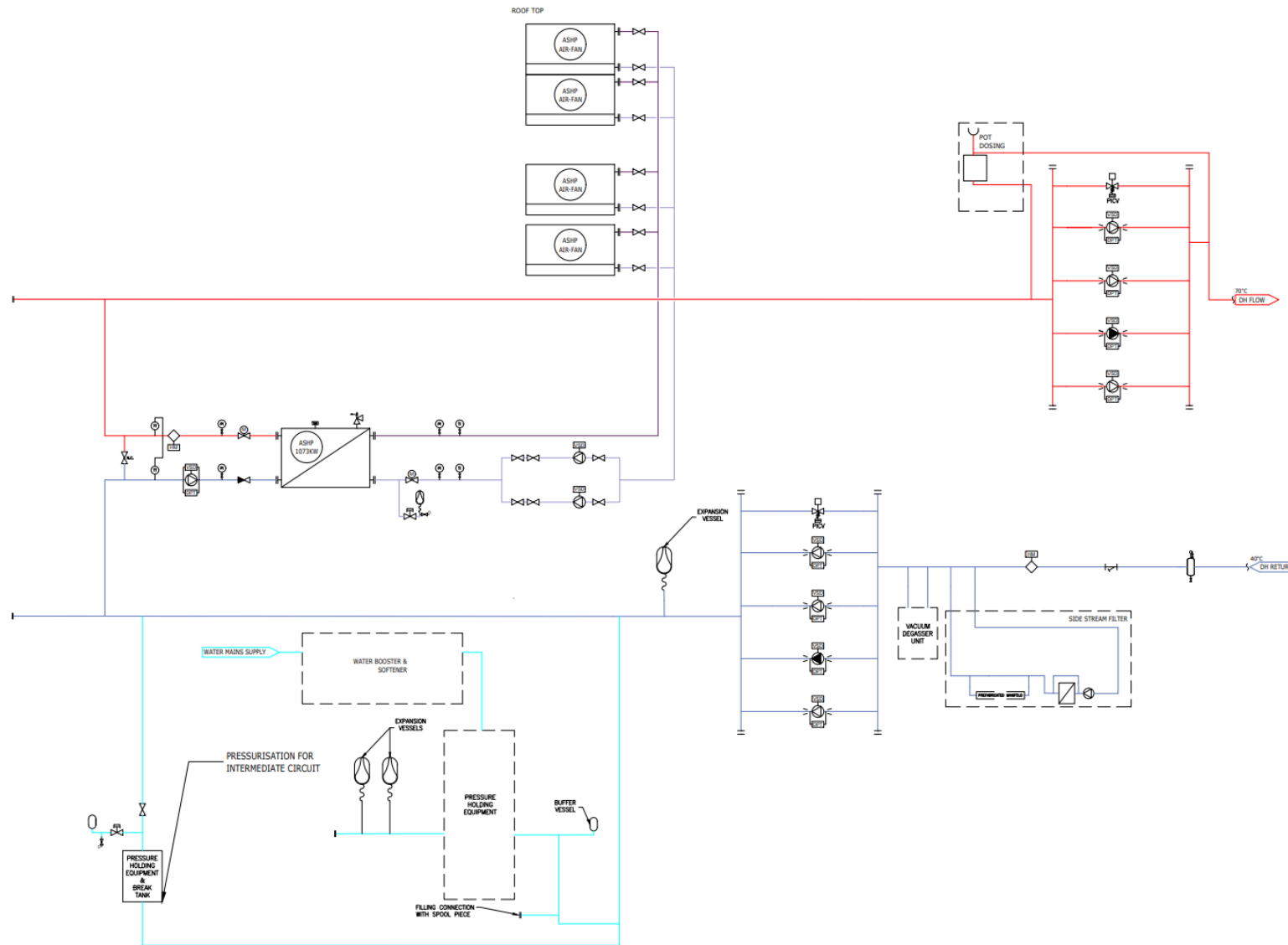


Figure 18: ASHP Energy Centre Schematic

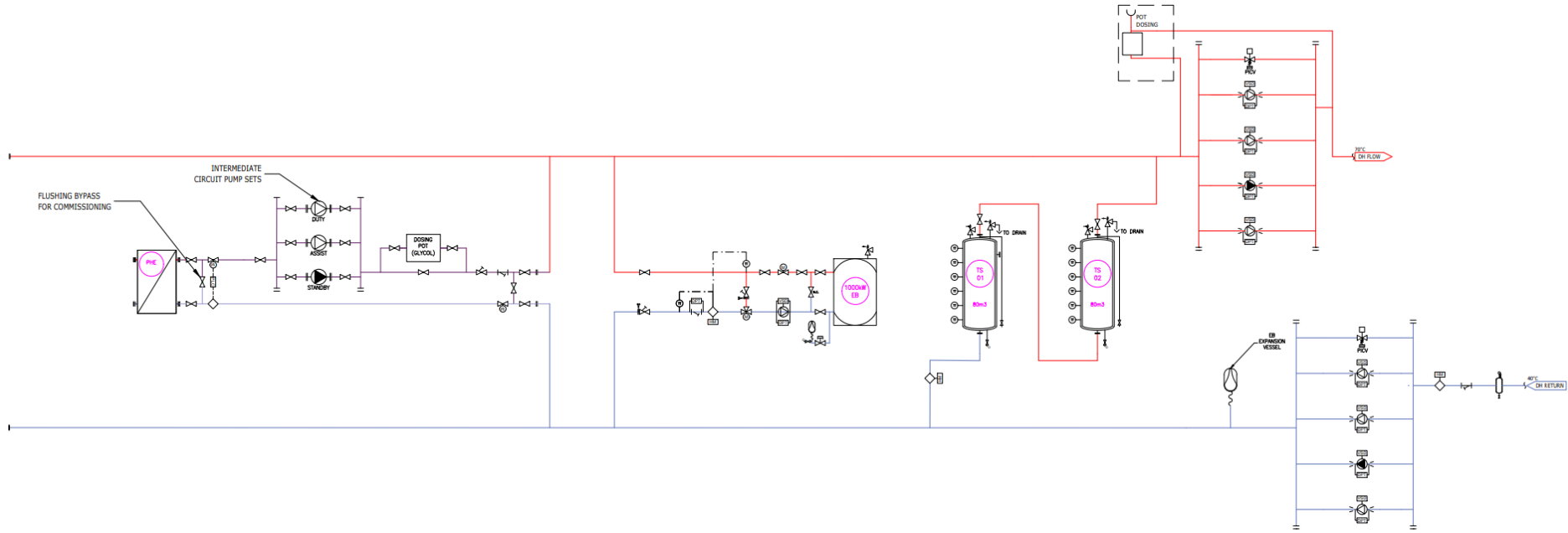


Figure 19: Peaking Plant Schematic

6.1.2 Utilities

Both the energy centre and peaking plant will require grid electricity connections as electricity is essentially the 'fuel' for the plant.

An initial assessment of the existing supply arrangements indicated that there is enough capacity in the existing electricity connection in Rehau to supply the peaking plant.

A new grid connection has been assumed for the WSHP site and costs were estimated. As it is assumed 1MW of heat pump is used, when assuming a power factor of 0.95, 1.1MVA will be required. This can be provided by a low voltage circuit.

It is recommended during the next stage of development to engage with the local DNO, SPEN and revisit the connection costs and any utilities related constraints (i.e. by submitting a 'budget' connection offer if necessary). If battery storage is to be considered alongside the heat pumps and electric boilers then this will need to be accounted for when understanding how much voltage will be required.

7. ENERGY DISTRIBUTION SYSTEM

7.1 District Heating Network

The DH network is one of the largest costs in the development of a DH scheme so minimising the cost of a heat network is key to the economic viability. Not oversizing the pipework will reduce the capital costs and the heat losses in operation. With every increase in nominal pipe size the heat losses increase by 10% and the capital costs by 15%.

High level hydraulic analysis was undertaken using our in house GIS based hydraulic model **District One**. This is used to inform the pipe schedule and pumping requirements.

Lengths of pipework were found using the network layout seen below and operating temperatures were set to 70°C on the flow and 40 °C on the return to maximise the efficiency of the heat pump system. The hydraulic model results are presented in Table 11.

Table 11: DHN Design Parameters

Hydraulic Modelling Results	Unit	Result
Total Flow	m ³ /h	58
Network length	m	5,118
Static Heat Loss	kW	110.0
Critical Path Pressure Drop	bar	9.2
DHN pipework material	-	Pre-insulated Stainless Steel
DHN pipework insulation class	-	Series 2

7.2 Network Layout

Figure 20 shows the proposed network layout. The pipework follows suitable routes that take into account land ownership and environmental barriers. Potential alternative routes are also shown.

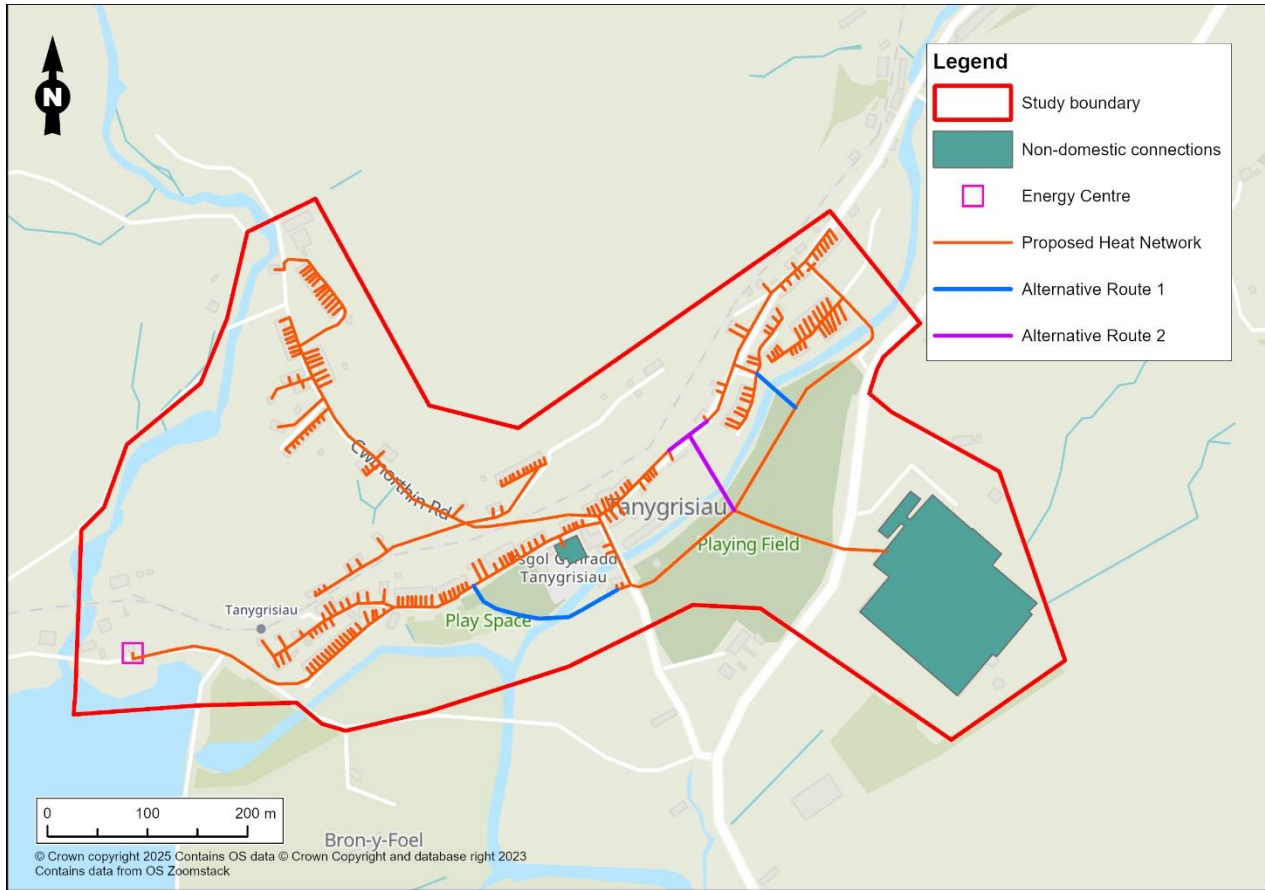


Figure 20: Network Layout and Alternative Routes

The assumed point of interface with the district heat network is the existing plant room (Rehau)/boiler location (residential) of each building. These connection points were georeferenced, and GIS tools were applied to deliver the most direct route. Preliminary routes were also shared with Energy Local and the Council team and adjusted to reflect their input and preference.

The proposed route was selected based on the following criteria:

- Maximising the use of soft dig areas that could reduce the installation cost.
- Maximising the use of council owned land to ease installation and potentially reduce cost.
- Avoiding physical constraints where possible. If unavoidable, the least onerous options should be selected first (e.g. railway crossings under than over the railway bridges).
- Minimising the requirement for parking suspensions, bus route diversions and access restrictions.
- Avoiding designated heritage assets, archaeological or ecological significant areas.
- Minimising traffic management if possible
- Commenting on any other significant constraints that are inevitable and likely to add risk to the route (i.e. change of surface levels).

Alternative routes shown may also be viable depending on further investigation of the land and roads in Tanygrisiau.

Figure 21 below shows the proposed route with pipe sizes found based on the assumptions and design parameters discussed.

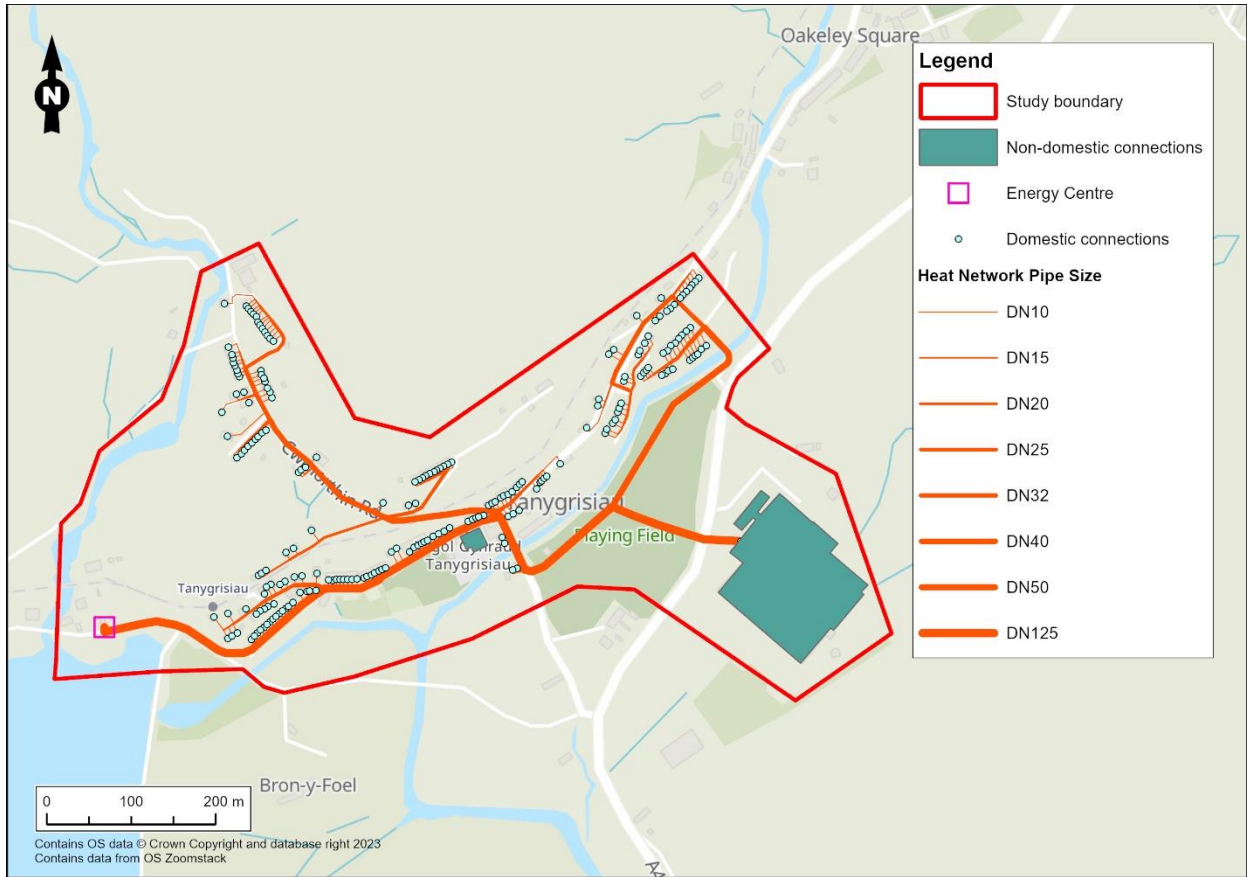


Figure 21: Proposed network layout showing pipe sizes and heat demand connections

7.2.1 Major constraints

A desk-based survey using Google Earth was initially undertaken to identify any major constraints along the route (i.e. railway and river crossings, roundabouts). We interrogated this mapping with focus on the constraints identified for the route between the EC and the potential customers’ points of interface.

We identified areas of engineering difficulty, which will need to be the subject of a more detailed analysis as the project progresses. When areas of Rail related constraints were identified, we provided our costed proposals to cross under the railway infrastructure through underpasses (preferred as the option with the least impact on their infrastructure).

The following major constraints were identified:

1. Rail Crossing
2. Water crossing – Next to school
3. Water crossing- North of Rehau

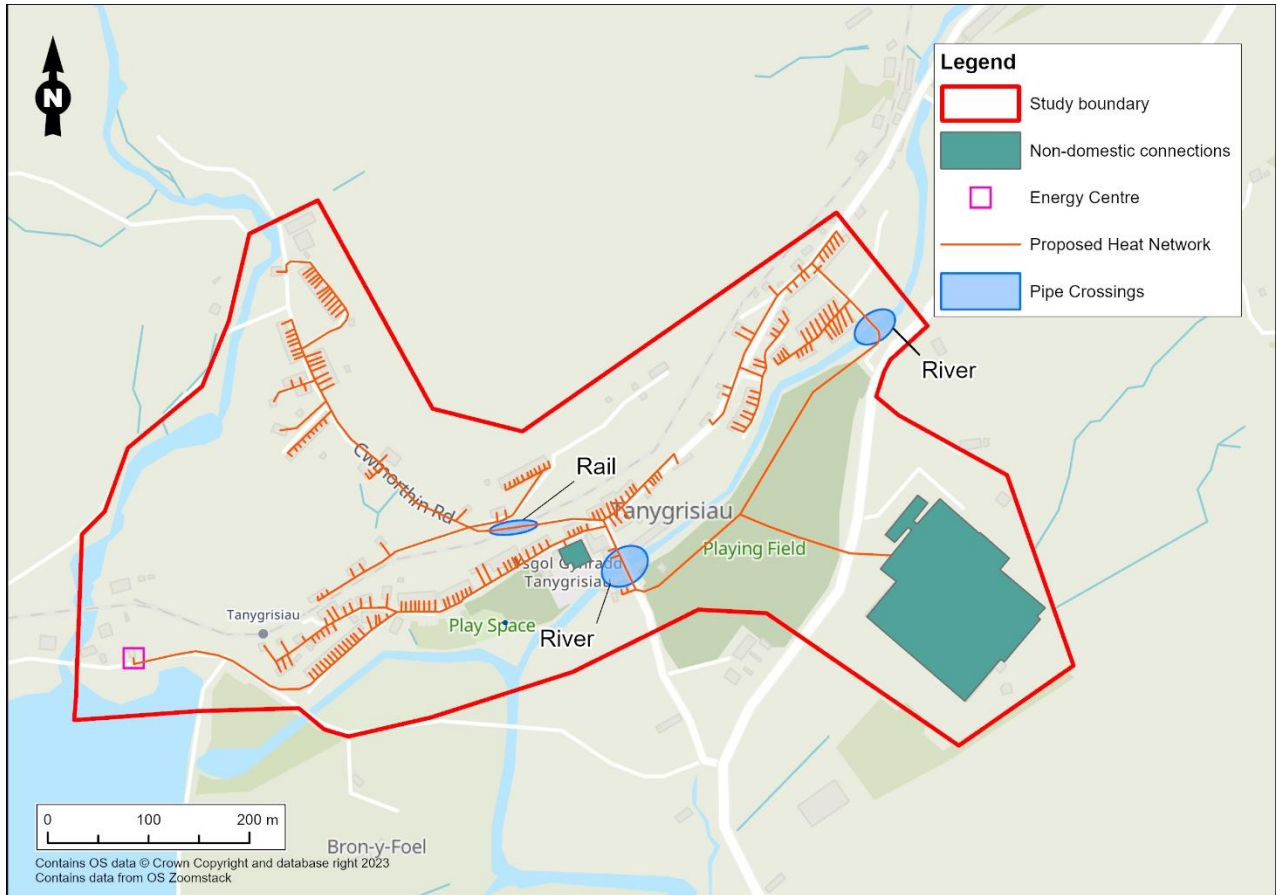


Figure 22: Major pipe crossings required

7.3 Underground Pipework Schedule

The pipe schedule shown in Table 12 contains the trench length required of each Nominal Diameter (ND) in the network. Uplifts and contingency are not accounted for in this schedule, to be detailed at a later stage.

Table 12: DHN Pipework

Nominal Diameter (ND)	Length of Pipe Trench
	(metres)
10	2,326
15	213
20	437
25	328
32	320
40	183
50	418
125	894
Total	5,118

7.4 Pipe branches to each house

To connect each house a DH 'service pipe' needs to connect to the Heat Network mains in the pavement / road in front of the house. The service pipe is assumed to be buried in the front and then

has to get through or round the house to the point where the current boiler is located and the new DH connection made. Pipework through the house is likely to be standard copper pipe unless there are other options such as laying pipe under suspended floors. This is an area where it will be important to explore in more detail at the next stage.

7.5 Leakage Detection

It is important to detect and repair leaks or damaged casing of underground district heating pipework early to minimise potential damage and disruption to the heat supply to customers. The presence of moisture within the pipework insulation or consumption of make-up water are key indicators of potential leakage with the DHN pipework system.

Within this project, plastic pipes provided by Rehau have been considered in the network design. Plastic piping does not require any leak detection systems, as suggested by Rehau, and therefore this has not been considered in this specific network design.

8. BUILDINGS CONNECTION DESIGN

8.1 Connection Strategy – Residential

To enable use of the HN heat delivered modifications will need to be made in each house. District heating requires radiators or underfloor heating to deliver space heating and for hot water the Heat Network (HN) can either heat a hot water cylinder or it can deliver DHW on demand like a combi boiler does (preferred arrangement).

The vast majority of houses are either oil/coal/wood or electrically heated. For houses currently using oil or coal it is assumed these have radiators and either hot water cylinders or combi boilers delivering instantaneous water heating. The design intention would be to reuse the currently installed radiators and connect them to the HN. The boiler would be removed and a Hydraulic Interface Unit (HIU) will then be installed in its place. The HIU contains the equipment to connect the house heating and domestic hot water (DHW) from the HN. The HIU would supply DHW instantaneously as this allows more efficient DH operation and can better work with low temperature heat networks.

Properties that are currently heated by electric storage heaters, will require the removal of the electrical heating systems and the installation of a HIU unit. In these properties, the existing hot water cylinder probably could not be re-used and it's technically better for the HN if an HIU delivering instantaneous DHW is installed.

The HIU includes a heat meter for the billing of heat used. It is recommended that the DH operator has ownership of the HIU and repairs and maintains the HIU. The correct setup and operation of the HIU is fundamental to achieve efficient DH operation.

It is beneficial to both the heat customer and the DH operator for the DH operator to take on responsibility for the reliable operation of the HIU. If the heat pump option is installed then it is important to minimise the required DH flow temperature and to lower the DH return temperatures from the houses, as the operating efficiency of a heat pump is sensitive to increases in DH temperatures.

The HIU and associated primary and secondary ancillaries will comprise the following main components, as shown in Figure 23 and Figure 24:

- Space heating and DHW PHEs
- Hot water and space heating circuit Pressure Independent Control Valves (PICVs)
- Space heating circuit variable speed circulation pump
- Return water limiter sensor
- Primary side heat meter
- Lockable isolation valves located at primary and secondary pipe entries in accessible positions for maintenance
- Suitable expansion vessel for the secondary heating circuit
- Cold water supply pressure absorber
- Quick fill connection
- Flushing bypass assembly complete with P/T plugs.
- Thermal insulation
- Local control panel / HIU controller

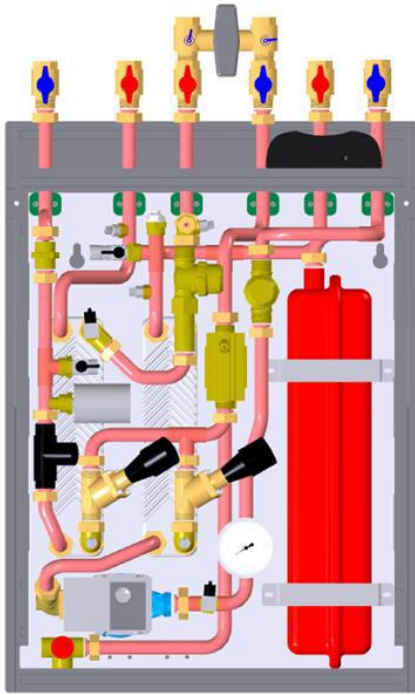
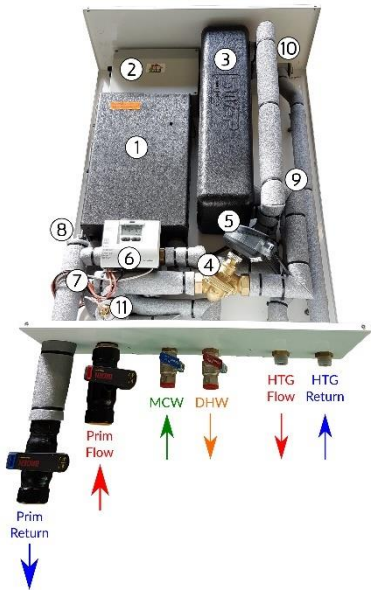


Figure 23: Example of Prefabricated HIU. Courtesy of Frese Ltd.



Item No.	Description
1	DHW HIU (Plate Heat Exchanger and ancillaries)
2	Node-iHIU Control
3	Space Heating Plate Heat Exchanger
4	Space Heating Control Valve
5	Space Heating Control Valve Actuator
6	Heat Meter
7	Primary Flow Temperature Sensor
8	Primary Return Temperature Sensor
9	Space Heating Flow Temperature Sensor
10	Manual Air Vent
11	Heat Meter Flow Temperature Sensor

Figure 24: Example of Prefabricated HIU. Courtesy of Thermal Integration Ltd.

The HIU will be complete with user interface panel at the front or an externally integrated one to allow HIUs meter readings to be taken without opening or removing any part of the HIU. All the components of the HIU will be individually Water Regulations Approval Scheme (WRAS) approved.

8.2 Connection Strategy – Rehau

For Rehau, it is assumed that an indirect heat substation will be installed within their existing heating plant (gas boiler room) and will act as the interface point between the DHN (primary side) and the individual building heating systems (secondary side).

It is suggested that 2 plate heat exchangers are installed for the indirect heat substation. At Rehou the total peak is 1.1MW. Therefore 2 heat exchangers of around 600MW will be required. These each will have the following dimensions: 2,250 x 750 x 2,500 (L x W x H (mm)).

8.2.1 Indirect DHN Substation

This type of substation is provided with a single Plate Heat Exchanger (PHE) which isolates the main primary circuit (i.e. energy centre to all buildings) and the internal heating circuits inside the building. Where building peak heat demands exceed 750kW, the heating substation arrangement will consist of two PHEs, each sized for 60% of the peak demand, to allow for additional flexibility on the substation performance with fluctuating demands across the year.

Figure 25 shows the typical schematic of indirect substation with a PHE, all relevant valves, sensors and gauges.

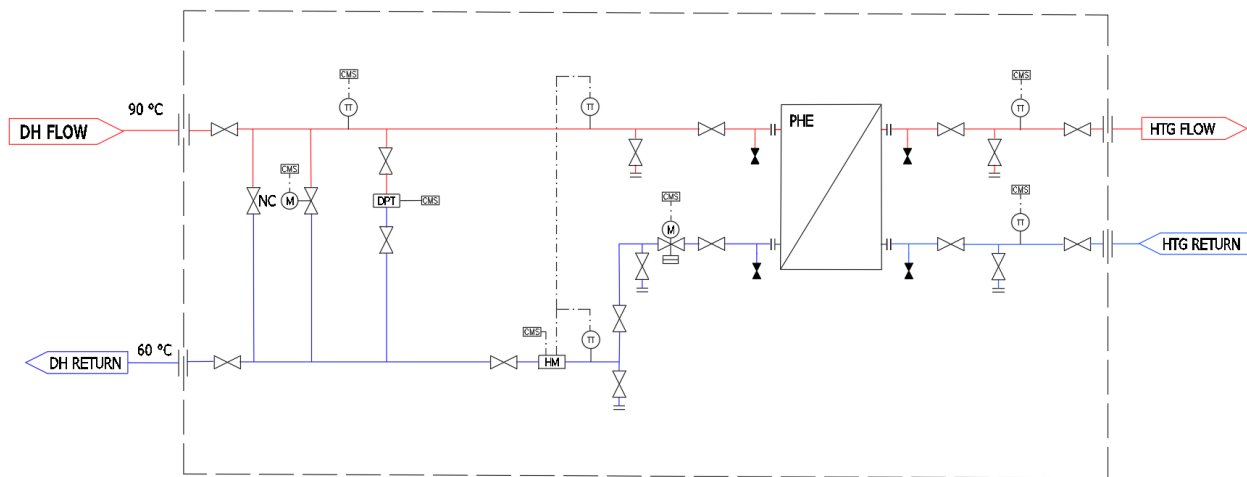


Figure 25: Typical Schematic of Indirect DHN Substation

A differential pressure sensor will be installed across each substation to provide a signal to the main energy centre pumps to control the flow rate of the DHN.

8.2.2 Indirect Space Heating and Centralised Hot Water DHN Substation

This type of substation is provided with a pair of plate exchangers, specifically sized for heating and hot water load. The heat from a DH substation is distributed inside the building in 4 pipes: heating-flow, heating return, hot water-flow, and hot water return. The cold-water feed will be directly connected to the hot water plate. The system allows for direct connection of both heating and hot water to each dwelling (no HIUs). The system also simplifies the maintenance strategy, as most of maintenance works will be carried out in the building's plantroom, rather than accessing HIUs of all heat customers. With no HIUs in the system, the overall capital costs of the heat network can be reduced.

Figure 26 shows the typical arrangement for indirect space heating and centralised hot water substation with a pair of plate exchangers along with relevant valves, sensors and gauges.

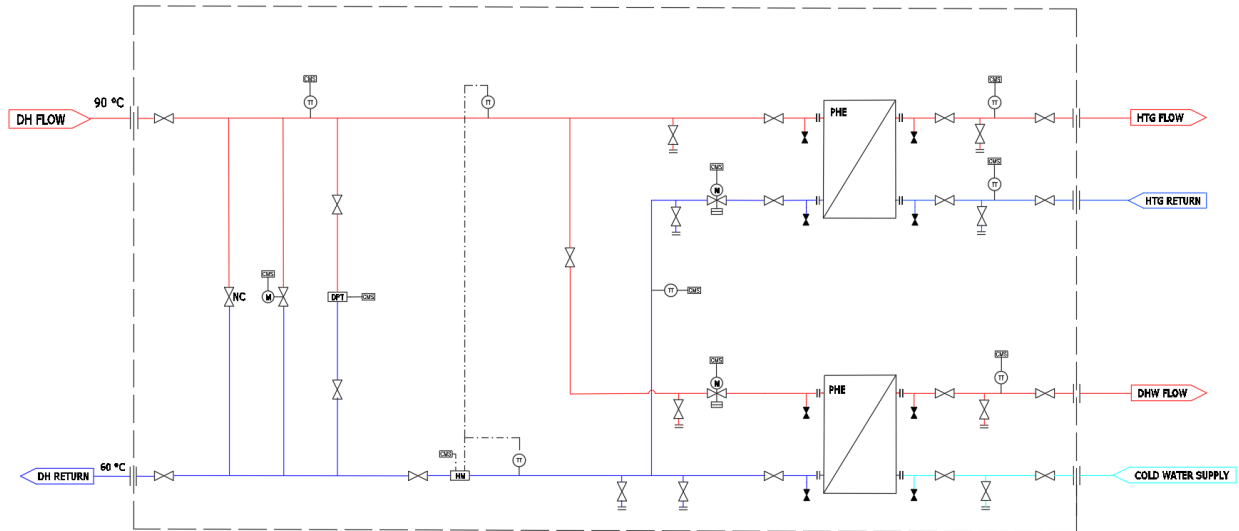


Figure 26: Typical Schematic of Indirect Space Heating and Centralised Hot Water Substation

A differential pressure sensor will be installed across each substation to provide a signal to the main energy centre pumps to control the flow rate of the DHN.

8.2.3 Plantroom General Layout

Figure 27 shows a typical substation plantroom layout. Each substation will be serviced by water, drainage and sufficient electrical power. The room should be readily accessible for inspection and maintenance as well as for disconnection and removal of equipment for repair or replacement without the need for removing external walls.

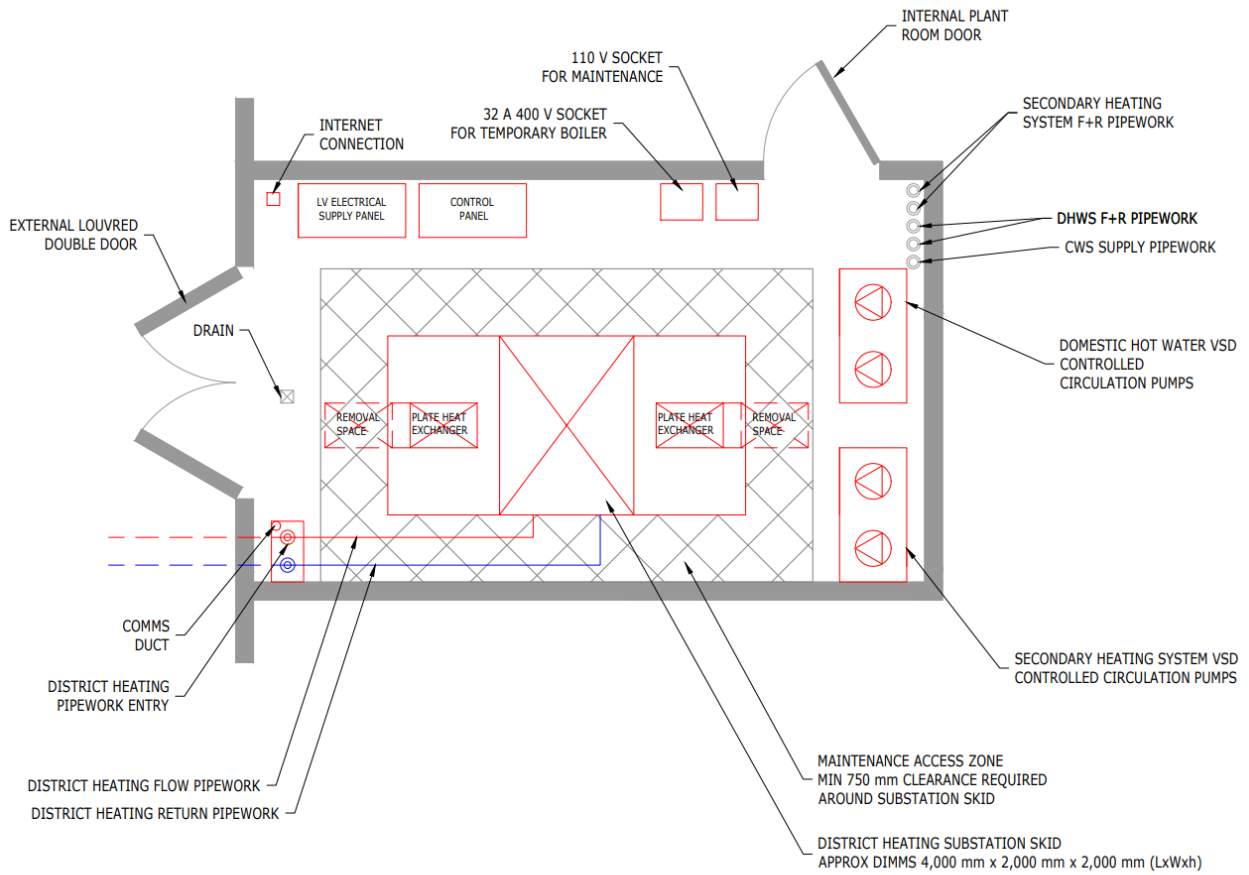


Figure 27: Typical Substation Plantroom Layout

9. ESTIMATES OF COSTS

9.1 Methodology

After the development of the heat network scenario, heat demand assessment, energy modelling and hydraulic modelling, an assessment of the scheme's costs was undertaken.

In line with the requirements set out in the scope, the economics provided the following analysis: Estimates of OpEx & CapEx for the project broken down in to

- CapEx - Energy Centre
- CapEx - Heat Network Infrastructure including Customer Connection
- CapEx for Retrofit Strategy
- OpEx – NOT including energy import costs

9.2 Assumptions

Assumptions around the key economic criteria are summarised in Table 13.

Table 13: Summary of Key Assumptions

Item	Assumptions
CAPEX	Based on Ramboll's internal supplier database and quotes received. Cost breakdowns are presented for each scenario.
OPEX	Operational costs are estimated using percentage of CAPEX costs alongside set costs per MWh of heat. Fuel costs are excluded.
Phasing	No phasing was assumed.

9.3 Counterfactual Scenarios

One counterfactual scenario was considered, which represents an alternative route to decarbonisation of the heat demands by using individual ASHPs for each load.

Summary costs of the capital and operational costs of each option and the counterfactual are shown below in Table 14.

Table 14: Cost Summary

Item	Unit	WSHP	ASHP	Counterfactual-individual ASHPs
CAPEX	M£	8.01	7.50	7.51
OPEX	M£	0.083	0.067	0.12

9.4 CAPEX and OPEX Breakdown

The CAPEX cost breakdown for each centralised option is represented in Table 15.

Table 15: CAPEX cost breakdown

CAPEX Breakdown	Units	WSHP	ASHP
Energy Centre Equipment CAPEX	k£	2,874	2,362
Heat Network Infrastructure and Connections CAPEX	k£	2,311	2,311
Fabric Efficiency Retrofit CAPEX	k£	2,829	2,829
OPEX	k£	83	67

Included in the energy centre equipment CAPEX is the electricity installation cost. A cost of £ 50K was assumed based on the energy centre footprint and previous Ramboll project costs. Also included are

the utility connection costs which consider electricity, drainage, comms and water connections and a total utilities capex of £ 136K was included.

9.5 Alternative Routing

As seen in section 7.2 there are alternative route options. Table 16 below shows an estimation of the change in CAPEX the alternative routes may have based on a change in pipework length and number of river crossings.

Table 16: Change in CAPEX for Alternative Routes

Route	Length (m)	Number of River Crossings	Change in Network Cost (£)
Proposed	5117.7	2	-
Alternative 1	5138.2	2	+ 7,407
Alternative 2	4940.1	1	- 89,242

9.6 Optional Secondary Side Costs

When installing a heat network, efficiencies can be improved by upgrading existing heating systems. They are also required if the connection does not have a wet system already in place. An example of these costs for residential dwellings are shown below in Table 17.

Table 17: Optional Secondary Side Costs for Residential Dwellings

Item	Units	Cost
Heating System (Radiators)	£/connection	1,150
Copper Twin Pipe (for non-wet systems)	£/connection	1,200

9.7 Business Model and Governance Structures

The business model and governance options for heat networks has been well documented by DESNZ. A broad spectrum of models for implementing projects is available. One option is the use of a special purpose vehicle, which can be either wholly owned by a public or private sector stakeholder, or jointly owned through public and private shares. Some of the more common options are illustrated in Figure 28.

Delivery Vehicle(s)				
Unbundled Model in a vertically separated market would use separate delivery vehicles (and thus roles and responsibilities) at the generation, transmission and retail points (as, for example, the electricity market).				
	A. Private Sector Led	B. Public-Private Shared Leadership	C. Public Sector Led	D. Community Company (CoCo)
	← Continuum of options →			
Description	Private sector company responsible for design, financing, building, owning and operation. The roles that define a project as private sector led are likely to be Funding, Asset Ownership and Operation.	Local Authority and at least one private sector company share the risks and returns. The roles that if shared define a project as private-public led are likely to be Governance and Funding or anchor Customer.	Local Authority responsible for design, financing, building, owning and operation. The roles that define a project as public sector led are likely to be Governance, Funding and Asset Ownership.	A community body has leading role in the business supplying heat. The roles that define a project as Community led are likely to be Customer, Governance and Sale of Heat.
Role in Heat Supply System				
1. Promotion	Developer / Local Authority / Landowner	Local Authority	Local Authority	Community Body
2. Customer	Customer / Landlord	Customer / Landlord	Customer / Local Authority	Customer / Community Body
3. Governance	Private ESCo / Contractor via contract with Promoter	Local Authority and Private sector shared	Local Authority	Community Body
4. Regulation	Private ESCo / Contractor via contract with Promoter	Local Authority	Other (Heat Trust?)	Local Authority
5. Funding	Private ESCo / Developer / Local Authority	Local Authority and Private sector shared	Local Authority	Local Authority (may include others)
6. Asset Ownership	Private ESCo / Developer / Landlord	Private ESCo / Developer / Landlord / Local Authority	Local Authority / Developer	Community Body / Local Authority
7. Development of Property	Developer (may include Local Authority)	Developer (may include Local Authority)	Local Authority (may include Developer)	Local Authority (may include others)
8. Land Ownership	Land Owner(s)	Land Owner(s)	Land Owner(s)	Community Body / Landowner
9. Landlordship	Landlord(s) / ManCo	Landlord(s)	Landlord(s)	Landlord(s) / Community Body
10. Installation	Private ESCo or Contractor	Private ESCo or Contractor	Contractor	Contractor
11. Operation	Private ESCo	Private ESCo or Contractor	Local Authority or Contractor	Contractor or Community Body
12. Sale of Heat	Private ESCo / ManCo	Local Authority / Private ESCo / ManCo / Developer / Landlord	Local Authority / ManCo / Developer / Landlord	Community Body
13. Supplier of Last Resort	ManCo / Landlord	Local Authority / Landlord	Local Authority	Local Authority / Landlord

Notes: Highlighted green: the roles that tend to indicate the delivery model type; Bold: the party which most frequently takes this role. ESCo, energy services company; ManCo, estate management company.

Figure 28: Different options for ownership and operation of heat network schemes (source: DESNZ, 2016c)

From discussions we understand the preferred business model going forward is for a community owned heat network (CoCo) under a CESCO model for delivery. In the UK there are few examples of this model to follow such as Swaffham Prior. In Denmark it is quite common for local co-operatives to own and operate DH networks outside of the larger towns and cities i.e. Jaegerspris Kraftvarme. However, such options entail operating risks due to the requirement to serve customers with 24/7 reliability.

Although our report focuses on the technical aspects of scheme development, clients should also consider the wider steps necessary to progress a heat network project towards implementation. It is usual at this stage to begin to develop an implementation strategy and to consider issues of ownership, control, contracts and procurement. It is recommended that this involves legal and financial experts alongside technical consultants to integrate these specialist perspectives during this stage.

The business case shall include an assessment of the potential and preferred business vehicle, taking into account key aspects including, for example:

- Procurement strategy: how should works and services be procured, when and by whom?
- Finance: how is the investment capital to be raised for the project?
- Risk: how should the high-level risks be allocated?
- Legal and contractual structures/issues
- Customer billing approach: including accompanying tariff structure(s), indicative minimum contract duration(s) and method(s) proposed for price escalation.
- Governance: where does overall control of the scheme development best lie?
- Exit strategy at the end of any contractual period.

This process will lead to a definition of the responsibilities of the various stakeholders in the scheme and a joint understanding of the overall project objectives.

To inform the procurement strategy, Energy Service Companies (ESCOs) shall be contacted to discuss the scheme. Some initial suggestions are offered below:

- Hemiko (former Pinnacle Power)
- Bring Energy
- Noventa Energy
- Dalkia (EDF Group)
- Metropolitan UK
- Vital Energi

Larger ESCOs typically involved in heat zoning type of networks.

- SSE
- E.ON
- Vattenfall

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

This study confirms that constructing a heat network to supply Tanygrisiau is technically viable and has the potential to deliver significant carbon savings. However, the economic viability of the scheme presents challenges, particularly given the lack of UK precedents for retrofitting district heating (DH) in a village setting.

A key barrier is securing voluntary customer connections, as there is no regulatory mandate for residents to join. Unlike many UK DH schemes, which are implemented in new developments or in social housing where connections can be mandated, the Tanygrisiau network would rely on individual buy-in. Additionally, the benefits offered—while environmentally significant—may not be compelling enough for residents to opt in without strong financial or practical incentives.

Despite these challenges, stakeholder engagement has been positive, and maintaining strong communication will be critical to progressing the scheme. Conducting a resident survey to gauge interest and ensuring that key private sector partners, such as Rehau, are actively involved throughout the project will be essential. Demonstrating the success of other DH schemes in providing affordable, low-carbon, and reliable heat could help build confidence in the proposal.

To maximize the likelihood of success, a not-for-profit or cooperative ownership model is recommended. Drawing on successful case studies from Denmark and collaborating with experienced UK energy cooperatives—while leveraging Danish expertise—could provide a viable framework for implementation. By adopting this approach, the project could establish a replicable model for community-driven district heating in similar village contexts across the UK.

10.2 Recommendations and Next Steps

It is recommended that the outlined overall network scheme identified and developed through Work Packages 1 and 2 of this project is progressed to a further Project Development stage to include technical, financial and commercial elements.

Key considerations of the study are as follows:

1. The findings of this study are primarily based on the assumed annual heating profiles of the proposed connections. The economic viability of the scheme is sensitive to heat demand and securing connections from the key stakeholders. Therefore:
 - a) Further engagement with key stakeholders (private and public) that could be heat customers of the scheme is highly recommended.
 - b) the demand data on which this study is based can be improved i.e. by installing heat monitoring equipment / temporary heat meters in houses to get actual demands. Doing so will enable the scheme to be designed with improved accuracy while reducing the project design risks.
2. The design and construction capital costs need to develop further to reduce risk. This is particularly relevant to the heat network element of the DH scheme.
3. The planning process can create unintended barriers that increase development costs and extends delivery schedules.
4. Given the ambitions of the council to tackle the local fuel poverty and the carbon emission targets set by the local authority and the UK government, this heat pump led DHN scheme would significantly aid the Council and region to achieve their goals. It has been assessed that 90% of the annual heat demand for the preferred option could be provided by the WSHPs supported by optimised thermal storage with the rest coming from the electric boilers.

Some recommended actions are as below:

- Contact heat pump manufacturers and arrange site visits to better understand the risks and potential costs of any suggested solutions. For the water source heat pump a water temperature dispersion modelling exercise is also recommended, as well as contact with Natural Resources Wales to identify any local environmental risks if equipment is to be placed within the Reservoir.
- Engage with Rehau to understand the feasibility of placing any peaking plant within their premises and any retrofit measures they may be required to connect efficiently to the network.
- Engage with the local electricity DNO, SPEN and align with local strategies in electrical grid infrastructure upgrades. It would also be beneficial to explore the implication of including battery storage.
- Engage with ESCOs to further inform the procurement case, as discussed in 9.7.
- Engage with a specialist DH network design and installation contractor i.e. Rehau, Eneteq Services Ltd (Specialist brand within Veolia) or Vital to further understand civil costs and potential implications and timescales if a crossing of an infrastructure is required.

APPENDICES

APPENDIX A

ENERGY CENTRE DRAWINGS AND SCHEMATICS

- 1620017133-007-RAM-DS-DE-00001_EnergyCentreLayout_ASHP_01
- 1620017133-007-RAM-DS-DE-00002_EnergyCentreLayout_WSHP_01
- 1620017133-007-RAM-DS-DE-00003_PeakingPlantLayout_01
- 1620017133-007-RAM-DS-DE-00004_EnergyCentreSchematic_WSHP_01
- 1620017133-007-RAM-DS-DE-00005_EnergyCentreSchematic_ASHP_01
- 1620017133-007-RAM-DS-DE-00006_PeakingPlantSchematic_01

APPENDIX B

DISTRICT HEATING NETWORK DESIGN

- 1620017133-007-RAM-MA-DE-00001_StudyArea_01
- 1620017133-007-RAM-MA-DE-00002_ProposedECLocation_01
- 1620017133-007-RAM-MA-DE-00003_HeatNetworkPipeSizes_01
- 1620017133-007-RAM-MA-DE-00004_MajorPipeCrossings_01
- 1620017133-007-RAM-MA-DE-00005_StakeholderLocations_01
- 1620017133-007-RAM-MA-DE-00006_ReservoirDistance_01
- 1620017133-007-RAM-MA-DE-00007_AlternativeRoutes_01