Heat Network Mapping and Masterplanning for Newport and Ryde (Nicholson Road)

Report #2: Heat Network Masterplanning - Newport Harbour

Report

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Glossary

AHU	Air handling unit	IoW	Isle of Wight
BEES	Building Energy Efficiency Survey (commissioned by BEIS)	IWC	Isle of Wight Council
BEIS	Department of Business Energy and Industrial Strategy	IWNHST	Isle of Wight NHS Trust
CCL	Climate Change Levy	IRR	Internal Rate of Return
CHP	Combined Heat and Power	JV	Joint Venture
CO_2	Carbon dioxide (emissions arising from energy use)	LCOE	Levelised Cost of Energy
CoP	Coefficient of Performance (of heat pumps)	LPHW	Low Pressure Hot Water
CRC	Carbon Reduction Commitment	MDPE	Medium Density Polyethylene (a form of plastic pipe)
CRT	Canals and Rivers Trust	MTHW	Medium Temperature Hot Water
C&I	Commercial & Industrial	MSW	Municipal Solid Waste
DC	District Cooling	NEED	National Energy Efficiency Data-Framework (BEIS)
DH	District Heating	NCV (LHV)	Net Calorific Value (Lower Hear Value)
DHW	Domestic Hot Water	NEED	National Energy Efficiency Database
DN	Nominal diameter in mm (Diametre Nominal)	NHS	National Health Service
DNO	Distribution Network Operator	NPV	Net Present Value
EED	EU Energy Efficiency Directive	O&M	Operation and Maintenance
GCV (HHV)	Gross Calorific Value (also referred to as Higher Heat Value)	PWLB	Public Works Loan Board
GIS	Geographic Information System	QEP	Quarterly Energy Prices (BEIS dataset)
GSHP	Ground-source heat pumps	RHI	Renewable Heat Incentive
HIU	Heat Interface Unit	ROC	Renewable Obligation Certificates
HOB	Heat-only Boiler	SPV	Special Purpose Vehicle – a company created for a specific purpose
HN	Heat Network	VAT	Value Added Tax
HNDU	Heat Network Delivery Unit (BEIS)	WACC	Weighted Average Cost of Capital
HNCP	CIBSE Heat Network Code of Practice	WDF	Waste Derived Fuel
HNIP	Heat Network Investment Project	WSHP	Water Sourced Heat Pump

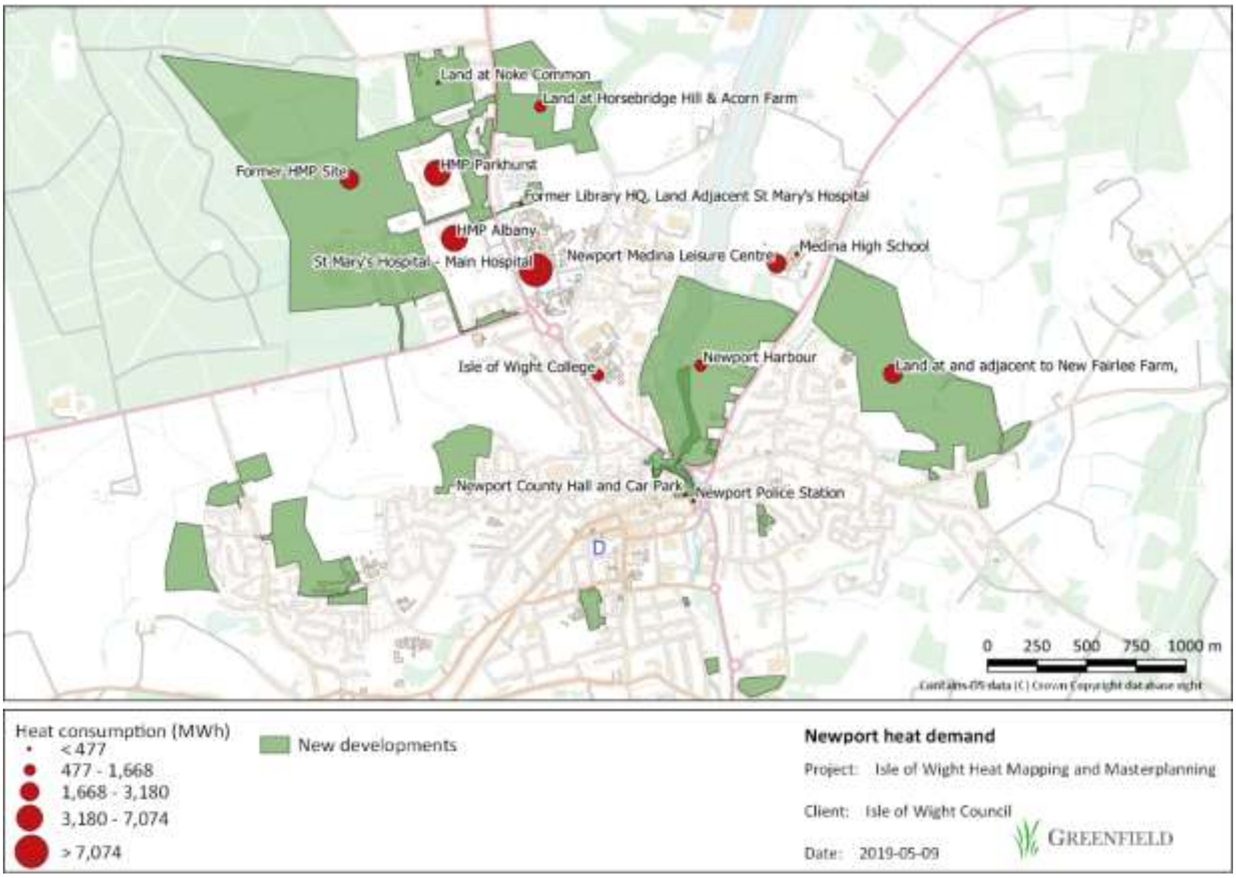
1 Executive summary

This report presents an investigation into the potential for the development of energy network solutions (heat networks) for North Newport, focused around the development at Newport Harbour, existing large consumers (prison, hospital, various colleges, and other public properties).

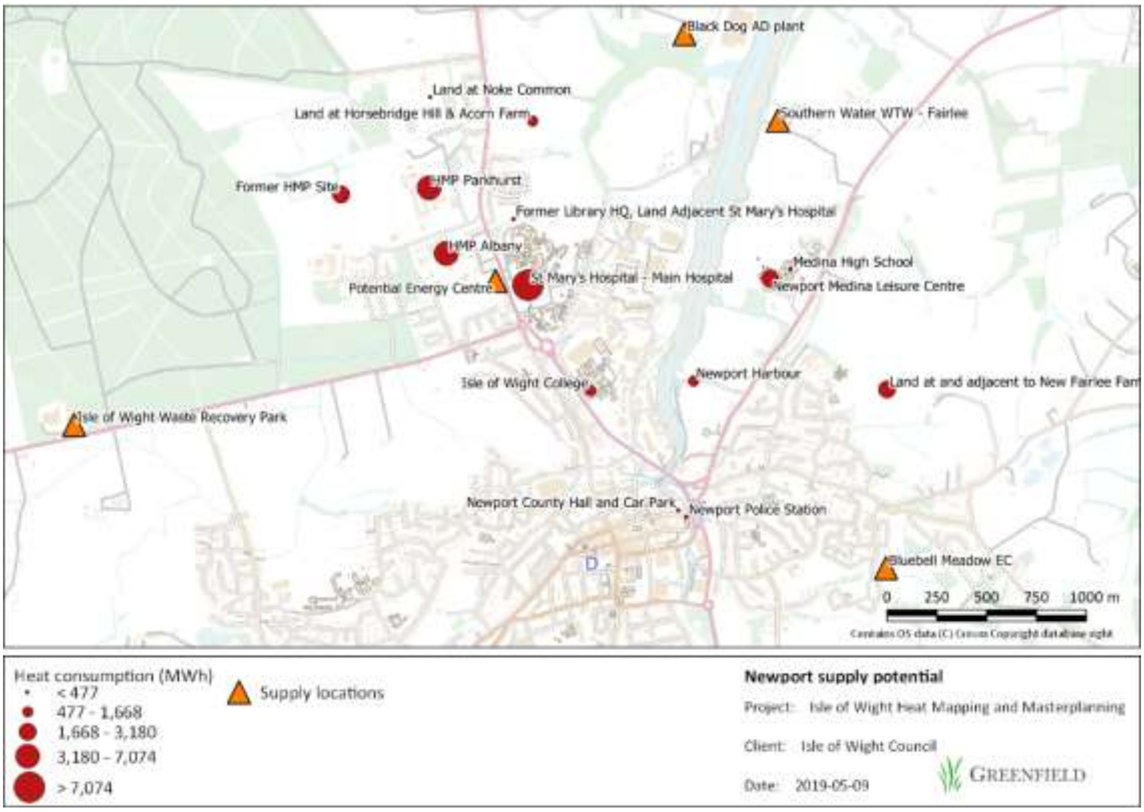
The work is defined as a mapping and masterplanning exercise. As such it involves a high-level review of potential consumers and low carbon supply opportunities, from which specific heat network opportunities have been notionally developed and tested. The testing explores economic and carbon reduction performance and the deliverability of the opportunities identified, drawing conclusions for the next steps of development, which would focus on detailed feasibility work.

Identifying consumers, low carbon supply and network options

Energy mapping based on primary consumption data, where available, or otherwise energy benchmarking was completed. The heat demand identified is shown below. Points or "bubbles" identify a heat load and its size represents the approximate quantum of demand and green zones represent planned new development. As can be seen, the demand identified sits primarily in two zones: the area around the prisons and hospital which presents a much larger and more dense heat load, and, the area around Newport Harbour, which largely relates to mixed new development.



The map below also locates a range of potential supply points (shown as orange triangles).



From review of the supply and demand opportunities four different network options were developed and then tested:

1. **Network 1: Newport Harbour development (with a number of existing adjacent properties)**

   This network presents a 'core' scheme based on the Newport Harbour development, which is a significant scheme being led by Isle of Wight Council (IWC). It has a relatively low energy demand density. A number of significant existing prospective consumers that are in close proximity have also been included.

2. **Network 2: Hospital and HMP Isle of Wight**

   This network focuses on the connection of the two existing prisons that make up HMP Isle of Wight (HMP Albany and HMP Parkhurst) and St Mary's hospital (an acute facility). These three campuses are in close proximity to each other on either side of Medina Road. Together they constitute a significant demand (thermal and power), present opportunities for locating energy centre facilities and have commercial and organisational drivers to address energy supply and cost issues in the near term.

3. **Network 3: Newport Harbour development + Hospital and HMP Isle of Wight**

   This network aims to test combining Network 1 and Network 2 consumers.

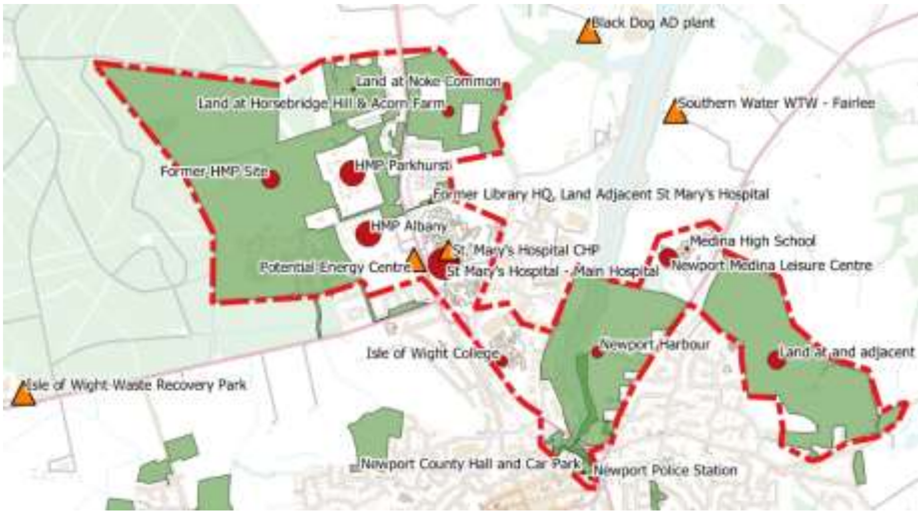
4. **Network 4: Network 3 + major urban extensions**

   This network presents a future/strategic scenario where large (private) urban extensions, assumed to consist primarily of residential properties (or relatively low density) are included. These urban extensions are understood to be at an early stage of development and hence are uncertain in terms of quantum and timing. However, much of the development is anticipated to be built after 2025, by which time gas connections to new properties are not likely to be possible (as per the government announcement by the Chancellor in March 2019). This would provide a strong driver for developers to develop alternative options including heat networks.

Network 1 consumer zone (Newport Harbour development)

Network 2 consumer zone (Hospital + HMP IoW)

Network 3 consumer zone (Newport Harbour, hospital & HMP IoW)



Network 4 consumer zone (Network 3 consumers + urban extensions)

For each, initial heat network designs, including indicative network routes (and sizing), supply technology selection, energy centre design and costings were completed, after which point they were tested through technical and financial modelling. As examples, the smallest and largest network solutions (Network 1 and 4) are shown in the plans below.

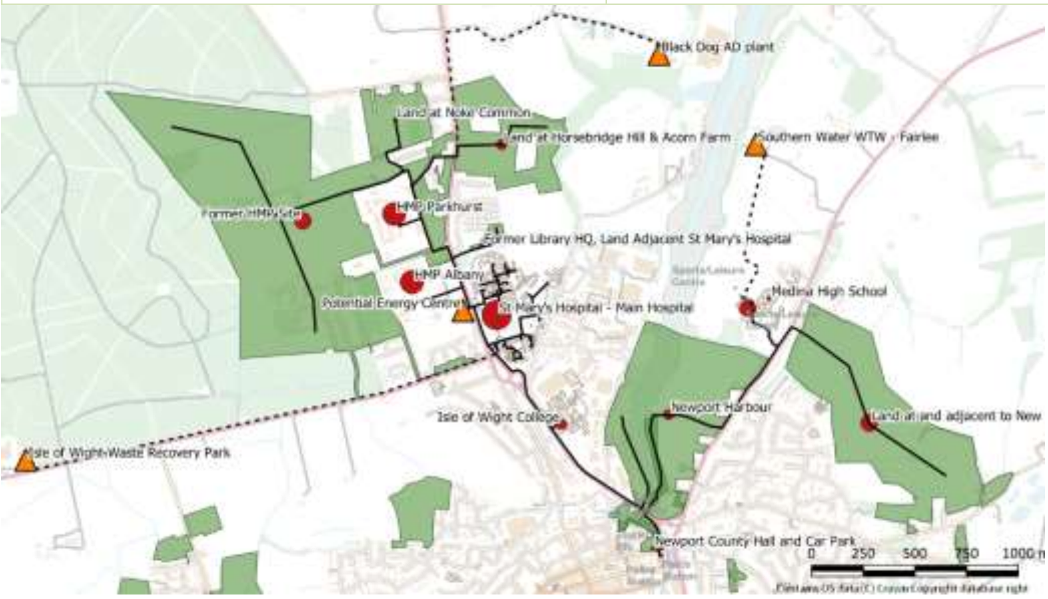
Across the network options that are a range of suitable low carbon supply technologies that have been considered (including in combination with each other):

1. Isle of Wight Waste Recovery Park (EfW heat recovery)
2. Black Dog Anaerobic Digestion Plant (heat recovery)
3. Water sourced heat pumps at Fairlee Water Treatment Works (WTW)
4. Gas CHP (new) strategically located to supply heat and power to the largest two consumers: the prison and St Mary's hospital

Water-sourced heat pumps (WSHP) using the River Medina and ground-sourced heat pumps (GSHP) were also considered. The use of the R/Medina was discounted because of lack of temperature and flow data (river is tidal at this point) whilst it is considered there are likely to be significant implementation risks. GSHPs were excluded due to unsuitable ground and limited underground water flow.

In each option, other than Network 1, a primary energy centre is proposed to be constructed in close proximity to HMP IoW and the hospital. This would house CHP (where included) and the main heat network pumps and controls system, peaking boiler and ancillary plant. The EfW, AD and WSHP would then feed into the network on a 'bulk' supply basis.

Network 1: showing supply options as dotted network connections



Network 4: showing supply options as dotted network connections

For Network 1, an energy centre location would need to be found in close proximity to primary supply points, potentially with a local boiler/control facility within the Newport Harbour development site. Discussions with the masterplanning team considering the Newport Harbour development options, following completion of the analysis, identified an under-utilised gas utility site off of Fairlee Road, on the eastern edge of the Riverside Centre. This would be a good location, if it were needed, subject to commercial arrangement with the land-owner.

For all options a variable temperature, variable flow, steel pipe heat network arrangement was proposed. Whilst operating temperatures would vary to suit energy demand at any given time, they were modelled to typically operate between 90°C flow and 55°C return (although variations to this were considered for some supply technologies).

Economic / carbon performance of the networks identified

The analysis of economic performance of the four network options, as they are presently conceived, illustrates a range of resulting rates of return and carbon savings potential as shown in the tables below.

		Network 1		Network 2			
		WSHP	Black Dog AD	EfW	Gas CHP	Gas CHP & EfW	Gas CHP & AD
Capital costs	£m	8.3	8.7	13.1	15.2	18.3	17.9
IRR-25yr	%	-3.5%	-2.7%	2.4%[1]	6.0%	6.7%	5.5%
NPV-25yr	£m	-5.5	-6.8	-1.6	4.1	6.6	3.9
CO_2 savings over 25 yr	%	51%	60%	28%	20%	38%	33%

		Network 3				Network 4		
		Gas CHP & WSHP		Gas CHP & EfW & WSHP	Gas CHP & AD	Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP
Capital costs	£m	24.4	22.1	27.2	24.0	43.2	40.7	45.6
IRR-25yr	%	3.1%	0.3%[2]	3.9%	2.1%	2.4%	0.5%[2]	3.1%
NPV-25yr	£m	-1.0	-7.8	1.1	-3.4	-4.4	-11.7	-1.8
CO_2 savings over 25 yr	%	26%	33%	39%	27%	27%	30%	35%

In summary the conclusions from this analysis are as follows:

Network 1 - Newport Harbour:

The analysis shows poor economic performance for both technology options, with negative rates of return estimated.

It is apparent that relatively low energy demand density (based on the 2017 masterplan) for the Newport Harbour development (and associated existing properties) combines with the fact that the networks are quite distributed (not least because of the River Medina).

In the region of the 70% grant support would be required to achieve an IRR (25 years) of 5%. Since this is highly likely to exceed the threshold for 'state aid' it is concluded that this network is not economically deliverable.

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[1] *Additional simplified analysis estimated potential uplift to above 9% where power is sold from the EfW plant to consumers*

[2] *Additional simplified analysis estimated potential uplift to just below 5%, where power is sold from the EfW plant to consumers (in both cases)*

There are likely to be opportunities to improve economic performance of these options, which could be considered including:

1. Inclusion of CHP to the WSHP option (reducing power costs). The scale of Network 1 may not support this solution but if it could, it may make a material improvement on rates of return but would also add complexity.
2. Implementation of the heat pump using water abstracted and discharged from/into the R. Medina, for which further information would be required.
3. Account for changes in the new Newport Harbour masterplan (the 2017 version being used in the study) when it is completed. Discussions in June (after the completion of the heat network analysis) with the Masterplanners highlighted that both energy energy demand density and energy consumption was likely to be lower than estimated from the 2017 masterplan because of changes to views on the developable areas and development density. This would have a negative impact on the economic performance of this network option, and, on the others where Newport Harbour is included (albeit diluted).

Network 2 – St Mary's Hospital and HMP IoW:

The techno-economic analysis shows strong economic performance for all three options involving CHP with IRR (25 year) sitting between 5.5% and 6.5%. This would support the case for public investment. With only grant contributions of between 4% and 27% of the estimated capital costs needed to make all options achieve between 7% and 10% IRR, which moves them towards being commercially fund-able.

The economic case for the heat network is largely driven by the heat demand density and the demand for power that could be supplied to consumers, both of which are not present in Network 1.

A CHP-only supply option is not recommended on economic and carbon grounds.

It is recommended that the three other heat supply options are considered within any future investigation. The Black Dog AD (heat recovery) and EFW (heat recovery) supply options appear credible, although further investigation is required to confirm this. Combining CHP with these bulk heat sources delivers better economic return. In addition, exploring direct power sales from the EfW plant (or Black Dog plant) may also support the case for excluding CHP altogether as significant improvement in economic returns may be possible (depending power costs and associated operating costs). This option was not developed or analysed in detail but should be further considered.

Network 3 – Network 1 and Network 2 combined:

The techno-economic analysis shows a low economic performance for all three options involving CHP with IRR (25 year) sitting between 2% and 4%. This suggests further improvements and/or grant support is required to meet public investment thresholds. It is estimated that between 11% and 40% of the capital costs is required to achieve between 5% and 10% IRR, which would move them towards being commercially fund-able.

It is apparent that connecting the two networks together essentially blends the economic performance of them individually, arriving at a performance between Network 1 and 2. However, this network would increase the scale of the carbon savings and would provide a stepping stone to connecting other consumers within the town centre and the urban extension(s) considered in Network 4, and the council's ambition to deliver decarbonisation of heat supply.

The same supply options considered in Networks 1 and 2 are applicable in Network 3 although they would need to be increased in capacity. A range of technology combinations have been assessed with limited difference found in the economic outcomes (based on the current assumptions). However, using heat recovered from the EfW is estimated to deliver a greater carbon saving. The inclusion of CHP reduces the carbon benefit, and this combined with an anticipated uplift in return from direct power sales from the EfW plant (or Black Dog facility) suggest this is worth further consideration.

This network will increase the scale of carbon savings to between 50 to 76 thousand tonnes of carbon saved (Network 2: 35 to 65 thousand tonnes)

It is recommended that Network 3 is further considered primarily because it provides the opportunity to maximise carbon savings and establishing infrastructure that would enable decarbonisation of further consumers across the town (or at least the northern side) which are likely to be identified over time and the urban expansions planned over the coming decade.

Network 4 – Network 3 + urban extension expansion:

This further expansion phase picks up significant new load but it is assumed to largely be low density residential development. The additional capital costs for proportionately less revenue marginally depresses economic performance (compared to Network 2, for example) for all three options, with IRRs sitting between 2% and 3%. This suggests further improvements and/or grant support is required even to meet public investment thresholds. It is estimated that between 16% and 47% of the (much larger) capital cost is required to achieve between 5% and 10% IRR, which would move them towards being commercially fund-able.

Again, this increase in network size would increase the scale of the carbon savings and would clearly go further in delivering a wide-scale decarbonisation of heat supply in Newport.

There is marginal difference between the three supply options considered (EfW, AD, WSHP and CHP in various combinations) in economic terms. There is also only a relatively small variation in carbon performance with the options varying between 27% and 35% with a greater absolute benefit of between 60 to 78 thousand tonnes of carbon saved (Network 2: 50 to 76 thousand tonnes). Carbon emission reduction are limited by the inclusion of the CHP, making important to consider whether low cost power could be sourced for consumers or supply plant, e.g. heat pumps from existing local sources, including the EfW and Black Dog facility.

It is recommended that Network 4 is further considered primarily because it provides the opportunity to supply the heat network infrastructure to the major urban extensions which will lead to a significant increase in carbon emissions unless a low carbon solution, such as a heat network is available. Furthermore, restricts on the use of gas post-2025 is likely to mean that these developments will require a low carbon alternative. In addition, existing IoW planning policy (DM1) requires any residential development over 250 properties to incorporate a heat network solution, where feasible, hence the development of area-wide heat network solution would be very supportive to developer to achieve this obligation

It should be noted that the solution for Network 3 requires Network 2 to be implemented, and implemented in time for the design/planning process for the development sites for them to be included in a heat network solution.

As per Network 3, the EFW and WSHP supply points appear credible and deliverable, although greater detail on each is needed. Combining with CHP provides good economic results, supporting the initial investment case (whilst limiting carbon savings) and also potentially provides a low risk initial option. As discussed earlier, heat recovery from the Black Dog AD plant could also be considered (it is likely to lead to marginal reduction in IRR, based on the current input assumptions). All three alongside CHP (and direct power supply from the EfW facility or Black Dog facility) should be further considered (as per recommendations for network 3).

Development Recommendations

As highlighted in the individual heat network sections of the report the development of the three larger networks (2,3 and 4) is recommended. If Network 1: Newport Harbour is to be implemented the economic case would need to be further developed but this may drive it toward being based on a low temperature strategy (and may not deliver a commercially viable scheme). Consequently, this may further negatively impact economic performance of the Networks 2, 3 and 4.

Rationalising the opportunities for heat networks in north Newport it is recommended:

1. The council should initiate an approval process to move all or some of the network options and supply variants on to a formal project development status

2. That detailed feasibility is commissioned to provide greater confidence in the preferred options:
    a. exploring key consumers connections
    b. exploring supply issues (to secure preferred options)
    c. exploring network and related risks
    d. engaging with key stakeholders (existing "anchor" consumers, property developers and operators of the potential supply plant)
    e. examining ownership, procurement and funding (post-feasibility) strategies[3]
    f. developing project delivery plan(s)

3. The council resolves with stakeholders how to establish a robust project management/governance arrangement, which, for the larger networks would lead to working partnerships. This process is best led by the council in Networks 1, 3, and 4 but in Network 2 it may be suitable for one if the key consumers (IWNHST or MoJ) could/would lead the process

   Initially, the council would need to act as a convener (of the key parties – MoJ, IWNHST trust, property developers and energy suppliers) and manage/commission the next stages of work (typically 'detailed feasibility' and 'detailed project development').

[3] *Various choices existing, including a publicly owned/operated heat network, a public joint venture, a private-public joint venture or various options for private ownership/operation, including a concessions contract arrangement*

2 Introduction

The scope of this study was to examine the feasibility of implementing a heat network in and around the Newport Harbour development (north Newport) development, which is being led by Isle of Wight Council (IWC). The work is defined as a mapping and masterplanning exercise and work is designed to be compliant with UK Heat Network Code of Practice (CP1).

The scope of this study has evolved as it has proceeded through the revision of energy demand mapping in Newport and exploration of the potential heat/energy network opportunities within the area around Newport Harbour. It became clear that beyond the Newport Harbour development site that there was an opportunity to consider heat networks of much greater scale, by including several major existing and planned prospective consumers properties, and, existing low carbon energy supply points.

The areas of focus was subsequently expanded to consumers beyond the development site. In Newport particularly, the eventual analysis, as shown in the report, includes consideration of several major individual consumers such as St Mary's hospital, the HMP Isle of Wight prison complex and urban extensions planned in the northern edges of Newport, and, a number of significant existing low carbon energy supply opportunities including heat recovery from the Forrest Road energy from waste scheme.

The report shows the stages of work from collection and estimation of energy demand, assessment of supply opportunities, the identification of heat network scenarios (consumers and supply options) and the subsequent concept design development and techno-economic testing of these.

3 Newport Heat network opportunities

3.1 Overview of prospective energy consumers

Initial mapping of prospective consumer properties (and associated energy demand or loads) within the study areas has been conducted as described in Appendix 1. The assessment of consumers in Newport followed on from an initial high-level mapping exercise[4].

The assessment of consumers has utilised various data sources, including:

- Metered or billing consumption data for existing consumers, where it was made available by property owners/operators
- Estates Return Information Collection (ERIC) - NHS Trusts
- Filed EPC and DEC records
- Isle of Wight Strategic Housing Land Availability Assessment
- Development site planning documents
- Open source information (e.g. Google Maps)

To maximise the certainty of the quantification of prospective demand, metered or billing data has been sought from all significant consumers. Where this was not available (and for smaller consumers), benchmarking was conducted using BEES[5] (non-residential) and NEED[6] (residential) consumption benchmarks to enable a reasonable representation of demands.

The heat demand identified is shown in Figure 3-1 in point-load format, where a point or "bubble" identifies a heat load and its size represents the approximate quantum of demand.

Notes and demand data for all prospective consumers are shown in Appendix 2, with key information also included in the heat network sections of the report (sections 3.4, 5, 6 and 7).

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[4] *Heat Network Mapping and Masterplanning for Newport Harbour, Newport and Nicholson Road, Ryde, Isle of Wight, Report #1: Newport Heat Mapping, December 2018, Greenfield Nordic*
[5] *Building Energy Efficiency Survey (BEES), BEIS*
[6] *National Energy Efficiency Data-Framework (NEED), BEIS*

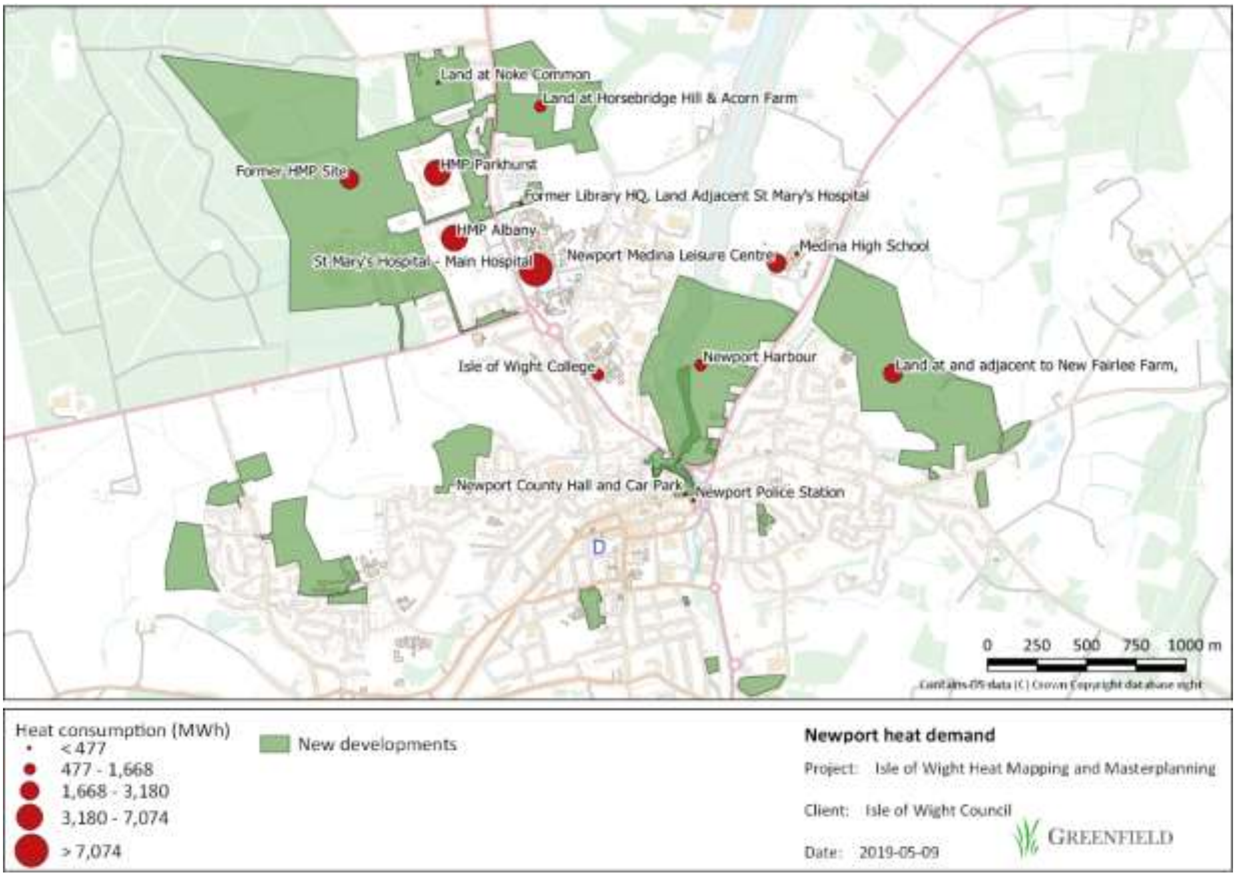

Figure 3-1. Newport heat demand points

Significant power demands were also identified and are shown in a similar point-load format in Figure 3-2. The investigation has focused on consumers that have a high likelihood to connect to a private wire power network. Power demands for the new development locations are shown, even for those that are largely anticipated to be residential developments, and are therefore unlikely to connect to a private wire network, to illustrate the scale of these additional loads.

Cooling demand is not mapped nor does it feature as a specific opportunity for any of the network options identified. During the course of data collection of prospective consumers, no significant specific cooling demands were identified, even though some is likely to exist and provision of cooling could potentially be delivered through a network solution. If any of the network opportunities is further developed, beyond this study, it is recommended that cooling demands are sought from property owner/operators and that network cooling supply is considered.

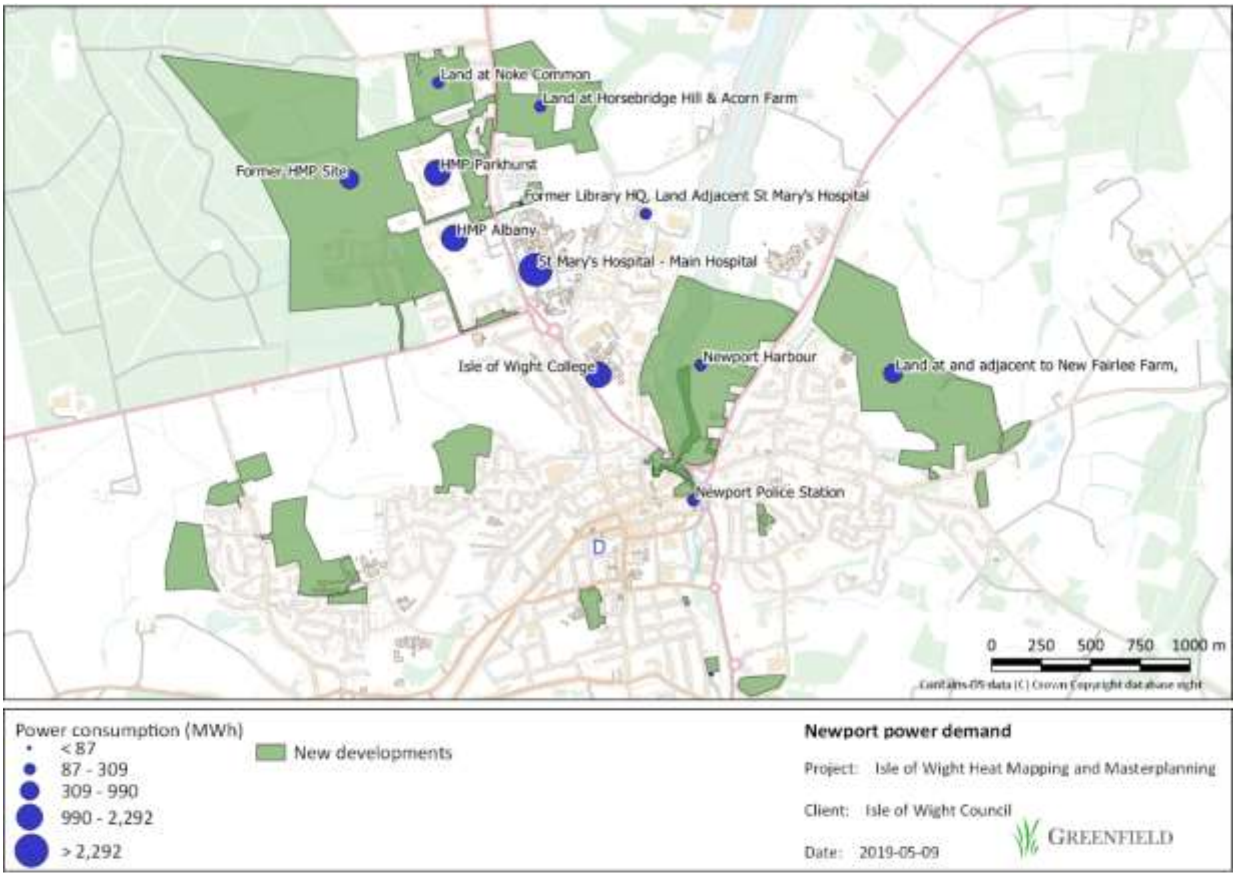

Figure 3-2. Newport power demands

3.2 Phasing of network development

Larger heat networks will typically evolve over time, being initiated in one or more locations and connecting new consumers when appropriate. The time at which a consumer might connect would be dependent on particular triggers, for example, construction timescales for new development, or the need to replace existing energy supply plant. Connection of existing consumers tends to be more flexible because the need to replace existing plant, except in the case of failure, is subjective and consumers may be prepared to connect earlier than required, especially if a heat network can offer sufficient benefit (commercial or operational).

Phasing will also be influenced by clustering of consumers and location of the supply plant, for example, a cluster of public sector properties would have greater expectation of connection and neighbouring consumers may be more incentivised to connect if this reduces connection costs. Finally, the location and timing of supply plant may also influence development phasing.

Prospective consumers may be lost if, for example, existing supply plant failures occur or development schemes need to fix their supply solution before a heat network is available. Implementation timing is therefore a significant issue.

At this early stage of investigation (masterplanning), there is uncertainty around consumer connection timing but, where available, anticipated timing of new development and the assumed availability of supply opportunities is used to inform the modelled connection timing. Any follow-on investigation work would need to consider this in detail.

3.3 Energy supply technologies

Major existing and new heat supply opportunities in Newport have been mapped. The orange triangle icons in Figure 3-3 identify locations in the context of the key demand points. These supply opportunities were identified from data including the BEIS Renewable Energy Database, open source map data and information received from Isle of Wight Council. Further information was developed for these opportunities through dialogue with the site owners/operators which is summarised below, with additional notes included in Appendix 3.

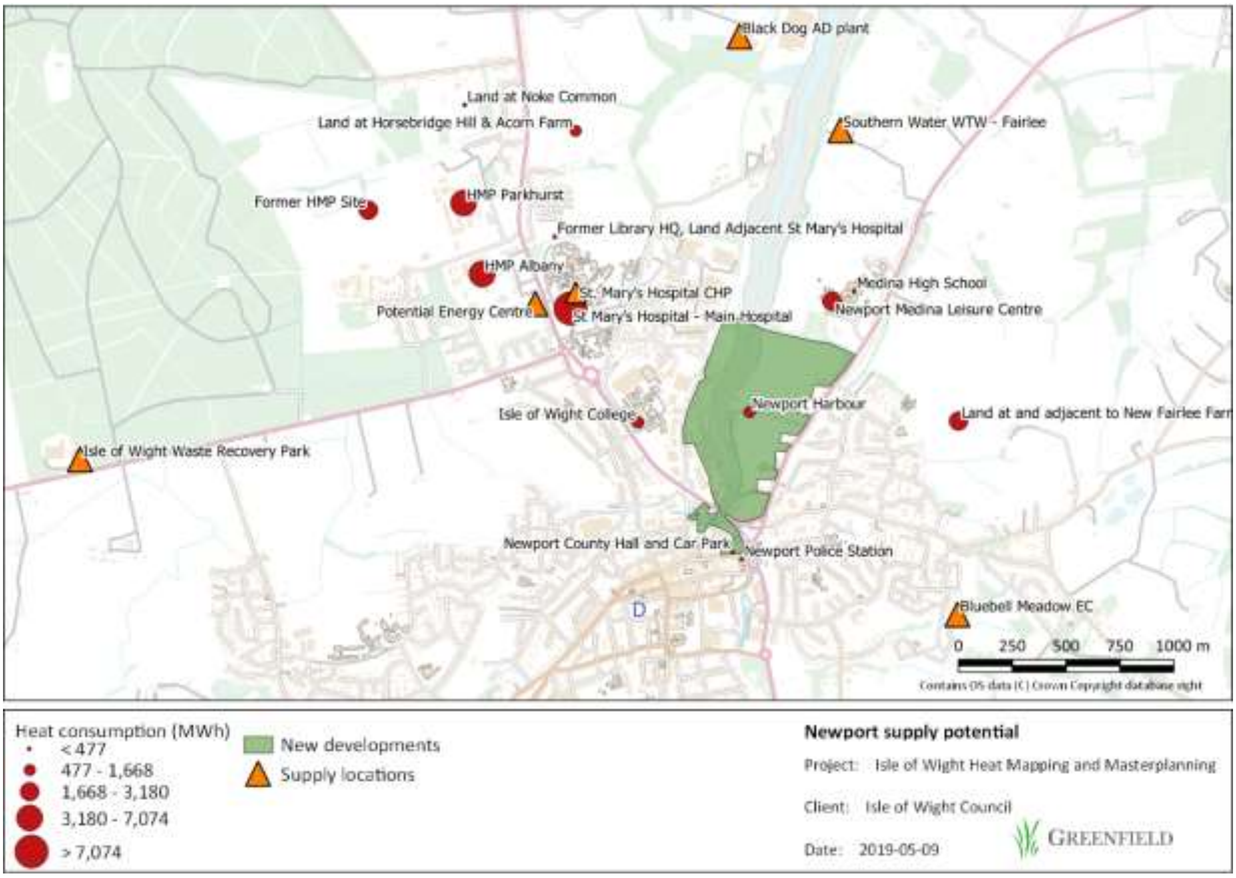

Figure 3-3. Newport supply potential and energy centre locations.

The following planned or existing, site specific, supply opportunities were identified in Newport, with general technology descriptions included in Appendix 3:

1. Isle of Wight Waste Recovery Park

Location:	Forest Road
Owner:	Amey (appointed through IWC waste management contract)
Engagement:	Amey are keen to explore this opportunity under direction of IWC. Limited information was available from Amey during the analysis and consequently capital costs for plant and bulk heat sale prices have been estimated
Summary:	Currently AMEY are refurbishing the existing Advanced Thermal Treatment (ATT) plant to provide power generation capacity (3.3 MWe). This plant is due to be commissioned in 2019. Addition plant could be added to enable the 'CHP-ready' facility (with a tapping point on the steam turbine) to enable heat export (with an estimated (by Amey) 2.5 MWth capacity. The plant is planned to operate 7,800 hours per year. It is anticipated that heat will be available as steam from the turbine's tapping point, providing hot water to the heat network via heat exchangers. A potential heat price range has been estimated to reflect the

uncertainty around z-factor, whether RHI is available (for the biogenic fraction) and the margin required by Amey. A base case cost of £3.15/MWh is used together with a sensitivity range of -£4.43 to +£12.08. The plant could also potentially supply power directly to consumer, through a private wire network work. Amey were not able to provide specific details and so a simple high level assessment of the benefit of this was conduct in relevant heat network scenarios.

2. Black Dog Anaerobic Digestion Plant

Location:	Stag Lane (north of the Newport Harbour development site)
Owner:	Black Dog Biogas Ltd / Earth Capital
Engagement:	Black Dog have confirmed interest in exporting heat from existing and future CHP capacity, subject to commercial benefit
Summary:	Existing facility incorporating a main anaerobic digester, post digester and a storage tank. The plant produces approx. 95,000 m3 of biogas per week which powers CHP units (gas engines) with total capacity of 1,137 kWe. The CHP plant operates 24/7, with shut-downs for planned maintenance every 2,000 hours. Exportable heat was estimated by Black Dog to be approx. 1.15 MW (hot water at 85 °C) and this would be available through the installation of heat exchanger units between the supply water circuit and the heat network water circuit.

3. Fairlee Water Treatment Works (WTW)

Location:	Site off of Fairlee Road (north of the Newport Harbour development site)
Owner:	Southern Water (SW)
Engagement:	SW have expressed interest in explore heat capture/sales as a test-bed for facilities within their portfolio of sites. Technical data on water flows provided
Summary:	Fairlee is a former wastewater treatment plant that is now used as a pumping station. It would be possible to extract heat from the high water flow moving through the site through the use of Water Sourced Heat Pumps. Source water temperature ranges from 5 °C to 23 °C and flow rates range between 200 m3/day to almost 2000 m3/day. A 2.3 MWth capacity available is estimated based on a 5°C delta T. It location to the north east of Newport and on the east side of R. Medina means it would be suitable for heat network opportunities on the east side of the Medina or where a network straddles the river.

4. St. Mary's Hospital gas CHP

Location:	Main campus building
Owner:	Isle of Wight NHS Trust (IWNHST)
Engagement:	IWNHST have confirmed they are keen to explore being both a consumer and also accommodating supply plant on the St Mary's campus, where possible. Engagement has been constrained with limited access to technical information after personnel changes. This has resulted in limiting the examination of integration issues for heat and power connections.
Summary:	The Hospital has an existing 300 kWe CHP installation used in a tri-generation application. At circa 10 years old, the existing plant, which is owned by the Trust, is coming towards the end of its useful life, and hence is not included within any of the heat network options. The Trust is keen to develop a solution to replace this facility and hence an energy centre could be located on or near to the site as part of a heat network scheme. New gas CHP plant has been considered in some network options which could displace this existing plant.

5. Bluebell Meadows – existing heat network

Location:	Barton (south west suburb of Newport) – energy centre located off Godric Road

Owner: NA
Engagement: Discussion with developer / consultant
Summary: This newly developed site is heated by a district heating scheme currently supplying heat to 400-450 homes. The network is heated by gas boilers at this stage, but a switch to biomass is planned with a supply chain for biomass being established. The network was installed by Barratts and subsequently gifted to Pan Management Company. This scheme is too far from the areas of focus within this study and so has not be included within the analysis

6. River Medina (WSHP)

Location: Runs through the centre of the Newport Harbour development area
Owner: NA
Engagement: Discussion and information exchange primarily with the Environment Agency
Summary: The EA confirmed water temperature range from 0°C to 29°C with the mean temperature being 14°C. They were not able to provide data which would be required to examine the variations in temperature over time. The EA also confirmed that they were not aware of any specific flow data. The river is tidal and as such flow rate and direction will continually vary. Without certainty around this it is impossible to design and size a water sourced heat pump solution. Hence this option was not pursued further at this stage. If this option were pursued, assuming flow/temperature data was available, developing a design for water abstraction and discharge addressing the tidal conditions will be a key challenge. In addition, it will be necessary to examine and the prove that there would be acceptable levels of ecological impact as a result of the project to the EA.

7. Ground Source Heat pump

Location: Flexible - boreholes can be drilled as appropriate
Owner: NA
Engagement: Initial investigation, including commissioning/interpretation of the British Geological Survey hydrology/geology report
Summary: Open-loop or closed-loop Ground Source Heat Pump installation providing heat for the network was considered possible. The location of equipment would be on a suitable land area to accommodate borehole array and, with the primary energy centre plant being located close to the primary demand points. The potential for GSHPs was assessed based on specific evidence provided by a BGS study commissioned for a different development site in Ryde which explored the possibility of heat transfer from sub-surface water and direct heat transfer from soil, with closed loop and open-loop heat pump systems, respectively. The study concluded that the Ryde location was not suitable for either open-loop or closed-loop GSHP systems. This is due to low flow rates of the accessible sub-surface water and poor thermal transfer potential of the soil/rock in this location. Thus this option was excluded from further analysis. It was also assumed that the hydrological and geological condition found in Ryde will be similar to that found in Newport and hence GSHPs were also not considered in the Newport heat network options. More detail regarding the reasons for exclusion can be found in Appendix 3.

In addition, to the above site-specific opportunitiesnew gas CHP has also been considered in some supply/consumer scenarios, including hybrid (heat pump / heat recovery) solutions. Gas CHP will provide both heat and power (through a private wire network) which offers a commercial benefit, however, it would displace grid-sourced power, the carbon emissions of which continues to decrease.

As such gas CHP is considered as a temporary solution and the would need to be displaced by lower carbon technologies in the long term.

3.4 General notes relevant to all heat network options

3.4.1 Network infrastructure routing and design

The routes for each heat network option have been developed to:

- minimise pipe lengths to limit cost and heat losses
- where possible, take advantage of land suitable for 'soft dig' to limit construction costs
- where possible, avoid routes along major highways to limit construction costs and traffic disruption (during installation and servicing)
- avoid significant constraints such as crossing major highways, rivers, other transport corridors and waterways

Any significant constraints that cannot reasonably be avoided have been identified and initial options to circumvent them are discussed, with specific costs attributed within the cost appraisals.

In all cases pre-insulated steel pipework has been selected and costed and pipe sizing has been conducted using the principles and the assumptions described in Appendix 4.

3.4.2 Air quality issues

All heat generation technologies that utilise combustion present a localised air pollution risk particularly in terms of NOx and particulates. This can be mitigated through the use of modern boiler technology (which is likely be required under Medium Combustion Directive licensing) and appropriate siting of the boiler plant/energy centre. Where energy centres are to be developed, evidence would need to be prepared, including flue gas dispersal modelling, to enable licencing by the Environment Agency. There are currently no AQMAs declared by Isle of Wight Council according to DEFRA UK Air Information Resource and as such there are no known specific air pollution concerns in any of the locations proposed for energy centres.

In the network options considered the following supply options are included: heat recovered from existing energy plant, WSHPs (with electricity and ambient heat as the primary energy sources) and gas CHP, with new gas boiler plant meeting peak loads. Heat networks would also displace existing or planned (in the case of new development) property-level boilers. The impact of a heat network will therefore be to reduce the total volume of combustion gases entering the atmosphere and to reduce air pollution overall, perhaps except in the case where gas CHP is used (since this is using gas locally to also generate power, which would otherwise be delivered via the 'grid'). This benefit is compounded by that fact that the individual boilers that would be displaced will be less efficient and more polluting than the highly managed energy plant within a heat network energy centre.

3.4.3 Revenue and operating cost assumptions

In terms of revenues (or income) for the heat network, consumer tariffs are based on a 5% reduction of a calculated counterfactual cost, i.e. cost of the alternative energy supply solution (assumed to be building-level gas boilers in all properties and grid supplied power). Tariffs will vary between consumer types, with domestic consumers paying more (per unit of energy delivered) than commercial properties, as per counterfactual costs. Connection fees would also be levied against each property when it connects to the network and this is assumed to be a 5% reduction of the calculated counterfactual cost of installing gas boilers. On this basis, connection fees would vary based on the heat capacity required by each consumer.

Revenue is also assumed to be available from the Renewable Heat Incentive (RHI) for the renewable energy options (heat pumps and potentially heat recovered from the biomass fraction of Energy from Waste plant), although it should be noted that the current RHI programme is due to close in Q1 2021 and a replacement or extension has yet to be proposed (a financial sensitivity has been modelled with the exclusion of RHI).

Revenue is also assumed to be available from CHP power sales.

Operating costs have been developed largely based on prior project experience accounting for the nature of the specific options to finalise key assumptions, e.g. fixed annual or variable on heat load and other parameters.

Key operating costs and revenue assumptions are scheduled in Appendices 7 and 8.

3.4.4 Consumer and other benefits

If developed as presently conceived, any of the heat network options could deliver a number of benefits to the town:

1. Reduced heating energy costs by a minimum of 5% compared to counterfactual estimates for connected consumers. In addition, there would be an additional reduction in power costs, where CHP is used, for the hospital (and potentially for additional power consumers if a private wire network was developed)
2. Mitigation of future energy cost increases especially in the case that renewable energy systems are used as a primary or secondary energy source
3. Operational benefits to connected consumers which would include reduced plant liability and releasing floor space which would otherwise be allocated to property-level energy supply plant
4. Short term reduction in carbon emissions for connected properties (each network section highlights specific carbon savings for each network option and will depend on supply technology and other design issues).
5. Long term, deeper reduction in carbon emissions through heat network expansion and/or the inclusion of additional low carbon supply technologies. This would be challenging to achieve by means other than a heat network.
6. Inward investment into the town of between £8.3m and £25.6m .
7. Support developers (of the large urban extension included in Network 4 – section 7) to meeting their obligation under IoW planning policy DM1 which requires any residential development over 250 properties to incorporate a heat network solution, where feasible
8. Development of a local energy generation / supply entity that would be an employer and would pay business rates to be a contributor to the local economy
9. Development of local, lower cost, lower carbon energy supply may encourage retention of existing businesses or relocation of new businesses to the town

3.4.5 Project risks

All heat network projects present risks. By their nature, they involve managing multiple uncertainties and options to arrive at optimised solutions during the development stages. During construction and operation, they present numerous risks that can undermine the intended outcomes. It is important to understand these risks and to ensure the economic, carbon and other benefits outweigh taking these risks, which will be somewhat of a subjective judgement.

For all heat network options, an initial risk register has been developed as shown in Appendix 11. This collates the key risks, showing generic risks (applicable to all options) and a number of specific risks associated to each network. Each heat network section of the report highlights any key risks that apply.

The risks are attributed to the following classifications (described on the first page of Appendix 11):

- Risks Type
    - Design risk
    - Construction risk
    - Operational risk
    - Commercial risk: Demand risk & Price risk
    - Regulatory risk
- Development stage
    - Project Development (PD)
    - Construction (C)
    - Operational & Management (O)

At this stage the key risks to focus on are those affecting the Project Development stage, although the others are important to review and plan for.

Generic risks which will be important include:

1. Capability and capacity amongst the development lead, e.g. the council and key stakeholders to effectively manage the project development process
2. Securing consumers. It will be important to secure consumers and maximise revenues from energy sales to support the case for investment. At this early stage of investigation there is not a high degree of confidence that the consumers identified would connect and this would need to be an important focus of any follow-up investigation. Securing the largest consumers and forming clusters of connections that can occur at the same time will be important.
3. Secure a location for the primary energy centre.
4. Minimising heat network construction/servicing impacts, e.g. highways.
5. Improving economic performance, where possible and developing the case for grant support.
6. Renewable Heat Incentive (due to close in quarter 1, 2021): will affect revenues if it were not available (see sensitivity analyses) and also long-term economics are impacted after 20 years, when RHI contract would expire.

3.4.6 Development governance

Recommendations for the governance of projects are discussed for each heat network with general recommendations shown in section 8. Key development recommendation include establishing development governance e.g. identifying a lead agency (where this is not the council) and managing the approval process to move any options to a formal project development status within the lead agency and conducting key tasks including further specific engagement with stakeholders; further development of the heat network design to address techno-economic improvement opportunities and mitigate key risks; review alternative design options that may add value; and; establish ownership, procurement and funding strategies.

3.6 Selected Heat Network opportunities

Four heat network opportunities were selected for development and investigation:

1. **Network 1: Newport Harbour development (with a number of existing adjacent properties)**

   This network presents a 'core' scheme based on the Newport Harbour development, which is a significant scheme being led by Ilse of Wight Council (IWC). It has a relatively low energy demand density. A number of significant existing prospective consumers that are in close proximity have also been included.

2. **Network 2: Hospital and HMP Isle of Wight**

   This network focuses on the connection of the two existing prisons that make up HMP Isle of Wight (HMP Albany and HMP Parkhurst) and St Mary's hospital (an acute facility). These three campuses are in close proximity to each on either side of Medina Road. Together they constitute a significant demand (thermal and power), present opportunities for locating energy centre facilities and have commercial and organisational drivers to address energy supply and cost issues in the near term.

3. **Network 3: Newport Harbour development + Hospital and HMP Isle of Wight**

   This network aims to test combining Network 1 and Network 2 consumers.

4. **Network 4: Network 3 + major urban extensions**

   This network presents a future/strategic scenario where large (private) urban extensions, assumed to consist primarily of residential properties (of relatively low density). These urban extensions are understood to be at an early stage of development and hence are uncertain in terms of quantum and timing. However, much of it is anticipated to be built after 2025, by which time gas connections to individual properties are not likely to be possible (as per the government announcement by the Chancellor in March 2019).

These network connection options are shown in Table 3-1 along with the supply technologies that have been considered for each.

Network	Consumers	Supply options	Demand (GWh)
Network 1	• Newport Harbour development • Newport County Hall • Newport Police Station • Medina Leisure Centre & Medina College	• Black Dog AD (heat recovery) • WSHP at Southern Water WTW	Heat: 5.1
Network 2	• Hospital (heat & power) • HMP IoW (heat & power) • IoW College (heat & power)	Combinations of: • Gas CHP • Forest Road EfW (heat recovery) • Black Dog AD (heat recovery) • WSHP at Southern Water WTW	Heat: 25 Power: 11
Network 3	• Newport Harbour development • Newport County Hall • Newport Police Station • Medina Leisure Centre & Medina College • Hospital (heat & power) • HMP IoW (heat & power) • IoW College (heat and power)		Heat: 31 Power: 11
Network 4	Network 3 consumers + urban extensions: • Former HMP Camp Hill site • Land at Noke Common • Land at Horsebridge Hill & Acorn Farm • Land adjacent to New Fairlee Farm	Combinations of: • Gas CHP • Forest Road EfW (heat recovery) • WSHP at Southern Water WTW	Heat: 38 Power: 11

Table 3-1. Selected Newport heat network options

The consumer zones for each of these network options are shown in the Figure 3-4, Figure 3-5, Figure 3-6 and Figure 3-7.

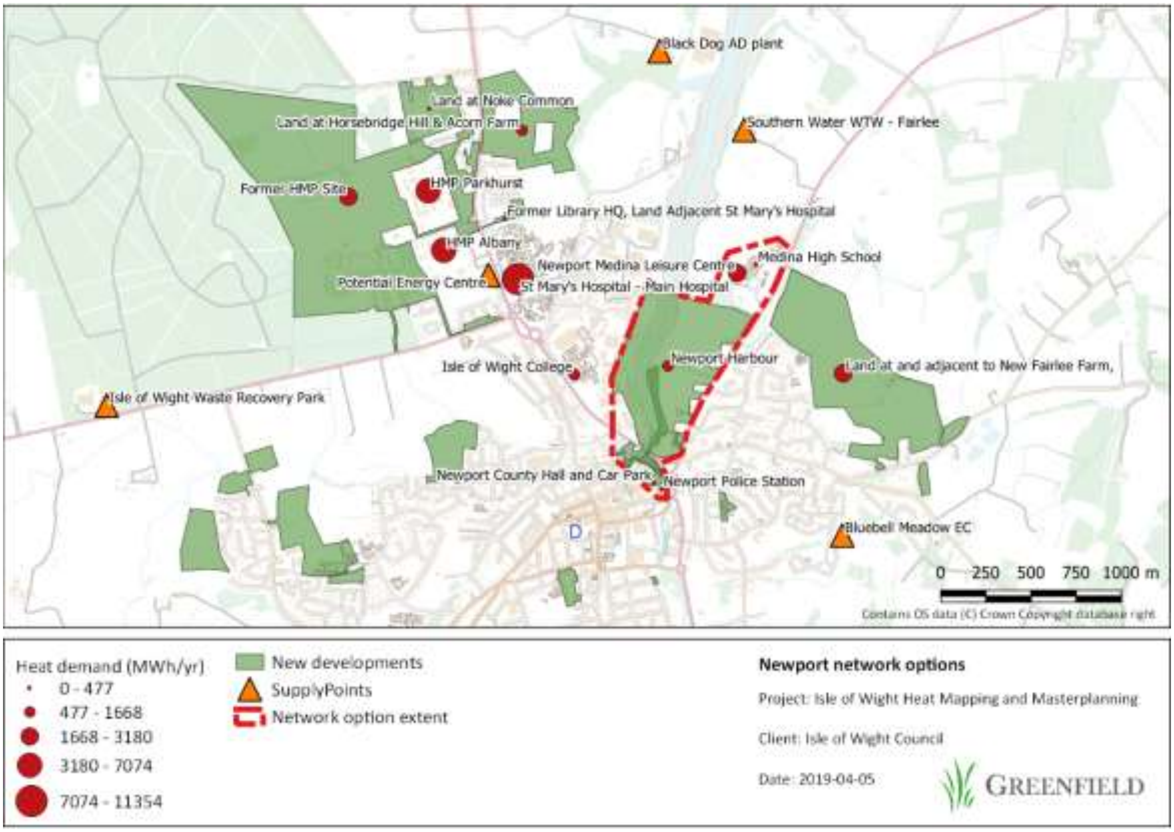

Figure 3-4. Network 1 consumer zone (Newport Harbour development)

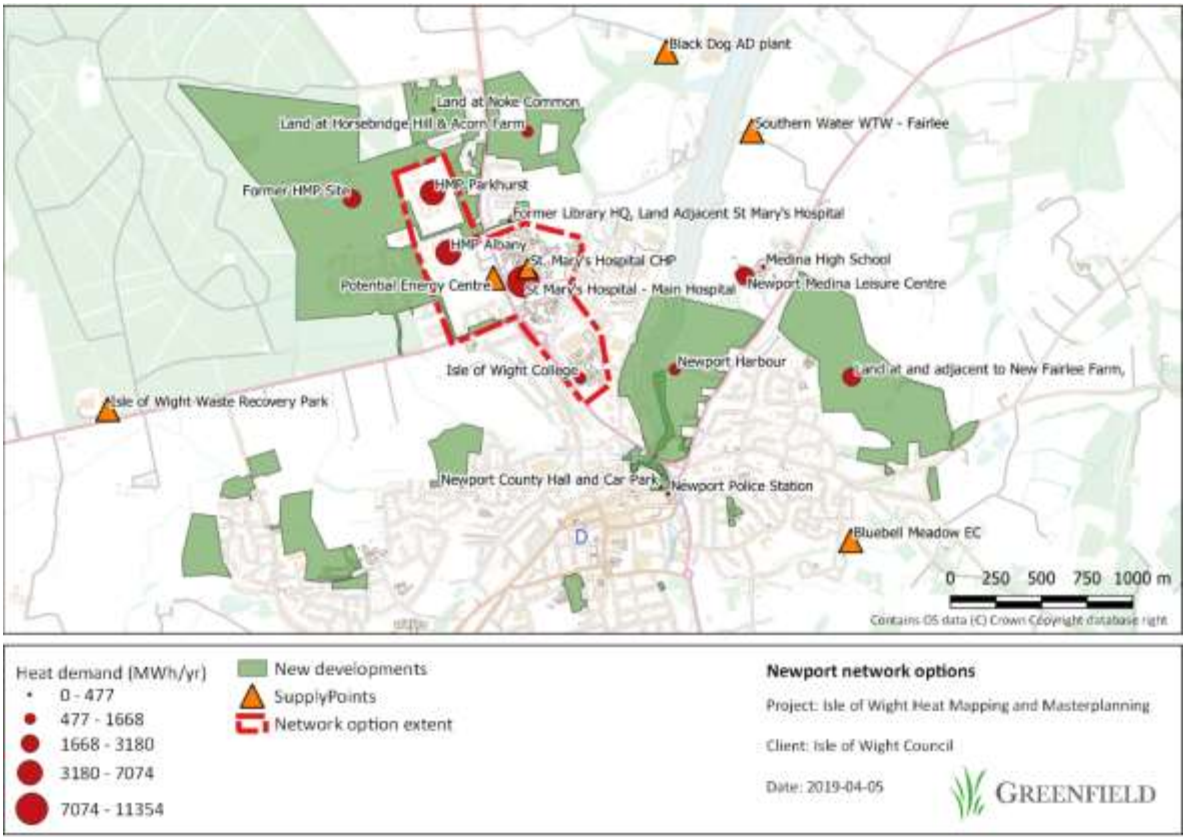

Figure 3-5. Network 2 consumer zone (Hospital + HMP IoW)

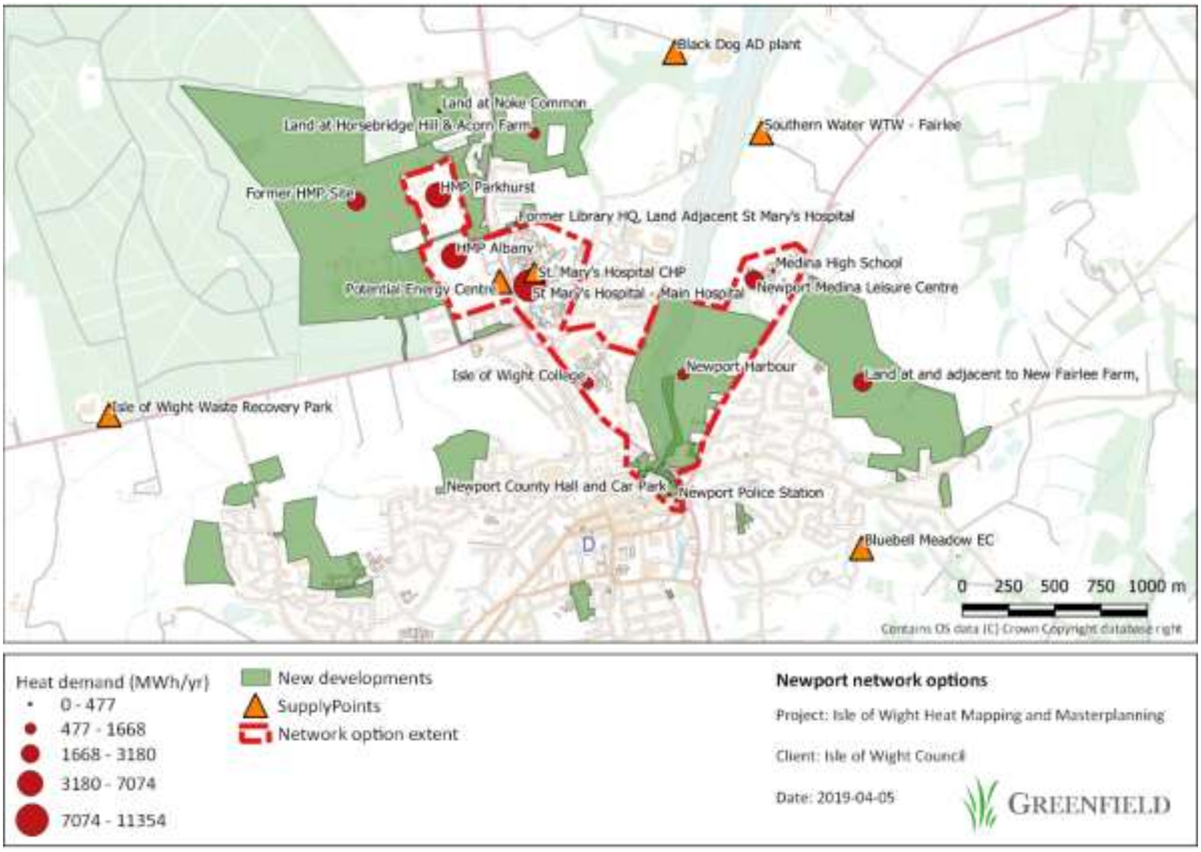

Figure 3-6. Network 3 consumer zone (Newport Harbour, hospital & HMP IoW)

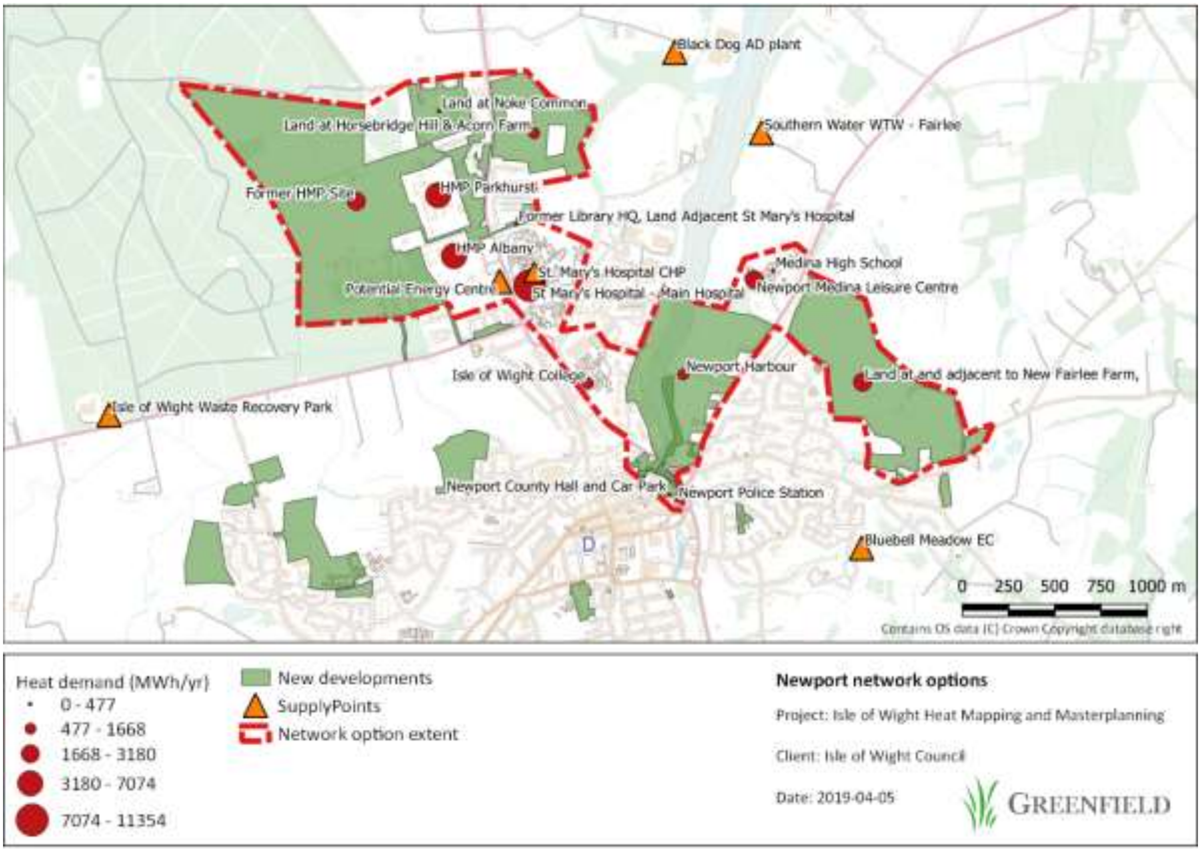

Figure 3-7. Network 4 consumer zone (Network 3 consumers + urban extensions)

4 Network 1 – Newport Harbour

4.1 Summary of heat network options

A list of consumers is provided in Table 4-1 with further details shown in Appendix 2. A revised masterplan for the Newport Harbour development is currently being developed. The information used in this analysis is drawn from the central option masterplan from the feasibility study conducted in 2017. Following completion of the heat network analysis discussion with the masterplanning team confirmed that scale and density of demand of the development is likely to be lower as both the area of land considered developable and quantum of residential development possible is considered lower than in the 2017 study. This is likely to depress the economic viability of a heat network solution. Further investigation in any follow-up work should review demand estimates, particularly with respect to the revised Newport Harbour masterplan.

Medina Leisure Centre and Medina High School are currently connected to the leisure centre plantroom which hosts an existing 62 kWe CHP unit. This is planned to be renewed in the near future and is assumed in the heat network analysis to be retained, with the plantroom being connected to the heat network, and that portion of heat not supplied by the CHP plant assumed to be supplied via heat network. It may also be possible for the heat network to co-opt this plant such that it is optimised as a heat supply for the network, however, it has relatively small plant and so is not likely to make a significant impact.

Site	Phase	Type	Peak heat (MW)	Annual Heat Load (MWh)	Data Source[7]
Newport Harbour	1&2	Mixed-use development	1.47	2,313	Development benchmarking
Medina Leisure Centre and Medina High School	1	Leisure / Education	1.37	1,867	Metering (IoW Council)
Newport County Hall and Car Park	1	Offices	0.29	425	
Newport Police Station	1	Emergency services	0.07	168	DEC
			3.19	**4,772**	

Table 4-1. Network 1 Newport Harbour consumers.

Based on review of potential consumers and spatial constraints, a provisional heat network route and energy centre location has been developed/identified as shown in Figure 4-1. Only a network 'spine' through the development site is shown since the masterplan is due to be revised, and costs for the secondary pipework (from 'spine' to consumer) has been estimated based on development density and the number of connections.

The heat network route takes advantage of land where 'soft-dig' should be possible, particularly across the new development site, and between the Fairlee WTW plant (where included) and Medina Leisure Centre. In the Town Centre area 'soft dig' opportunities are limited, but where possible, it is assumed to be used.

A key route constraint is the need to cross the River Median, to ensure supply to both sides of the Newport Harbour development. It is assumed that the existing road bridge on Medina Way is utilised for this crossing, by mounting the heat pipes on the side or underside of the bridge. Should this not be possible, an alternative is to install the pipes in a trench construction at the bottom of the river itself,

[7] *BEES and NEED refers to benchmarking used*

or underneath the river (using directional drilling). This will require assessment of ecological impact and would need to receive approvals from the Environment Agency and other waterway stakeholders.

Two baseload supply scenarios are examined for Network 1:

- Water-source heat pumps at Fairlee Water Treatment Works (WTW)
- Black Dog AD plant (heat recovery)

Supply strategies and energy centre locations are described in section 4.3.

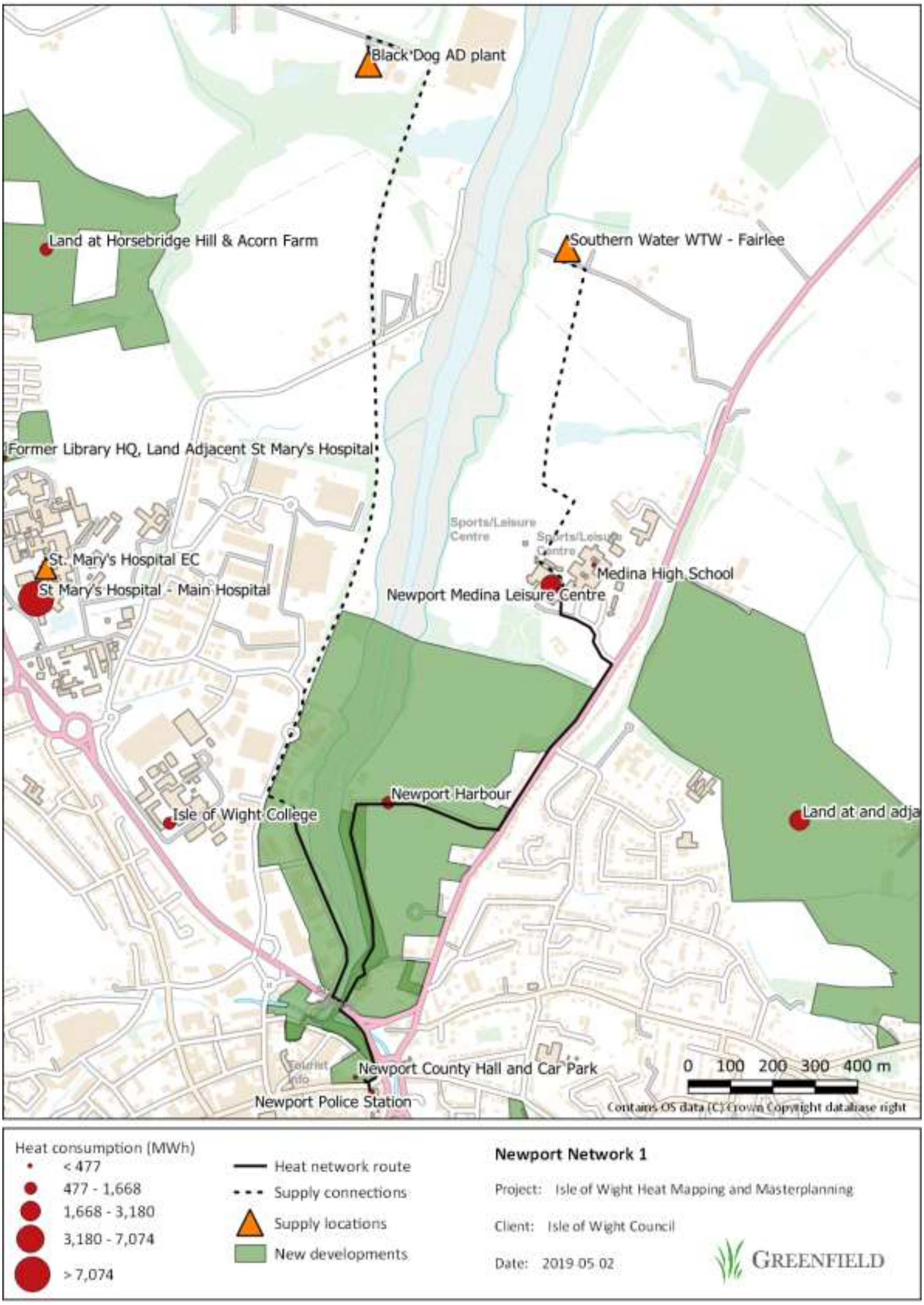

Figure 4-1. Network 1: Newport Harbour network routing and connections

Key parameters of this heat network are presented in Table 4-2.

	Unit	WSHP	Black Dog AD
Demand			
Heat demand	GWh/yr	4.8	4.8
Peak demand	MW	3.2	3.2
Number of connections Non-residential Residential (dwellings) Total	 No. No. No.	 4 250 254	 4 250 254
Network			
Network trench length	km	4.6	5.7
Linear heat density	GWh/yr/km	1.0	0.8
Main pipe size	DN	200	150
Heat losses	%	10 %	10 %
Design temperatures[8] Flow Return	 °C °C	 80 45-55	 85 45-55
Soft dig Hard dig	% %	74 % 26 %	80 % 20 %

Table 4-2. Network 1 Newport Harbour key parameters

4.2 Phasing

This heat network scenario assumes early connection to the existing consumers at the time of initial construction of the Newport Harbour scheme, with the new developments being connected as they are predicted to be built (see Appendix 2). Annual heat demand growth during the build-out phase is shown in Figure 4-2.

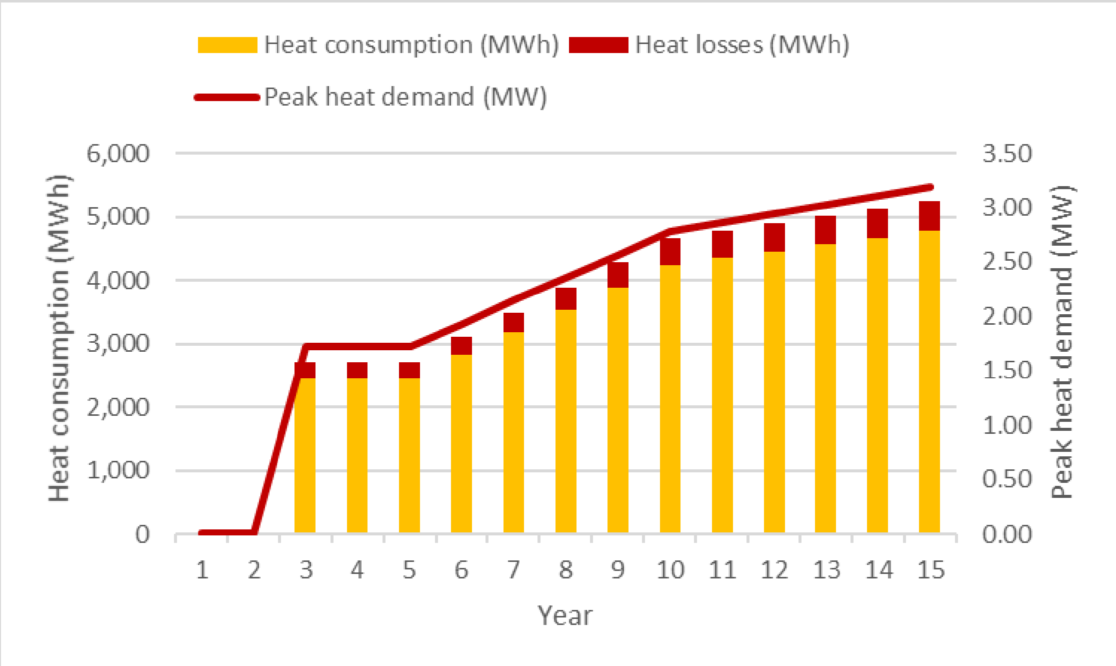

Figure 4-2. Annual heat demand increase – Network 1.

[8] *See Appendix 4 for further detail*

4.3 Energy supply concept design & plant sizing

Baseload supply options for this heat network were WSHP (at the Fairless WTW plant) and heat recovery from the Black Dog AD CHP plant. In both cases it is assumed that gas boilers (to meet peak heat demand requirements) and associated plant are also assumed located on or near these sites.

Plant capacity modelling for the baseload production options was conducted to determine the economically optimal plant sizing against hourly demand profiles. The following principles/assumptions, with key commercial assumptions shown in Appendix 7, were used in the analysis:

- WSHP at Fairlee WTW plant:
  - Heat supply capacity is estimated on data received from Southern Water. According to the data (quarter hour metering data for one full year), temperature of the water flow at the facility varies seasonally between 11°C and 21°C on average. Flow rates vary between 10 l/s and 240 l/s with an average flow rate of 109 l/s. With a 5°C delta T this corresponds to 2.27 MW capacity. Flow rate and flow temperature data indicate that heat is available around the year with no restrictions.
  - System performance is modelled with a maximum outlet temperature of 80°C from the heat pumps condensers. Output flow from the heat pumps can be boosted with gas boilers where higher temperature are required. If network temperature requirement is lower, the output temperature would be reduced.
  - The Coefficient of Performance is estimated to vary between 2.8 and 3.2, depending on inlet and outlet temperatures in the condenser and evaporator circuits. Heat pump systems would need to be designed to achieve a COP of at least 2.8 to be eligible for RHI income.
  - Availability: assumed 8,592 hours per year (accounts for annual shut-down and maintenance of one-week during summer and assumed sequential maintenance (multiple units proposed)).
  - In 'base case' modelling, revenue from the Renewable Heat Incentive is assumed. A sensitivity is also calculated with no RHI income, to account for the uncertainty of RHI being available after Q1 2021.
- Black Dog Anaerobic Digestor (AD) plant - heat recovery:
  - The AD plant has two existing CHP units (500 kWe and 637 kWe) producing power and heat for the AD process.
  - Black Dog confirmed approximately 1.15 MW excess heat capacity (as 85°C hot water).
  - Availability: CHP units operate 24/7 with planned 5-hour maintenance every 2,000 hours (availability is 8,735 hours per year). Due to this regular planned maintenance occurring also in wintertime, back-up gas boiler capacity has been dimensioned to meet the network's total peak demand.
  - Cost of exported heat is assumed constant with no time-of-day variance.
- Thermal storage was included within the optimisation analysis and gas boilers have been dimensioned for back-up and reserve capacity.

Plant sizing has been resolved through hourly modelling of supply strategies accounting for equipment life cycle costs accounting for variable costs and revenues (heat, power, RHI). For the purposes of economic modelling, targeted sizing of the baseload systems has been set above the thresholds set by the EU Energy Efficiency Directive (EED) definition of efficient heat networks (required for Heat Network Investment Project (HNIP) funding). For WSHP and recovered waste heat, the threshold is set at 50% of annual heat supply.

Option 1: WSHP at Fairlee WTW.

The economically optimal capacity was determined to be 700 kW coupled with a 50 m^3 thermal store – see results in Figure 4-3. A 700 kW capacity would supply 67% of total heat demand, exceeding the EED threshold.

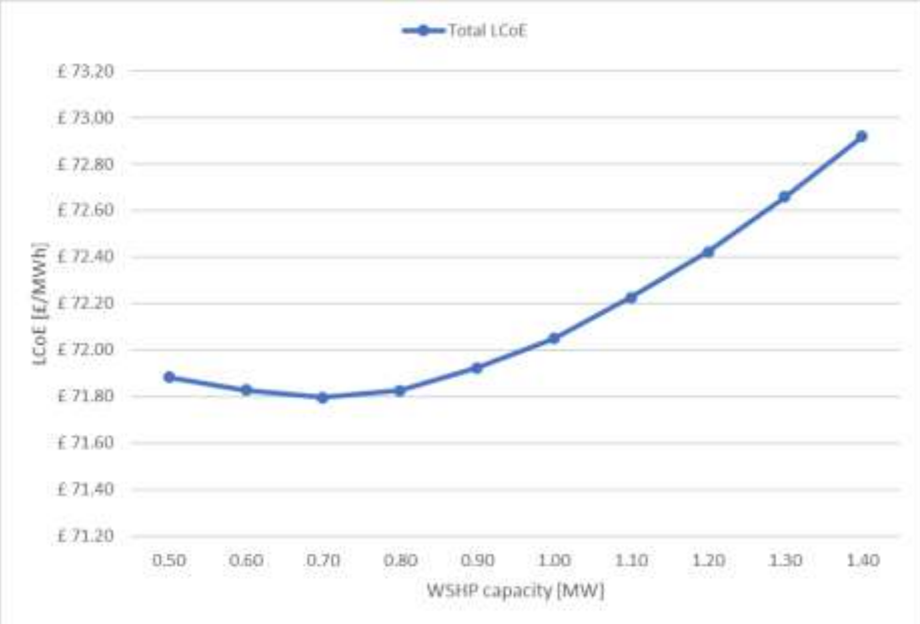

Figure 4-3 Capacity optimisation results - Network 1 (WSHP).

Figure 4-4 shows the modelled load-duration curve for the fully built-out network. This shows thermal storage is being heavily utilised during periods of lower demand; during periods of high heat demand the WSHP units are often estimated to operate a full load. The thermal storage would be recharged by the WSHPs during off-peak electricity price hours with heat utilised during peak hours to minimise WSHP operating costs.

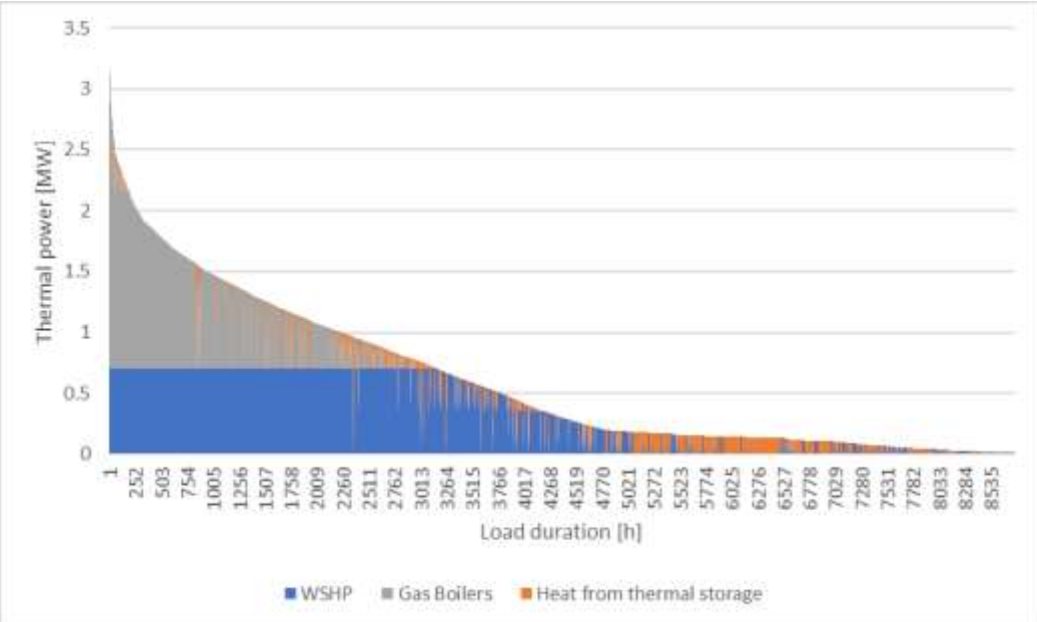

Figure 4-4 Load-duration curve –Network 1 (WSHP).

Option 2 : Heat recovered from the Black Dog AD plant.

The AD plant is located some distance away from the heat network, with a relatively significant network connection cost. Analysis identified that connecting the full supply capacity (1,150 kW) would be optimal as heat recovery equipment costs are small in comparison to the estimated heat purchase. Due to high baseload supply capacity of the plant and 24/7 availability (other than schedule maintenance), thermal storage would not be required essential and is therefore not included. Figure 4-5 shows the modelled load-duration curve for the fully built-out heat network.

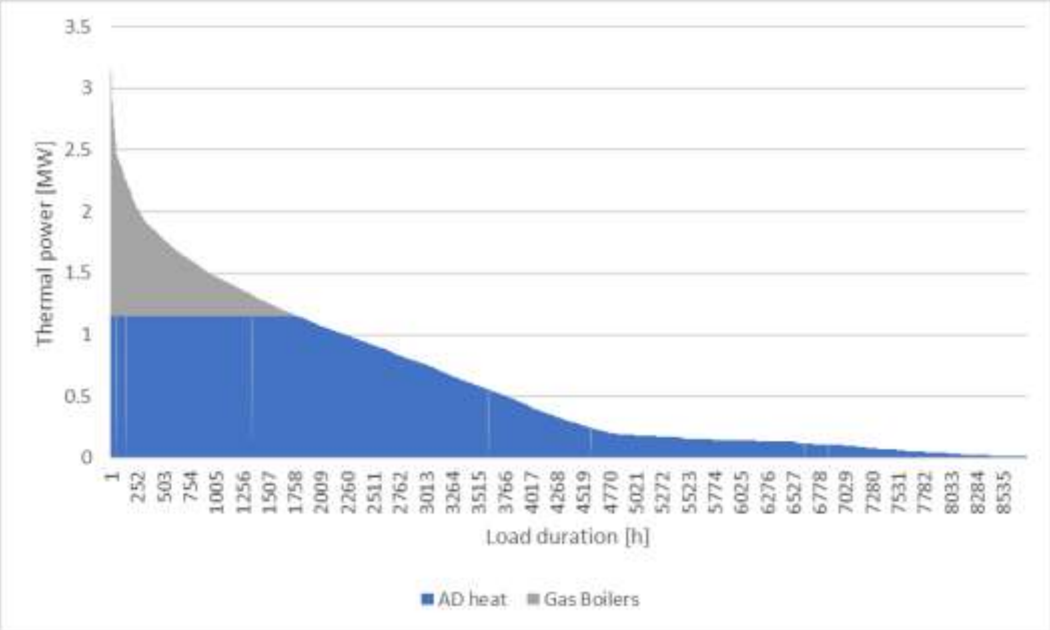

Figure 4-5 Modelled load-duration curve - Network 1 (Black Dog heat recovery).

A summary of the energy modelling results for both Network 1 technology options is shown in Table 4-3.

	Unit	WSHP	AD plant heat purchase
Supply capacity			
WSHP	kW	700	-
Heat purchase (AD plant)	kW	-	1,150
Gas Boiler	kW	3,430	4,130
Thermal storage	m^3	50	-
Heat production share			
Heat production	GWh/yr	5.3	5.3
WSHP	%	65.6 %	0 %
Heat purchase (AD plant)	%	-	83.9 %
Gas boilers	%	44.4 %	16.1 %

Table 4-3. Heat production summary - Network 1.

Indicative Energy Centre arrangement drawings are shown in Appendix 5 for the options considered.

4.4 Capital costs, operating costs and revenue

A summary breakdown of capital costs is shown in Figure 4-6 with a more detailed breakdown shown in Appendix 6. In total, the costs are estimated at £8.3m for the WSHP option and £10.9m for the Black Dog AD heat recovery option. At this stage where costings rely on a range of assumptions the tolerance on capital costs applied is ±20%.

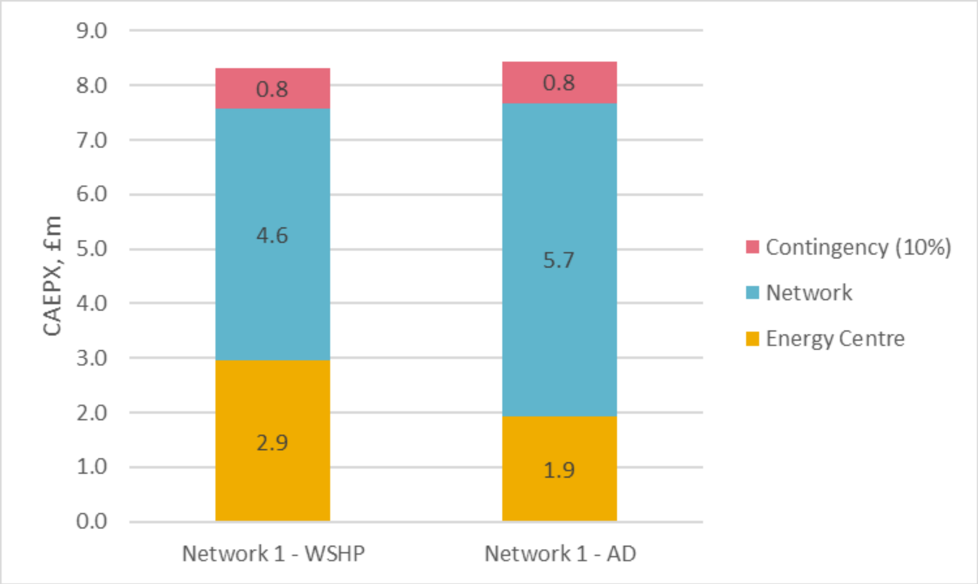

Figure 4-6 Capital cost - Network 1: Newport Harbour.

The estimated annual revenue and operating costs for the options are shown in Table 4-4, with Appendix 7 and 8 showing key operating cost and revenue assumption, including tariffs/connection fees for each consumer/consumer type.

4.5 Results of techno-economic analysis

Economic modelling has been conducted for each option and the results are presented in the figures below, with summary tables also included in Appendix 9.

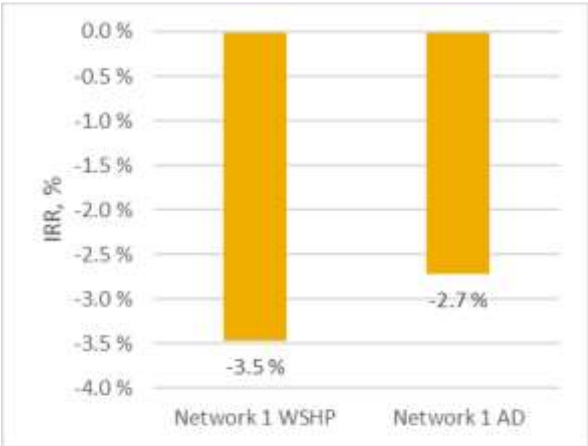

Figure 4-7. Internal Rate of Return - IRR (25 years) for Network 1 Newport Harbour

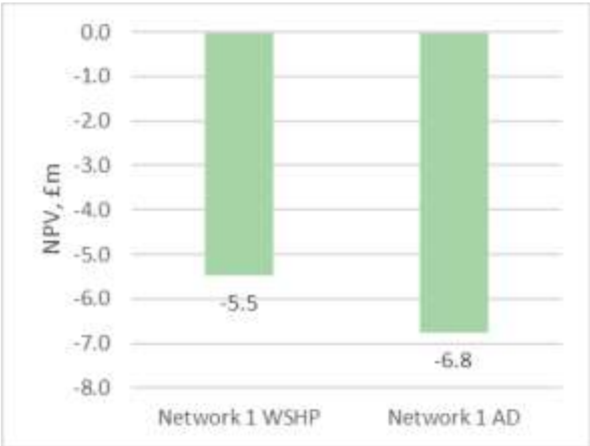

Figure 4-8. -NPV (25 years @ 3.5%) for Network 1 Newport Harbour

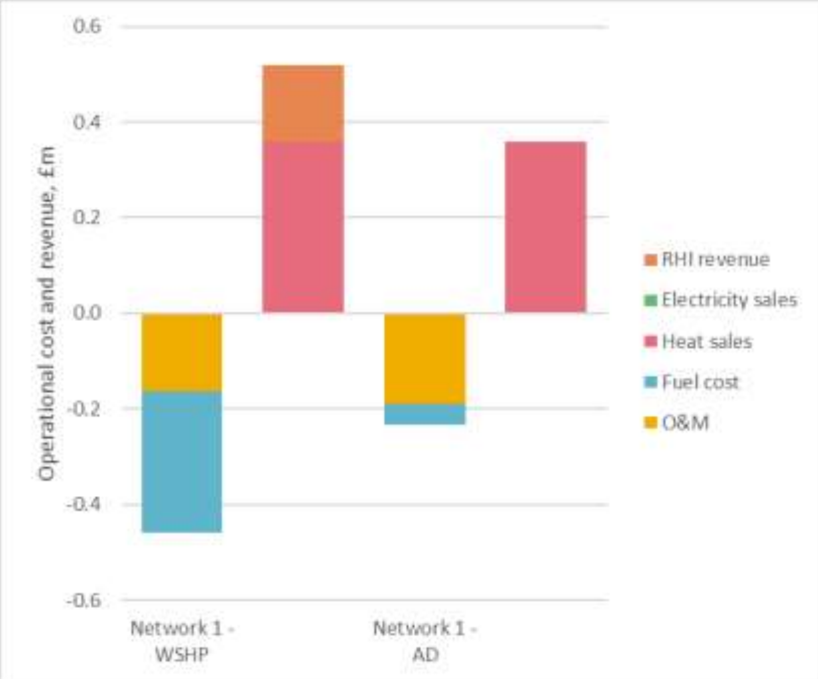

Figure 4-9. Annual operational cost and revenue - Network 1 Newport Harbour.

A summary of the key output parameters from the economic analysis presented in Table 4-4 and discounted cash flow graphs are presented in Figure 4-10.

Techno-economic analysis results			
	Unit	WSHP	Black Dog AD
Financial			
Total CAPEX (full scheme)	£m	8.3	8.7
Total REPEX (full scheme)	£m	2.3	2.0
Total OPEX (full scheme)	£m/yr.	0.5	0.2
Annual revenue (full scheme)	£m	0.5	0.4
Blended heat tariff to consumers (full scheme)[9]	£/MWh	54.1	54.1
Total connection fees	£m	0.5	0.5
NPV (25 yr @ 3.5 %)	£m	-5.5	-6.8
IRR (25 yr)	%	-3.5 %	-2.7 %
Social IRR (25 yr)[10]	%	-2.9 %	-2.2 %
Bulk heat purchase cost AD	£/MWh	-	10.7
LCOE (25 yr)	£/MWh	164.5	185.5
Minimum grant to achieve 6 % IRR	£m	5.8	7.4
Carbon			
CO_2 savings over 25 yr	$ktCO_2$/yr.	12.3	14.5
CO_2 savings over 25 yr	%	50.8 %	60.2 %
CO_2 savings per £1,000 grant	tCO_2/£1,000	2.1	2.0
Cost of CO_2 savings	£/tCO_2	1,342	1,278

Table 4-4. Techno-economic analysis results for Network 1 Newport Harbour.

[9] *Including variable and fixed heat tariff*

[10] *Social IRR accounts for impacts accrued to the heat network operator and those connected to the networks, as well as to the wider community and society as a whole. The calculation includes net impact on heating costs, carbon emissions and air quality.*

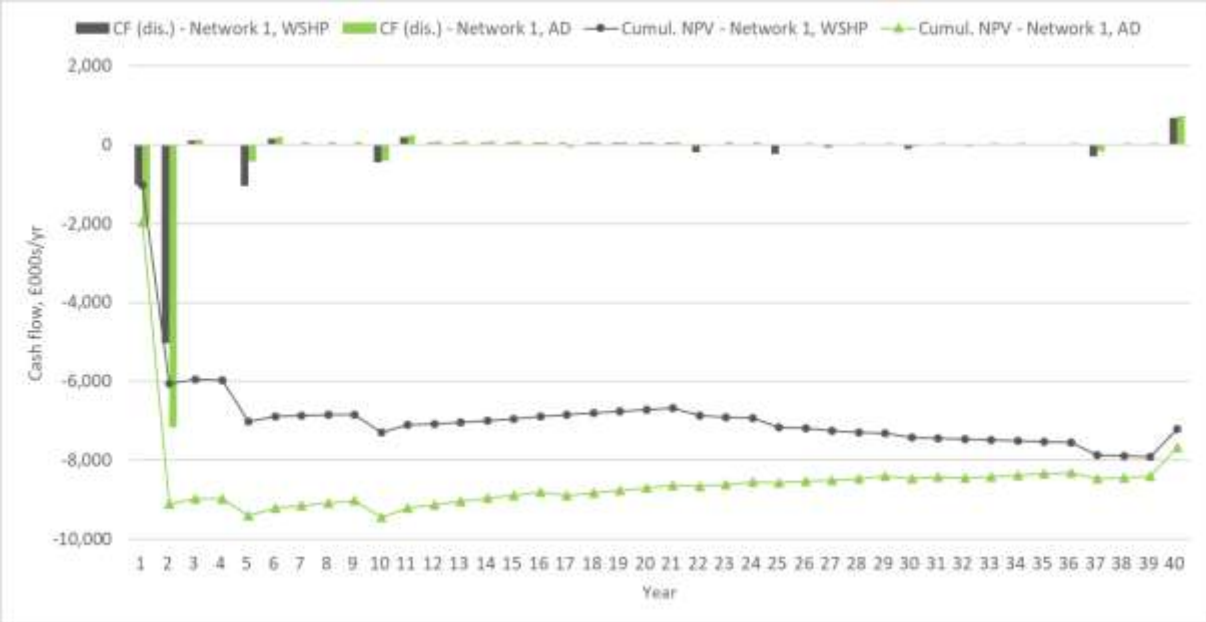

Figure 4-10. Discounted cash flow for Network 1 Newport Harbour.

Within the financial modelling, sensitivities of key parameters have been assessed to examine the strength of the economic case for each option. Parameters have only been considered independently although, in reality, individual parameters could change together and have a compound impact (positive or negative); this should be considered in any subsequent investigations. The results of the sensitivity analyses are shown in Figure 4-11 and Figure 4-12.

The figures highlight impact to IRR with the variation of a number of sensitivities showing the significance of individual issues. In particular, the loss of the RHI (WSHP option only), changes in consumer tariffs and gas prices are most significant. Capital costs and energy demand are shown to be significant.

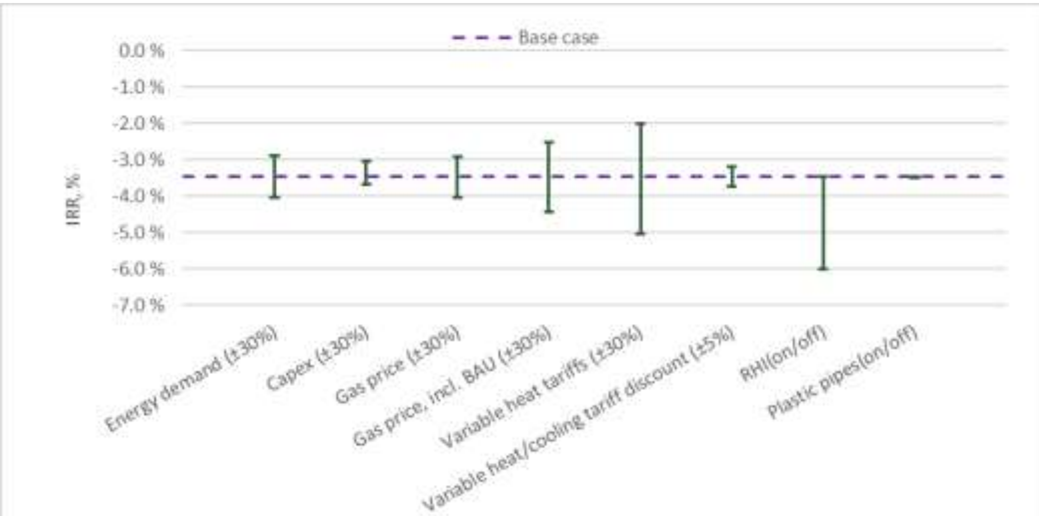

Figure 4-11. IRR sensitivities for Network 1 Newport Harbour (WSHP)[11]

[11] *"Gas price incl. BAU" considers changing the cost of gas in both the operation of the heat network and the setting on energy tariffs (which are based on counterfactual costs)*

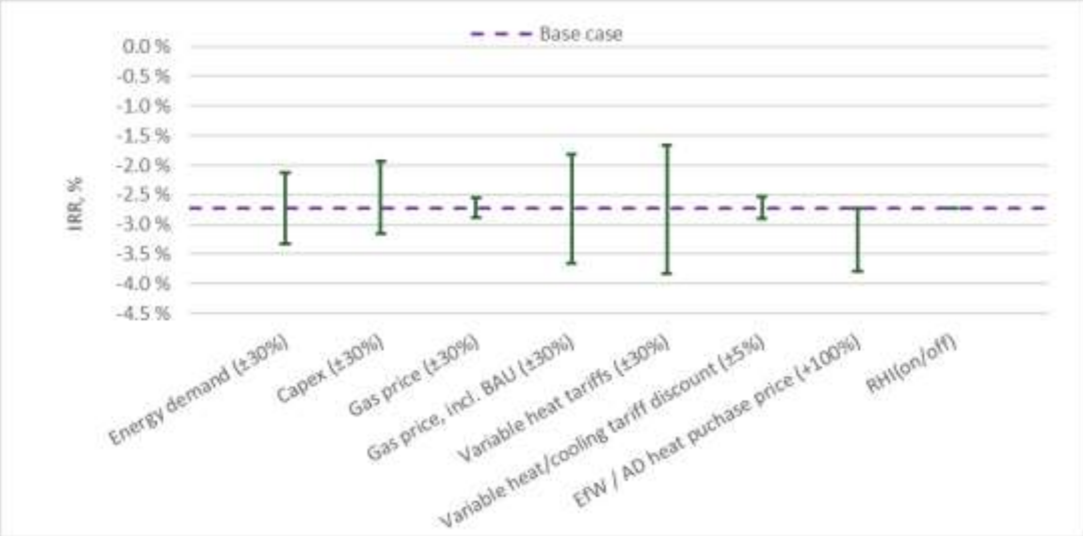

Figure 4-12. Sensitivities for Network 1 Newport Harbour (Black Dog AD plant)[11]

Table 4-5 also shows the level of the grant support (e.g. HNIP) that would be required to achieve specific rates of return. A 3-7% rate of return is assumed to be required for a wholly public funded project and above 10-12% is assumed to be required for a wholly privately funded project.

		1 WSHP	1 Black Dog AD
IRR 5.0 %	£m	5.7	7.2
	% capex	68.4 %	66.3 %
IRR 7.0 %	£m	5.8	7.5
	% capex	69.7 %	69.1 %
IRR 10.0 %	£m	5.7	7.6
	% capex	69.0 %	70.0 %

Table 4-5. Gap funding required to reach investment thresholds (IRR-25 year).

4.6 Techno-economic conclusions

The analysis shows very poor economic performance for both technology options, with negative rates of return estimated. The heat recovery option performs better, despite involving a longer connection to reach the main heat network and consumers. This difference is due to the lower capital costs associated with the heat recovery plant and also lower operating costs, which will be influenced by the assumed price paid to Black Dog as the operator of the AD plant, which would be negotiable. In contrast, operating costs for the WSHP options will largely be dictated by the costs of electricity to run the main heat pump and ancillary plant.

The sensitivity analysis shows that none of the individual parameters assessed move either network option above a negative IRR, reinforcing the evidence of a poor economic case.

There are likely to be opportunities to improve economic performance of these options which are discussed below but it is clear that the relative low energy demand density (based on the 2017 masterplan) of the Newport Harbour development (and associated existing properties) combines with the fact that the networks are quite distributed (not least because of the River Medina). This ensures that costs (capital and operating) are high compared to the available energy related revenues.

As the table shows both options are shown to require more than 68% gap funding to achieve even an IRR of 5%. Since this is highly likely to exceed the threshold for 'state aid' it is concluded that these options are not economically deliverable.

4.6.1 Heat Network benefits

As discussed in section 3.4.4 there are a range of economic and environmental benefits that are estimated to be derived for these heat network options, assuming they were developed. In summary they are:

1. A general 5% reduction in consumer energy costs (the basis for revenue modelling) and mitigation of future energy cost increases
2. Operational benefits including reduced plant liability and releasing property floor space
3. Reduction in short term carbon emissions of between 51% and 60% for connected consumers – (depending on supply technology)
4. Potential to deliver sustained carbon reduction through expansion and switch to lower carbon technologies
5. Inward investment into the town of between £8m to £11m, depending on option
6. Development of a local energy generation / supply entity
7. Encourage commercial/residential tenant retention in the town

4.6.2 Project risks

As discussed in section 3.4.5 there are a range of project risks that will need to be addressed. An initial risk register has been developed (see Appendix 11), which collates the risks all of heat network options, showing generic risks (applicable to all options) and a number of specific risks associated to individual heat networks. For Newport Harbour, the key risks include:

1. Improving techno-economic performance: this is the biggest risk for this scheme because of the poor performance that has been shown. Economic performance cannot be sufficiently improved through grant support due to state-aid funding restrictions, which means that the only possible solution would be to make major changes to the heat network design concept. Potential adjustments are discussed in section 4.6.3.
2. Securing consumers: this risk is minimised because the council are leading the new development scheme and can set development objectives and also can presumably bring their own properties into a heat network
3. Development Governance: it is anticipated that the council would need to lead development and so the primary risk resides around their ability to bring forward the resources and capability to implement.
4. Potential network construction and servicing risks: the primary specific risk here is the need to cross the River Medina; a solution would need to be resolved early in the development process, whilst firming up the network routing generally.
5. Renewable Heat Incentive revenues: RHI is due to close in quarter 1, 2021 (with no extension/replacement currently planned). In any case, where a project relies on the RHI income this will expire after year 20, which is the standard contract term applicable. As shown in the sensitivity analyses, having no-RHI would remove any case for investment into the WSHP option. To address both issues, if this network option is further pursued then these risks should be further examined.

4.6.3 Techno-economic Improvement opportunities

The concept design for these networks has been developed to address both the needs of a stand-alone network but also the extension to other parts of Newport. As subsequent sections show, a larger network is likely to have a strong case for development, and will rely, in part, on including the majority of consumers identified, including those in the Newport Harbour network.

On a stand-alone basis it could be case that the Newport Harbour networks may better suit a low temperature arrangement. This would require the new development buildings to be designed to operate at lower than normal temperatures, requiring the inclusion of large heat emitters, such as underfloor heating. This will also create some challenge to connecting existing properties, i.e. as Medina Leisure Centre, Medina school and council properties, which will operate at typical temperatures. To connect these to a low temperature network would either require internal energy service adaptations and/or localised heat upgrade plant at individual properties.

In addition, there are a number of changes that could deliver economic improvements (with or without the switch to a lower temperature network):

1. Inclusion of CHP to the WSHP option (reducing power costs). The scale of Network 1 may not support this solution but if it could, it may make a material improvement on rates of return, but would also add complexity.
2. Implementation of the heat pump using water abstracted and discharged from/into the R. Medina. This was not considered because of the lack of flow/temperature data and a lack of understanding of how tides would impact the availability of water for the river. However, if reliable access to water or sufficient flow could be determined and it was possible to develop low cost solution to water abstraction / discharge, noting ecological sensitivities and the need to establish licencing for both with the Environment Agency. This solution is anticipated to reduce capital costs overall, because the supply point is in close proximity to the consumer and so avoids the connecting heat pipe infrastructure to either the Black Dog or Fairlee WTW.
3. Account for changes in the new Newport Harbour masterplan (the 2017 version being used in the study) when it is completed; greater energy demand density, greater energy consumption or variation in demand profiles (e.g. as a consequence of changing the property types) could improve economic performance.

4.7 Development recommendations

Network 1 focuses on the Newport Harbour development and nearby existing consumers. At this early stage of investigation, the network as conceived, appears to be deliverable (with few significant risks) but not capable of achieving reasonable commercial performance. If delivered it would provide benefits to consumers and to the town in terms of economic development and providing a solution to long term decarbonisation of heat consumption.

Several improvement opportunities exist, including exploring a hybrid WSHP/CHP supply strategy, considering a low temperature system, and, accounting positive variation (from an energy perspective) to the Newport Harbour development masterplan. Without additional improvement, grant support cannot be used to deliver make it deliverable as it is likely to break state-aid rules.

There are numerous uncertainties and project development risks that will need to be further considered in any subsequent investigation. The following risk are considered most important:

1. Improving techno-economic performance: see discussion above.
2. Securing consumers, e.g. Newport Harbour and existing consumer (seen as a limited risk as the council are leading the new development and should able to bring their own properties into a heat network).
3. Development Governance: requires the council to develop is capacity and capabilities to lead the implementation process.
4. Network routing: the primary specific risk here is crossing R. Medina; a solution would need to be resolved early in the development process.

5. Renewable Heat Incentive revenues: address the possibility of zero RHI revenue, i.e. drop the WSHP option and end of revenue after 20 years, i.e. adjusting operating strategy, focusing of running the WSHP plant only at periods of low power costs

Key development recommendations for these options are as follows, assuming that key stakeholders agree to continue to development and commit the necessary resources (could be part funded by BEIS):

- Critically examine the council's objectives to delivering a heat network solution here, independent of a wider heat network development. Where this is seen as a critical, and there are no other localised solutions that meet the council objectives, then it will be necessary to critically re-examine design options.

Assuming this identifies a viable option then the council would need to implement the following development tasks:

- Establish development management process. The nature of the project would require the council to take the lead on development. It is anticipated that the council would need be the commissioning/procurement agency with a role in securing the finance, either through raising debt (such as PWLB) or negotiating private investment.
- The council would need to establish internal governance and project management arrangements and implement the implementation plan that will come from this.
- The council should initiate the approval process to move the opportunity on to a formal project development status.
- The council would need to commission/implement a number of critical tasks (using internal and external resources), including:
  - further engagement with stakeholders (fairly limited in scope);
  - further develop heat network design to address techno-economic improvement opportunities and mitigate key risks;
  - review alternative design options that may add value, e.g. low temperature heat network design, exploration of the River Medina as the feed source for a WSHP solution; and;
  - establish ownership, procurement and funding strategies

General development recommendations (across all network options) are also discussed in section 8.

5 Network 2: hospital and prison

5.1 Summary of heat network options

A list of consumers is shown in Table 5-1 with further details shown in Appendix 2. Further investigation in any follow up work will be required to confirm demand estimates, particularly with respect to the hospital to better understand how a heat network would integrate the existing campus in which most buildings are not currently interconnected (from a heat supply perspective).

The principal consumers in this network, the prison and hospital have indicated commercial and organisational drivers to connect to a heat and power network solution, subject to this reducing costs and maintaining/improving energy supply resilience.

Site	Phase	Type	Peak heat (MW)	Heat Load (MWh)	Data Source[12]
St Mary's Hospital - Main Hospital	1	Hospital	4.67	11,354	Metering (NHS)
HMP Parkhurst	1	Prison	2.80	7,074	Metering (MoJ)
HMP Albany	1	Prison	2.17	5,488	Metering (MoJ)
Isle of Wight College	1	Education	1.04	1,526	Metering (IoW College)
TOTAL (ALL)			**10.69**	**25,443**	

Table 5-1. Network 2 (Hospital and HMP IoW) consumers.

Four supply scenarios options are examined for Network 2:

- Isle of Wight Waste Recovery Park (EfW)
- Gas CHP
- Gas CHP & EfW
- Gas CHP & Black Dog AD Plant

These have been explored to consider the relative benefits of the existing available low carbon heat supply technologies and to consider the relative benefit of including power generation, through gas CHP.

Based on review of potential consumers and spatial constraints, a provisional heat network route and energy centre location where developed/identified as shown in Figure 4-1. Supply strategies and energy centre locations are further described in detail in section 5.3.

As with Network 1, the heat network route is designed to take advantage of soft-dig land where possible and avoid main roads (highlighted in purple on the network map). The main distribution network would be installed adjacent to Medina Way to avoid traffic impacts and to utilise land where 'soft-dig' would be possible. Some road crossings would be required, and it will be important to carefully design these to limit the impact during construction and servicing. Connections to the two supply locations at Isle of Wight Waste Recovery Park and Black Dog AD plant also take advantage of the land available for 'soft dig' adjacent to Forest Road (IoW WRP) and along Stag Lane (Black Dog AD).

[12] *BEES and NEED refers to benchmarking used*

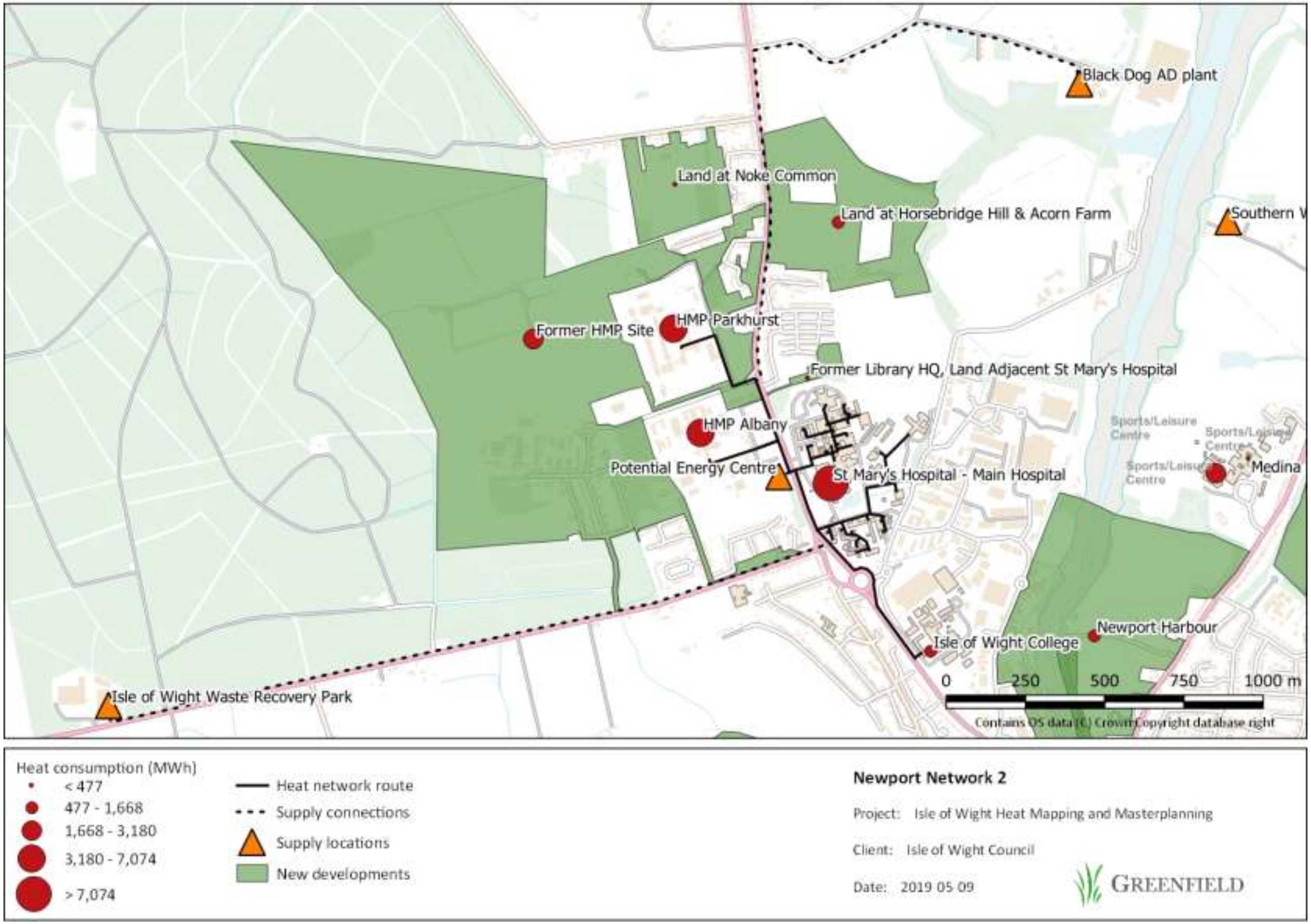

Figure 5-1. Network 2 (Hospital and HMP IoW) - heat network and connections.

Key parameters of the heat network options are presented in Table 5-2.

Heat demand and network details					
	Unit	EfW	CHP	CHP & EfW	CHP & AD
Demand					
Heat demand	GWh/yr	25.4	25.4	25.4	25.4
Peak demand	MW	10.7	10.7	10.7	10.7
Number of connections					
Non-residential	No.	4	4	4	4
Residential (dwellings)	No.	0	0	0	0
Total	No.	4	4	4	4
Network					
Network trench length	km	6.0	3.6	6.0	5.8
Linear heat density	GWh/yr/km	4.2	7.1	4.2	4.4
Main pipe size	DN	300	300	300	300
Heat losses	%	10 %	10 %	10 %	10 %
Design temperatures[13]					
Flow	°C	90	90	90	90
Return	°C	45-55	45-55	45-55	45-55
Soft dig	%	62 %	38 %	62 %	52 %
Hard dig	%	38 %	52 %	32 %	42 %
Overground	%	6 %	10 %	6 %	6 %

Table 5-2. Network 2 (Hospital and HMP IoW) - heat demand and network details.

5.2 Phasing

Network 2 focuses around the most significant consumers in the area: the hospital and HMP IoW. The Hospital is probably the most critical consumer with the need to replace existing CHP plant, and, therefore, the most likely initiation point. Regarding the HMP IoW campus it is anticipated that an early connection would be required to seek to mitigate rising energy costs. On this basis it is assumed all consumers are connected from the first year of construction, with no known timeline constraints for any of the supply technologies considered. Annual heat demand growth through the build-out period is shown in Figure 5-2.

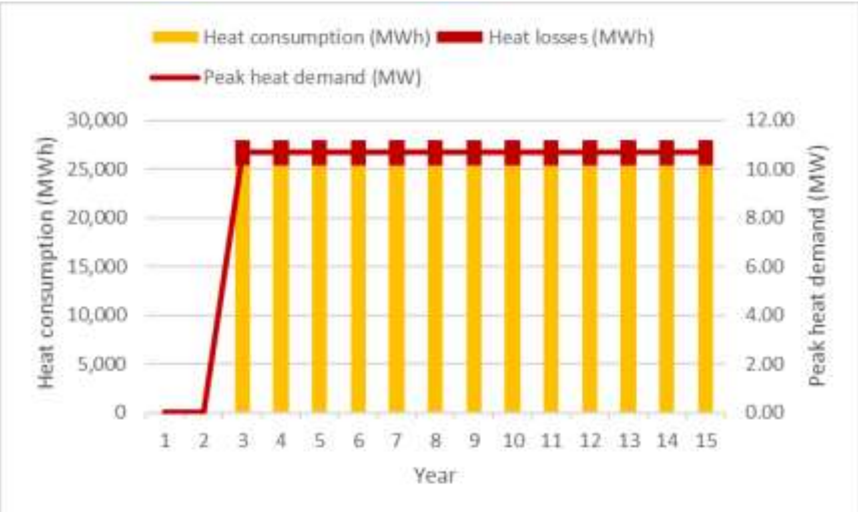

Figure 5-2. Annual heat demand increase – Network 2.

[13] *See Appendix 4 for further detail*

5.3 Energy supply concept design & plant sizing

The following baseload production options were reviewed for the Hospital and HMP IoW zone heat network:

- Isle of Wight Waste Recovery Park (EfW) heat recovery
- Gas CHP
- Gas CHP + Isle of Wight Waste Recovery Park (EfW) heat recovery
- Gas CHP + Black Dog AD plant heat recovery

Energy centre locations:

- Isle of Wight Waste Recovery Park (EfW): connection to EfW heat at the Waste Recovery Park site with a primary energy centre (with gas boilers and ancillary plant) on MoJ land opposite the Hospital site, as shown in Figure 5-1. This would save significant network investment compared to the alternative of the primary energy centre being located at the EfW site since the full capacity of energy would not be required to be distributed from the EfW site (over a distance of approx. 2 km).
- Gas CHP: primary energy centre to be located as shown in Figure 5-1.
- Gas CHP + Isle of Wight Waste Recovery Park (EfW): CHP would be located in the energy centre located as shown in Figure 5-1.
- Gas CHP + Black Dog AD plant: connection to AD plant for bulk heat supply with a primary energy centre as shown in Figure 5-1.

Plant capacity modelling for the options was conducted to determine the economically optimal plant sizing against hourly demand profiles. The following principles/assumptions with key commercial assumptions shown in Appendix 7 were used in the analysis:

- Gas CHP:
  - Gas CHP is modelled to produce heat and electricity with a power to heat ratio of 0.93 and efficiency of 83%, i.e. it produces 1 MWh of heat and 0.93 MWh of electricity while consuming 2.33 MWh of fuel.
  - Power produced is distributed (by Private Wire) to St Mary's Hospital, the prisons and to the Isle of Wight College. Excess electricity is assumed to be exported to the regional power network.
  - The availability of CHP units is 8,592 hours per annum (accounting for annual shut-down and maintenance for one-week period during summer). Maintenance of the units is sequential (multiple units are proposed).
- Isle of Wight Waste Recovery Park (EfW):
  - According to the Waste Recovery Park's planning documents which were received for background information, there is 2,500 kW heat available for heat recovery and purchase at the facility.
  - The availability of heat supply from the EfW facility is 7800 hours per annum. Time of non-availability is not known, therefore it is modelled that constant 8760 hours per annual supply of 2,226 kW is available, which amounts to same annual energy available in MWh as 2,500 kW for 7800 h/a.
  - Cost of EfW facility heat is assumed constant (at £3.15/MWh) with no time-of-day variance.
- Black Dog AD plant heat purchase: as per notes for Network 1
- Gas boilers are dimensioned for back-up and reserve capacity with thermal storage included.

- Plant sizes have been explored through hourly modelling of supply strategies accounting for equipment life cycle costs accounting for variable costs and revenues (heat, power, RHI).

For the purposes of economic modelling, targeted sizing of the baseload systems was set above the thresholds set by the EU Energy Efficiency Directive (EED) definition of an efficient heat network, which is a requirement for Heat Network Investment Project (HNIP) funding. For EfW and other waste heat installations, the threshold is set at 50% of annual heat supply and for Gas CHP the threshold is set at 75% of annual heat supply.

Option 1: Heat recovery from the IoW Waste Recovery Park (EfW) facility.

The EfW facility is located some distance away from the heat network, which increases investment costs of the network connection. The modelling showed that if EfW facility's heat supply is connected it is recommended that the total 2,500 kW supply capacity available is connected as the heat recovery equipment cost is small in comparison to the assumed heat purchase price (range). Figure 5-3 shows the modelled load-duration curve for a fully built out Network 2.

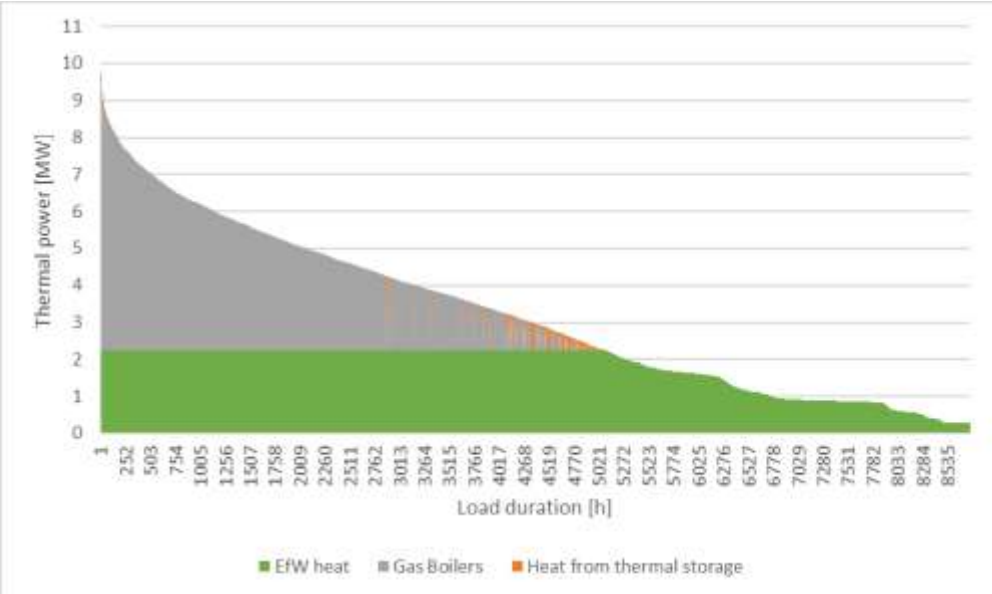

Figure 5-3 Modelled load-duration curve – full Network 2 (EfW)

Option 2: Gas CHP

The minimum CHP capacity requirement for Network 2 based on the abovementioned EED threshold is approximately 3,500 kW. However, this is far above the actual cost-optimal CHP capacity according to the simulations and results in significant amounts of electricity export to the national electricity grid (43% of total electricity produced by the CHP units). The cost-optimal Gas CHP capacity according to simulations is 1,800 kW thermal power with a 100 m^3 thermal storage, as shown in Figure 5-4, and this was selected for base-case modelling.

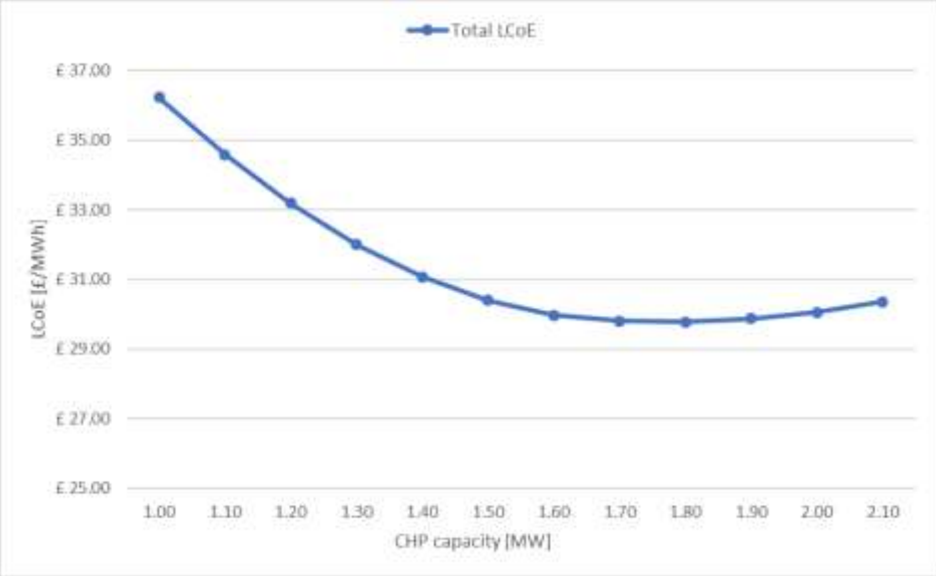

Figure 5-4 Gas CHP capacity optimisation results for Network 2.

Figure 5-5 shows the modelled load-duration curve for a fully built-out network. Thermal storage is mostly utilised during periods of lower demand.

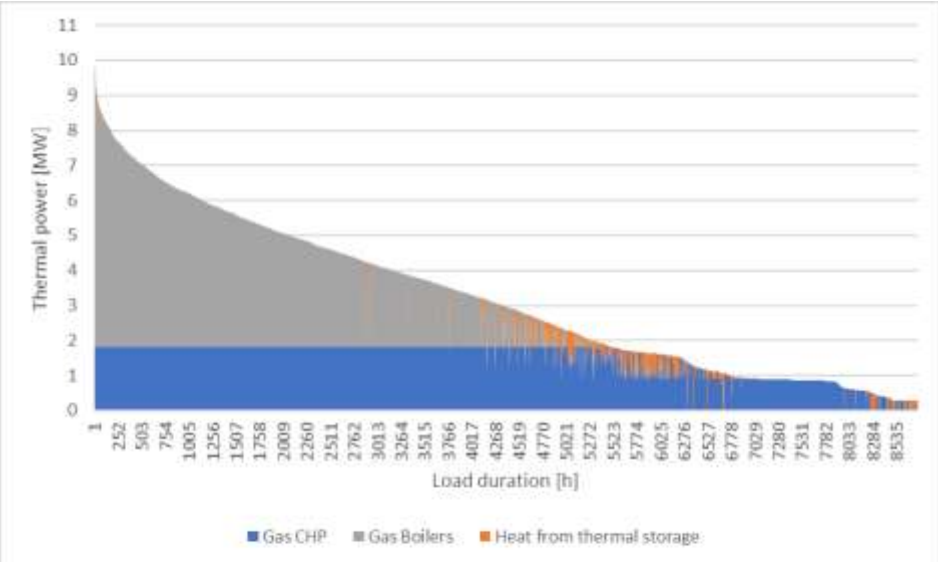

Figure 5-5 Modelled load-duration curve – full Network 2 (Gas CHP).

Option 3: Hybrid - Gas CHP and recovered heat from the EfW facility.

The cost-optimal CHP capacity for the combined supply option is 1,800 kW. As stated per other options the total available 2,500 kW capacity is assumed to be connected. Figure 5-6 shows the modelled load-duration curve for the fully built-out network. As with the CHP case, thermal storage is mostly utilised during periods of lower demand; during periods of high heat demand the CHP units already supply the network at full capacity; CHP is cheapest to operate when Private Wire power consumption is available, thus it has priority over EfW heat most of the time.

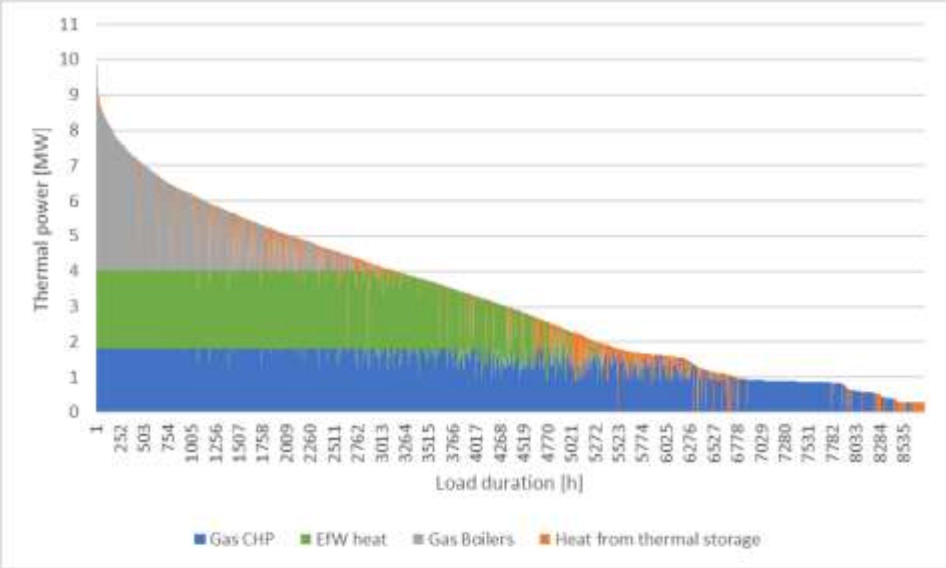

Figure 5-6 Modelled load-duration curve – full Network 2 (Gas CHP and EfW)

Option 4: Hybrid - Gas CHP and heat recovery from the Black Dog AD plant.

The cost-optimal CHP capacity for the combined supply option is 1,800 kW. Like the EfW facility, the AD plant is also located some distance away from the heat network, which increases investment costs of the network connection. The modelling showed that if the AD plant's heat supply is connected, it is recommended that full available 1,150 kW supply capacity is installed as heat recovery equipment cost is small in comparison the estimated heat purchase price.

Figure 5-7 shows the modelled load-duration curve with 1,800 kW Gas CHP and 1,150 kW AD heat recovery baseload production plus 200 m^3 thermal storage. As with the CHP case, thermal storage is mostly utilised during periods of lower demand with the CHP and AD plant being suited to meeting peak loads until the peak gas boiler are required. Gas CHP is estimated to provide the cheapest heat and is therefore given priority over AD heat recovery most of the time.

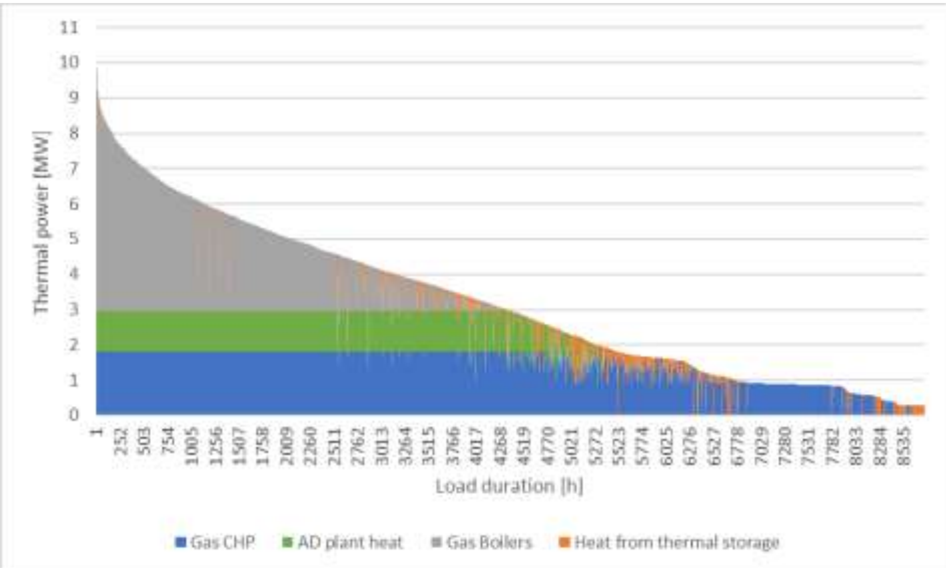

Figure 5-7 Modelled load-duration curve – full Network 2 (Gas CHP and AD plant)

A summary of the energy modelling results for Network 2 supply options is shown in Table 5-3.

Heat and electricity production					
	Unit	EfW	Gas CHP	Gas CHP + EFW	Gas CHP + AD plant
Supply capacity					
Gas CHP	kW	-	1,800	1,800	1,800
Heat purchase (EfW)	kW	2,500	-	2,500	-
Heat purchase (AD plant)	kW	-	-	-	1,150
Gas Boiler	kW	11,000	11,700	9,200	10,550
Thermal Storage	m^3	100	100	200	200
Heat production share					
Heat production	GWh/yr	28.3	28.3	28.3	28.3
Gas CHP	%	-	47.4 %	45.4 %	46.8 %
Heat purchase (EfW)	%	55.4 %	-	37.2 %	-
Heat purchase (AD plant)	%	-	-	-	21.0 %
Gas Boiler	%	44.6 %	52.6 %	17.3 %	32.2 %
CHP electricity					
CHP electricity production	GWh/yr	-	12.5	11.9	12.3
Consumed by EC site	%	-	2.3 %	2.3 %	2.3 %
To Private wire network	%	-	85.6 %	90.5 %	87.9 %
To grid	%	-	12.1 %	7.2 %	9.8 %

Table 5-3. Network 2 heat and electricity production.

Indicative Energy Centre arrangement drawings are shown in Appendix 5 for the options considered.

5.4 Capital costs, operating costs and revenue

A summary breakdown of capital costs is shown in Figure 5-8 with a more detailed breakdown shown in Appendix 6. In total the costs are estimated at £13m for the EfW option, £15m for the CHP option, £18m for the combined CHP and EfW option and £18m for the hybrid CHP/AD heat recovery plant option. At this stage where costings rely on a range of assumptions the tolerance on capital costs applied is ±20%.

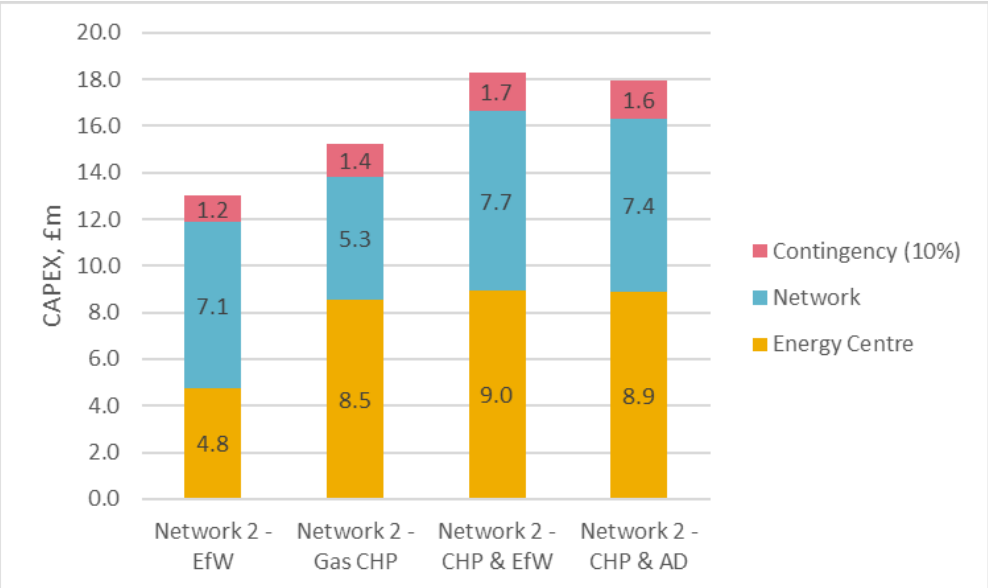

Figure 5-8 Capital cost for Network 2.

The estimated annual revenue and operating costs for the options are shown in Table 5-4, with Appendix 7 and 8 showing key operating cost and revenue assumption, including tariffs/connection fees for each consumer/consumer type.

5.5 Results of Techno-Economic Analysis

Economic modelling has been conducted for each heat network option. Results are presented in the figures below, with summary tables in Appendix 9.

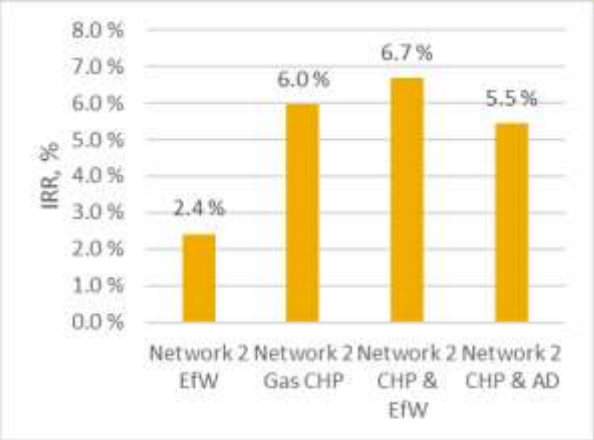

Figure 5-9. Internal rate or return - IRR (25 years) for Network 2.

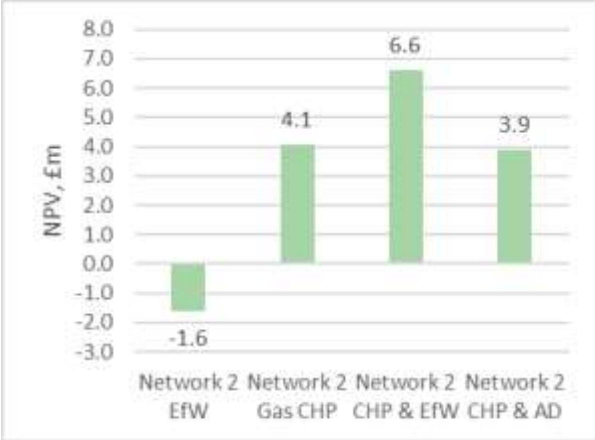

Figure 5-10. Net present value - NPV (25 years @ 3.5%) for Network 2.

Figure 5-11. Annual operational cost and revenue - Network 2.

A summary of the key economic assessment parameters is presented in Table 5-4 and discounted cash flow graphs are shown in Figure 5-12.

Techno-economic analysis results					
	Unit	EfW	Gas CHP	Gas CHP & EfW	Gas CHP & AD
Financial					
Total CAPEX (full scheme)	£m	13.1	15.2	18.3	17.9
Total REPEX (full scheme)	£m	4.8	8.5	9.3	8.9
Total OPEX (full scheme)	£m/yr.	0.9	2.0	1.6	1.8
Annual revenue (full scheme)	£m	1.4	3.1	3.1	3.1
Heat tariff to consumers (full scheme)[14]	£/MWh	36.1	36.1	36.1	36.1
Total connection fees	£m	0.9	0.9	0.9	0.9
NPV (25 yr @ 3.5 %)	£m	-1.6	4.1	6.6	3.9
IRR (25 yr)	%	2.4 %	6.0 %	6.7 %	5.5 %
Social IRR (25 yr)[15]	%	3.8 %	5.6 %	7.2 %	5.8 %
Bulk heat purchase cost AD EfW	 £/MWh £/MWh	 - 3.2	 - -	 - 3.2	 10.7 -
LCOE (25 yr)	£/MWh	58.3	42.9	36.1	43.5
Minimum grant to achieve 6 % IRR	£m	4.1	0.0	0.0	0.8
Carbon					
CO_2 savings over 25 yr	ktCO_2/yr.	39.1	34.2	64.9	56.9

CO_2 savings over 25 yr	%	27.7 %	20.0 %	37.9 %	33.2 %
CO_2 savings per £1,000 grant	tCO_2/£1,000	9.4	715.4	0.0	67.6
Cost of CO_2 savings	£/tCO_2	873	735	326	447

Table 5-4. Techno-economic analysis results for Network 2.

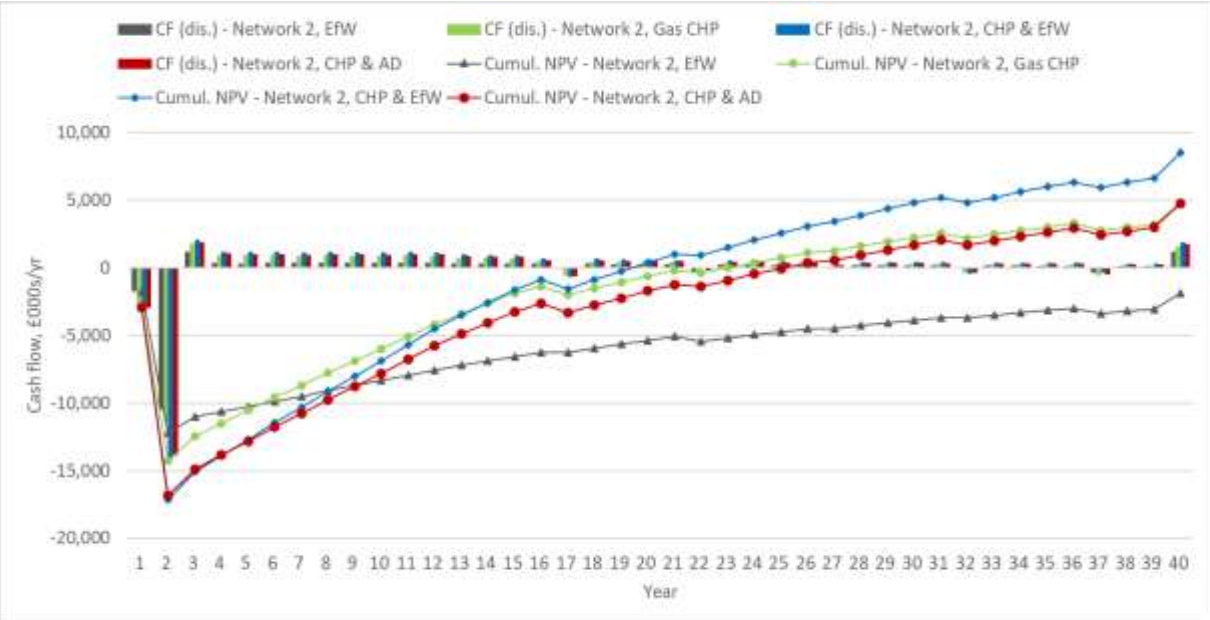

Figure 5-12. Discounted cash flow for Network 2.

After completion of the analysis a variant to Network 2 (EfW only) was briefly examined where it was assumed that along with heat, power was also purchased from the EfW facility and sold to large consumers (hospital, prisons and IoW College). The power purchase cost from the EfW facility was assumed to be equivalent to a 'wholesale' power price (accounting for time of day variation) and the consumer purchase price was a retail equivalent (as per the assumptions used in assessment of CHP private wire options). It is estimated that this would incur a further £1.4m investment but would increase annual cash flow from £555k to £1,544k and result in a 25-year IRR of 9.1%[16], making it

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[14] *Including variable and fixed heat tariff*

[15] *Social IRR accounts for impacts accrued to the heat network operator and those connected to the networks, as well as to the wider community and society as a whole. The calculation includes net impact on heating costs, carbon emissions and air quality.*

[16] *See Appendix 7 & 8 for full assumptions.*

potentially the best performing solution. This clearly suggests a significant improvement in the case for investment for this option. Future work should refine this analysis, in liaison with Amey.

Within the financial modelling, sensitivities of a number of general parameters have been assessed to examine the strength of the economic case for each option. Parameters have only been considered independently although, in reality, individual parameters could change together and have a compound impact (positive or negative); this should be considered in any subsequent investigations. The results of the sensitivity analyses are shown in Figure 5-13, Figure 5-14, Figure 5-15 and Figure 5-16.

The figures highlight the impact on IRR (25-year) of variation of a number of sensitivities showing the significance of individual issues. The impact of sensitivities, as would be expected, varies between the options, making it complex to succinctly interpret the results, however, it is clear that the following appear most significant according to the analysis:

- Variable component of the heat tariff, particularly for the EfW (alone) options
- Change in gas prices, although this, in practice is likely to be mitigated by the fact that increasing gas prices will also reasonably allow adjustment in heat tariff and lessen the impact
- Capital cost change has a significant impact, particularly on those options with CHP. Cost reductions also appear to have a more significant (positive) impact than cost increases (negative)
- Energy demand: increase in (e.g. new consumers) has similar scale of impact to loss of demand, e.g. revising consumption estimates downwards from the current assessment or loss of consumers
- Change in the EfW bulk heat price – although the impact is muted in in the CHP/EfW supply combination options. The analysis has used a low value of -£4.43/MWh (based on a scenario with RHI and a high z-factor (of 10)) to £12.03/MWh (based on no-RHI and a low z-factor (just over 4)).

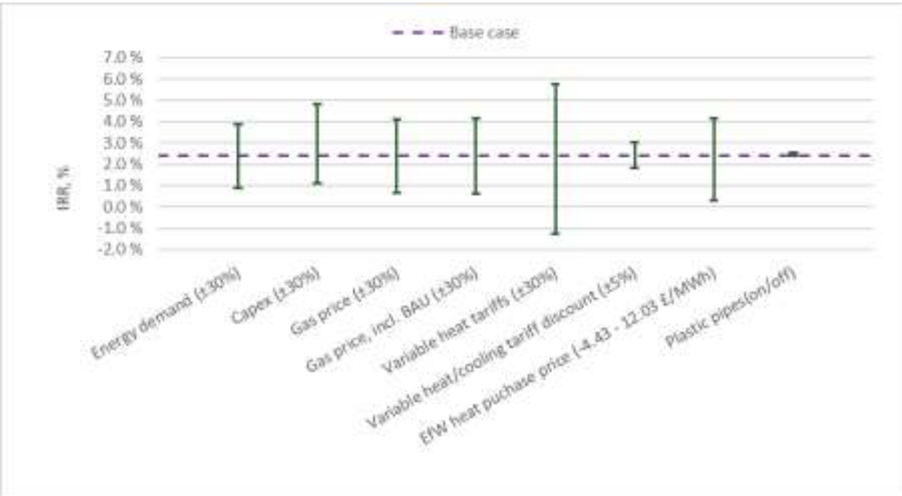

Figure 5-13. IRR sensitivities - Network 2 (EfW) [17]

[17] *"Gas price incl. BAU" considers changing the cost of gas in both the operation of the heat network and the setting on energy tariffs (which are based on counterfactual costs)*

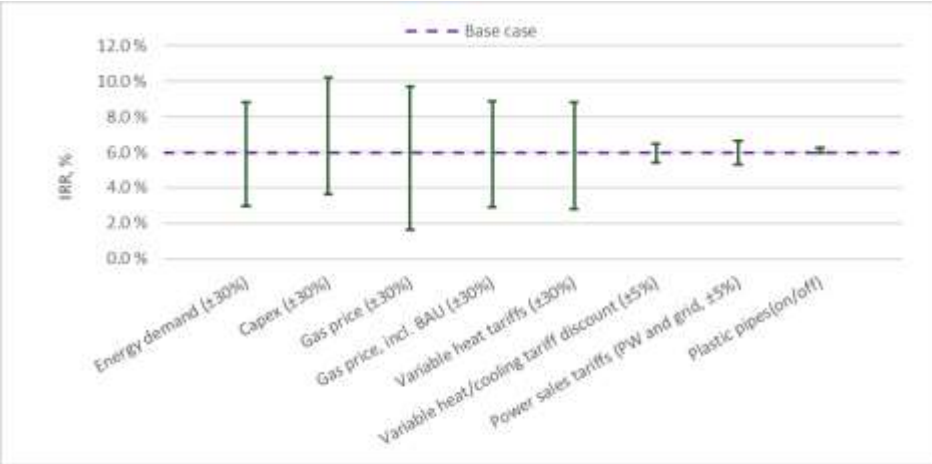

Figure 5-14. IRR sensitivities for Network 2 (Gas CHP)[17]

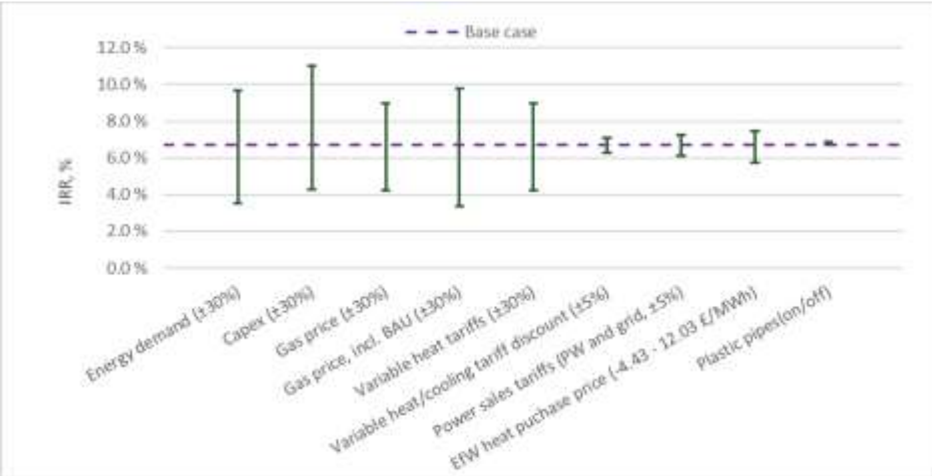

Figure 5-15. IRR sensitivities for Network 2 (Gas CHP & EfW)[17]

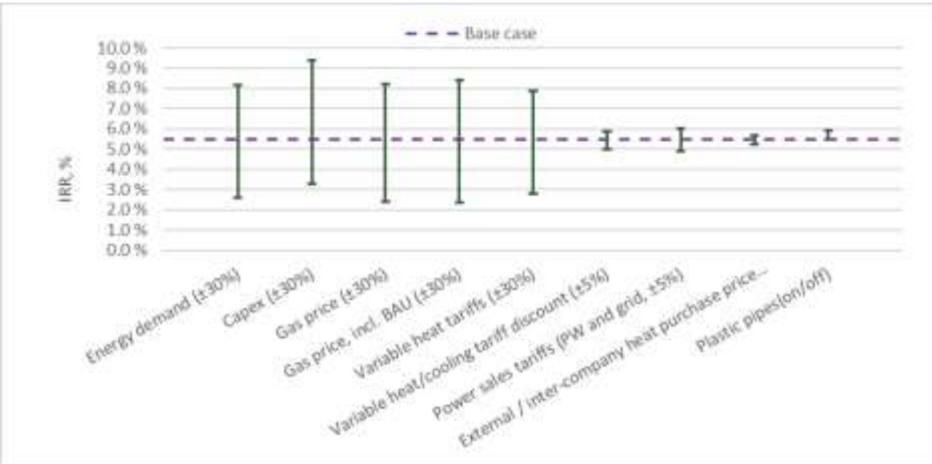

Figure 5-16. IRR sensitivities for Network 2 (Gas CHP & AD)[17]

In addition, Table 5-5 shows the level of the grant support (e.g. HNIP) that would be required to achieve specific rates of return. A 3-7 % rate of return is assumed to be required for a wholly public funded project and above 10-12% is assumed to be required for a wholly privately funded project. It should be noted that the CHP solution (sized to achieve the optimal-economic performance) is estimated to deliver less than the 75% of heat supply required to meet the HNIP criteria for funding. Hence, this option would not be able to secure HNIP funding unless the Gas CHP option is combined with a low-carbon production technology or heat recovery, which would reduce the threshold to 50%.

		2 EfW	2 CHP	2 CHP & EfW	2 CHP & AD
IRR 5.0 %	£m	3.3	NR	NR	NR
	% capex	25.3 %	NR	NR	NR
IRR 7.0 %	£m	4.8	1.2	0.5	2.2
	% capex	36.9 %	8.0 %	2.5 %	12.1 %
IRR 10.0 %	£m	6.1	3.7	3.7	4.9
	% capex	46.8 %	24.1 %	20.4 %	27.4 %

Table 5-5. Gap funding required to reach IRR investment thresholds[18].

5.6 Techno-economic conclusions

The techno-economic analysis shows strong economic performance for all three options involving CHP with IRR (25 year) sitting between 5.5% and 6.7%. This would suggest they would support a case of public investment. As the grant funding calculation shows only between 4% and 27% of the estimated capital costs would need to be sought from HNIP (or equivalent) to make any of the options achieve between 7% and 10% IRR, which moves them towards being commercially fund-able.

It is clear that the economic case for a heat network is largely driven by the heat demand density and the demand for power that could be supplied to consumer, both of which are not present in Network 1, for example.

There is marginal difference between the three CHP options (CHP-only plus the two hybrids). However, there is an appreciable difference in carbon performance with CHP fairing worst (20% reduction over 25 years, with this likely to worsen over time as the UK power grid continues to decarbonise, reducing counterfactual carbon emissions. Based on the worse carbon performance, the fact that the CHP-only option would not comply with HNIP requirements (restricting grant) and the fact that other credible options exist, it is recommend that CHP-only is not taken forward a suitable solution.

It is recommended that the three other options are considered. The AD and EFW supply points appear credible, (although greater detail on the EfW option needs to be ascertained to improve certainty) and combining with CHP provides good economic results. The third option of EfW alone should only be considered in detail where it is (a) identified as possible to also sell power from the EfW plant direct to consumers (by Private Wire), and, (b) the assumptions used in the modelling prove to be similar to what could be achieved, e.g. through further dialogue with Amey. It should be noted that the sensitivity analysis for EfW does indicate variability of rates of return based on the price of heat which will be influenced by the eligibility of RHI payments, biogenic fraction of waste streams and the final z-factor of the heat extract point used.

In general, the sensitivity analysis shows that project IRR can be significantly affected by a number of key parameters, which is not untypical of heat network project. This will require close attention to the design and analysis of the options assuming follow-on development/feasibility work is implemented.

5.6.1 Heat Network benefits

As discussed in section 3.4.4 there are a range of economic and environmental benefits that are estimated to be derived for these heat network options. In summary they are:

1. A general 5% reduction in consumer energy costs (the basis for revenue modelling) and mitigation of future energy cost increases
2. Operational benefits including reduced plant liability and releasing property floor space

[18] *NR – not required*

3. Reduction in short term carbon emissions (between 20% (CHP-only) and 38% (CHP+EfW) for connected properties - depending on supply technology)
4. Potential to deliver sustained carbon reduction through expansion and switching to lower carbon technologies.
5. Inward investment into the town of between £13m to £18m
6. Development of a local energy generation / supply entity
7. Encourage commercial/residential tenant retention in the town

5.6.2 Project risks

As discussed in section 3.4.5 there are a range of project risks that will need to be addressed. An initial risk register has been developed as shown in Appendix 11, which collates the risks all of the network options, showing generic risks (applicable to all options) along with specific risks for each heat network option. Key risks with these heat network opportunities include:

1. Securing consumers: clearly connection of HMP IoW and the hospital will drive this opportunity.
2. Development Governance: if this network were only to be developed on a stand-alone basis, i.e without the express intention to expand to wider network at some point than it will be important that an agency, presumably the IWNHST or MoJ leads the development process going forward. Clealry they could engage direct with the private sector (noting the likely need to access HNIP (or equivalent) funds). If there is an ambition to expand the network, e.g. as per Network 3 or 4 then a joint arrangement with the council would be important.
3. Energy centre location: it is important that this is secured at the MoJ site proposed with other land being required within the curtilage of the EfW, Black Dog and/or Fairlee WTW sites, where these contribute to heat supply. For the main primary site, whilst the MoJ site is preferred other locations on the St Marys estate are likely to be possible.
4. Potential network route constraints: whilst no significant specific risks were identified it will be import to secure the route as early as possible by looking at land ownership and over ground and underground constraints, .e.g. existing buried services, as early as possible
5. Improving / maintaining techno-economic performance: whilst the economic performance has been shown to be strong for a number of options, various indicators suggest that the economic case is sensitive to a number of key parameters. It will be important to review and revise the economic assessment in future work to give confidence to stakeholders and, ultimately, to investors (whether public or private). Specific techno-economic improvements are highlighted below. The network options (other than gas CHP-only) are likely to eligible for HNIP funds because of its scale (and scope to grow) and the carbon savings achievable, and this would be a direct solution to address the economic performance. However, it should be noted that HNIP currently has a limited life span which would put additional time pressure / risk on delivering this option.

5.6.3 Techno-economic Improvement opportunities

Other than addressing the possibility of including power supply from the EfW plant, the general need to improve certainty and reliability of the analysis (e.g. capital costs, operating costs and revenues), and, the need to address risks, no obvious opportunities to improve the techno-economic case for these network options have been identified.

5.7 Development recommendations

Network 2 focuses on the neighbouring hospital and HMP IoW as key consumers, together with the Isle of Wight college. At this early stage of investigation, the network, as conceived, appears to be deliverable with interested key stakeholders, credible options for energy supply (including low carbon solutions from the start) and location for an energy centre, and, limited development risks. The analysis also confirms the heat network would be capable of achieving a good commercial performance (across the 3 of the four option considered; the fourth, EfW heat recovery without CHP, could also become viable where direct power sales are also available from the EfW plant). The heat network is anticipated to be relatively low cost with good and secure annual revenues, with scope to expand the network over time. It would provide benefits of lower consumer costs, inward investment and provide a solution to long term decarbonisation of heat consumption across Newport, providing the basis for the delivery vehicle to implement this (particular where a public company/joint venture drives this).

There are uncertainties and project development risks that will need to be further considered in any subsequent work, which is recommended. The following risk are considered important:

- Securing the anchor consumers
- Securing one or more of the supply options
- Not having the necessary project governance/management arrangements in place to implement the project, including establishing which organisation would take the lead
- Network routing: this is general risk for all heat network schemes – land ownership and buried services should be examined to develop the proposed network arrangement

Key development recommendations for these options are as follows, assuming that key stakeholders agree to continue to development and commit the necessary resources (could be part funded by BEIS):

- The council should initiate an approval process to move the opportunity on to a formal project development status
- Establish project governance/management arrangements. Ideally this would include a development agreement with IWNHST and MoJ (and perhaps with one or more of the possible energy suppliers after further technical/commercial appraisal) with the council taking a leading role to secure the long term expansion and decarbonisation potential of the project. The council may also wish to have an investment and operational role within the scheme. Initially, the council would need to act as a convener (of the key parties) and manages/commission the next stages of work (typically ‘detailed feasibility’ and ‘detailed project development’).
- Detailed feasibility work: whilst move specific project opportunities towards being a formal investment opportunity it should address key risks, uncertainties and improvement opportunities including:
    - Securing one or more of the supply options: the various supply options will need to be assessed and refined to develop/fix the initial design. Key issues include land allocation, planning permission, contract terms (term, supply liability, price) and capital/operating cost assumptions to revise the financial modelling. The option for CHP alone presents the risk of not meeting the HNIP funding requirements, but grant support may not be required (depends on the return of investment); the development of CHP may be an options for the first iteration of the heat network, if other supply options are not immediately available.
    - Securing the anchor consumers: it will be important to hold further engagement to move toward agreeing formal heads of terms or establishing a partnership agreement. It will also be important to consider the technical/design issues regarding connection and timing risks.

- Review alternative design options that may add value, for example, power sales from the EfW plant and adding addition consumers (also covered in the review of Network 3 and 4); and;
- Review/establish ownership, procurement and funding strategies

General development recommendations (across all network options) are also discussed in section 8.

6 Network 3: Newport Harbour, hospital & prison

6.1 Summary of heat network options

This network assumes that the consumers from Network 1 and Network 2 are combined. A list of consumers is shown in Table 5-1 with further details shown in Appendix 2. Further investigation in any follow-on work into consumer issues is highlighted under the Network 1 and 2 sections of the report.

Site	Phase	Type	Peak heat (MW)	Heat Load (MWh)	Data Source[19]
St Mary's Hospital - Main Hospital	1	Hospital	4.69	11,354	Metering (NHS)
HMP Parkhurst	1	Prison	2.80	7,074	Metering (MoJ)
HMP Albany	1	Prison	2.17	5,488	Metering (MoJ)
Newport Harbour	1&2	Mixed-use development	1.47	2,313	New development benchmarking
Medina Leisure Centre and Medina High School	1	Leisure / Education	1.37	1,867	Metering (IoW Council)
Isle of Wight College	1	Education	1.04	1,526	Metering (IoW College)
Newport County Hall and Car Park	1	Office	0.29	425	Metering (IoW Council)
Newport Police Station	1	Emergency services	0.07	168	DEC
TOTAL (ALL)			**13.88**	**30,214**	

Table 6-1. Network 3 consumers.

Four supply scenarios are examined for Network 3:

- Isle of Wight Waste Recovery Park (EfW) & WSHP at Fairlee WTW
- Gas CHP & WSHP at Fairlee WTW
- Gas CHP & EfW & WSHP at Fairlee WTW
- Gas CHP & Black Dog AD Plant

A CHP-only option was not included but the relative benefits (compared to other options) can be inferred from the Network 2 techno-economic analysis. The analysis provides the opportunity to compare the WSHP at Fairlee WTW and Black Dog heat recovery options.

Based on review of potential consumers and spatial constraints, a provisional heat network route and energy centre location has been developed shown in Figure 4-1. It is intended to house a principal energy centre (with peaking plant, CHP (where used), controls and ancillary plant) close to the hospital

[19] *BEES and NEED refers to benchmarking used*

and HMP IoW with one or more of the existing supply points (WSHP at Fairlee WTW, Black Dog heat recovery and Amey EfW heat recovery) acting as satellite bulk heat contributors.

As the network is a combination of networks 1 and 2, the routing decisions and constraints are discussed earlier.

Network 3 – Newport Harbour+ consumer zone + Hospital and HMP IoW zone

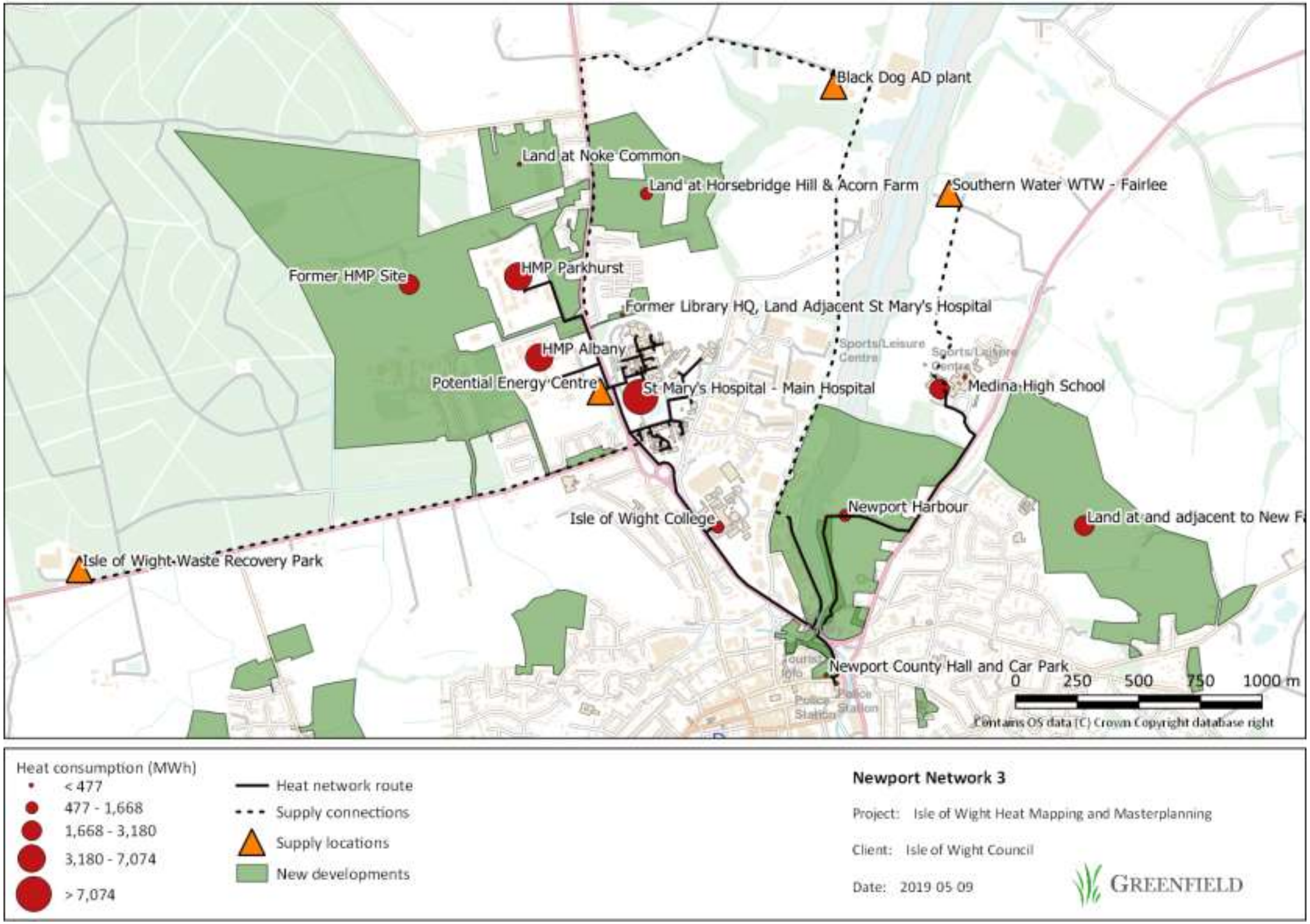

Figure 6-1. Network 3 heat network and connections.

Key parameters of Network 3 are presented in Table 5-2.

Heat demand and network details					
	Unit	Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP	Gas CHP & AD
Demand					
Heat demand	GWh/yr	30.2	30.2	30.2	30.2
Peak demand	MW	13.9	13.9	13.9	13.9
Number of connections					
Non-residential	No.	8	8	8	8
Residential (dwellings)	No.	250	250	250	250
Total	No.	258	258	258	258
Network					
Network trench length	km	8.7	11.1	11.1	10.0
Linear heat density	GWh/yr/km	3.5	2.8	2.8	3.1
Main pipe size	DN	300	400	400	300
Heat losses	%	10 %	10 %	10 %	10 %
Design temperatures[20]					
Flow	°C	90	90	90	90
Return	°C	45-55	45-55	45-55	45-55
Soft dig	%	59 %	68 %	68 %	54 %
Hard dig	%	37 %	29 %	29 %	42 %
Overground	%	5 %	4 %	4 %	4%

Table 6-2. Network 3 - heat demand and network details.

6.2 Phasing

Network 3 is a combination of networks 1 and 2, and therefore the same timings apply as described in sections 4.2 and 5.2. St. Mary's Hospital, HMP IoW, Isle of Wight College and IoW Council buildings are connected as soon as the energy supply plant is constructed, while properties in the Newport Harbour development are connected as the site is built out.   Although not explicitly considered as a supply option, where constraints to any of the low carbon supply options become apparent, an initial gas CHP alone solution could be implemented, assuming a longer term plan to secure low carbon supply is also enacted. Annual heat demand growth for the build-out phase is shown in Figure 6-2.

[20] *See Appendix 4 for further detail*

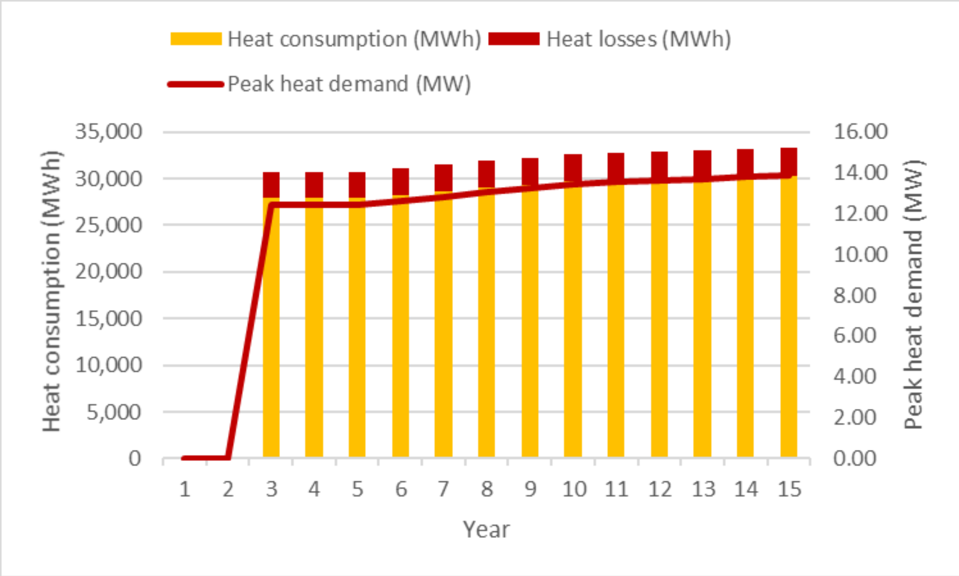

Figure 6-2. Annual heat demand increase – Network 3.

6.3 Energy supply concept design & plant sizing

Baseload production options considered were:

- Gas CHP + WSHP at Fairlee WTW
- WSHP at Fairlee WTW + IoW Waste Recovery Park (EfW) heat recovery
- Gas CHP + WSHP at Fairlee WTW + IoW Waste Recovery Park (EfW) heat recovery
- Gas CHP + Black Dog AD plant heat recovery

Plant capacity modelling for the options was conducted to determine the economically optimal plant sizing against hourly demand profiles. The following principles/assumptions with key commercial assumptions shown in Appendix 7 were used in the analysis:

- Gas CHP: as per notes for Network 2
- WSHP at Southern Water WTW Plant: as per notes for Network 1
- Isle of Wight Waste Recovery Park (EfW): as per notes for Network 2
- Black Dog AD plant heat purchase: as per notes for Network 1
- Gas boilers are dimensioned for back-up and reserve capacity
- Thermal storage sizing is included in the optimisation
- Plant sizes have been explored through hourly modelling of supply strategies accounting for equipment life cycle costs accounting for variable costs and revenues

For the purposes of economic modelling, targeted sizing of the baseload systems was set above the thresholds set by the EU Energy Efficiency Directive (EED) definition of an efficient heat network, which is a requirement for Heat Network Investment Project (HNIP) funding. For Heat Pump and Waste Heat installations the threshold is set at 50% of annual heat supply and for Gas CHP the threshold is set at 75% of annual heat supply.

Supply capacity dimensioning for the network was conducted on the basis that Networks 1 and 2 are connected but also capable of operating individually, assuming they develop in parallel. This will also improve the network's resilience and ensures security of supply for both east and west sides of heat network in situations where the connection between Networks 1 and 2 is compromised.

Option 1: Gas CHP and WSHP at Fairlee WTW

The cost-optimal Gas CHP capacity remains as 1,800 kW since the addition of Network 1 does not change the Private Wire power demand. Taking into account HNIP plant sizing requirements the sizing analysis identified a preferred capacity of 700 kW, with 200 m^3 of thermal storage.

Figure 6-3 shows the modelled load-duration curve for the fully built-out network. Thermal storage is mostly utilised during periods of lower demand as during periods of high heat demand the baseload production units already supply the network at full capacity.

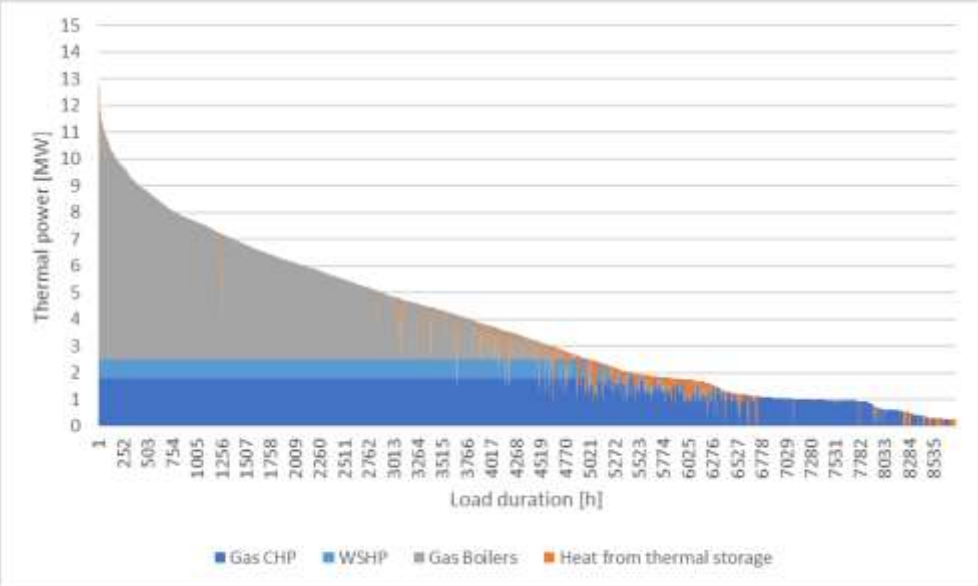

Figure 6-3 Modelled load-duration curve – full Network 3 (Gas CHP and WSHP).

Option 2: Hybrid – IoW EfW and WSHP at Fairlee WTW

The recommended baseload supply capacities for this supply option are 700 kW WSHP and 2,500 kW EfW with 200 m^3 thermal storage. Figure 6-4 shows the modelled load-duration curve for a fully built-out network.

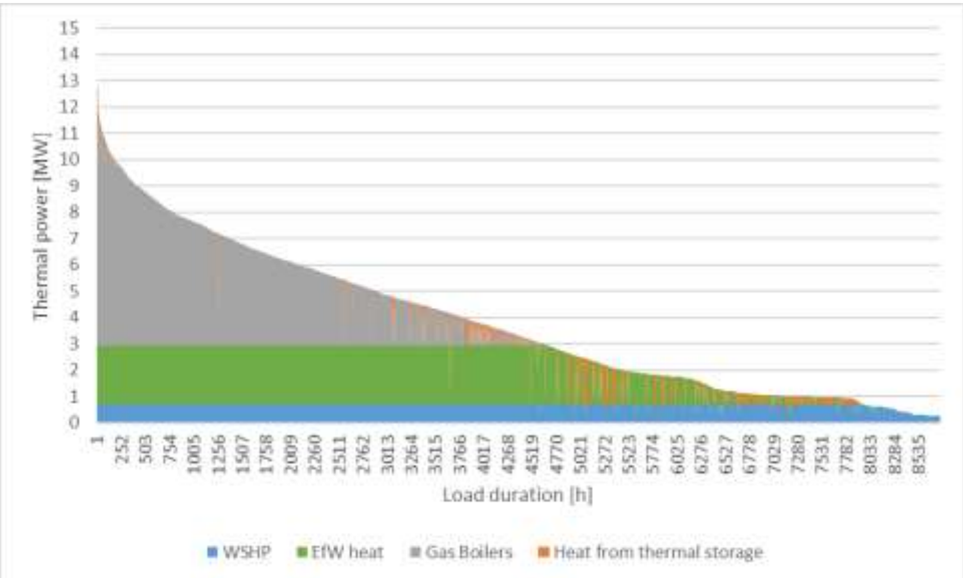

Figure 6-4 Modelled load-duration curve – full Network 3 (WSHP and EfW)

Option 3: Hybrid - Gas CHP, WSHP at Fairlee WTW facility and IoW EfW

The recommended baseload supply capacities for this supply option are 1,800 kW Gas CHP, 700 kW WSHP and 2,500 kW EfW with 200 m³ of thermal storage.   Figure 6-5 shows the modelled load-duration curve for the fully built-out network.

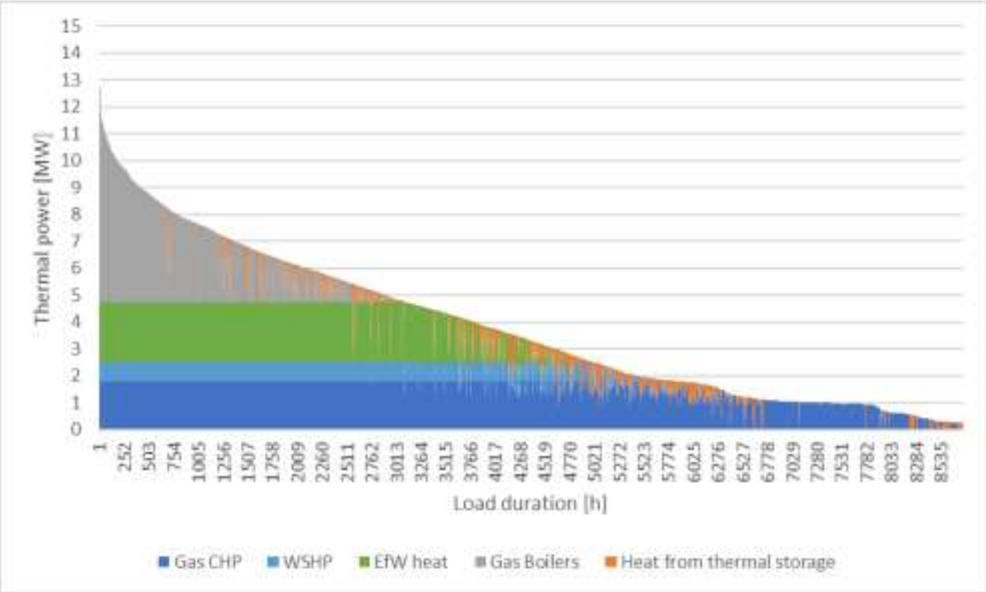

Figure 6-5 Modelled load-duration curve – full Network 3 (Gas CHP, WSHP and EfW)

Option 4: Hybrid – Black Dog heat recovery & Gas CHP

The recommended baseload supply capacities for this supply option are 1,800 kW Gas CHP and 1,150 kW heat purchase from the AD plant with 200 m³ of thermal storage. Figure 6-6 shows the modelled load-duration curve for the fully built-out network.

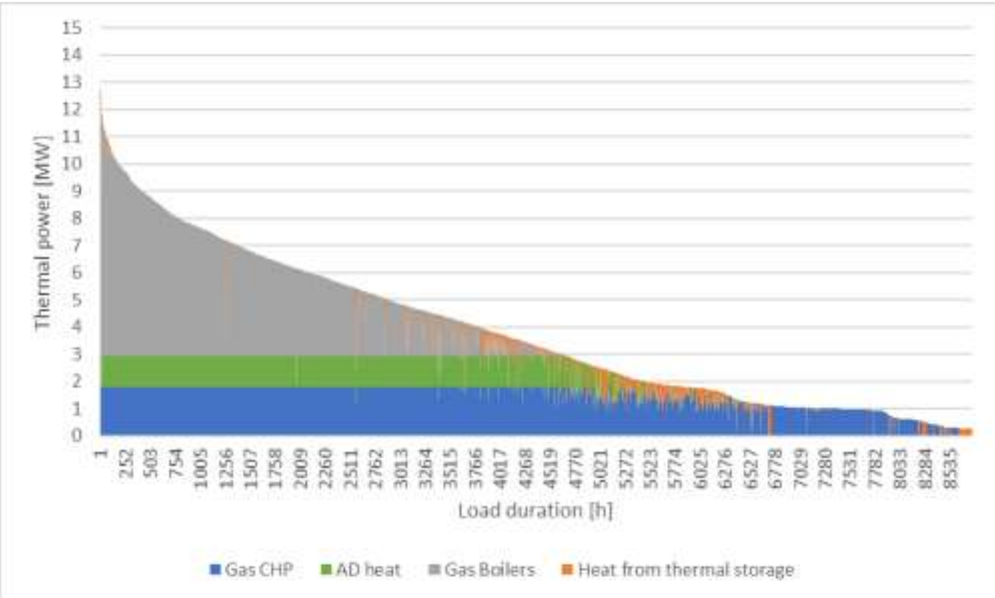

Figure 6-6 Modelled load-duration curve – full Network 3 (Gas CHP and AD heat purchase)

A summary of the energy modelling results for Network 3 supply options is shown in Table 6-3.

Heat and electricity production					
	Unit	Gas CHP + WSHP	EfW + WSHP	Gas CHP + EfW + WSHP	Gas CHP + AD
Supply capacity					
Gas CHP	kW	1,800	-	1,800	1,800
WSHP	kW	700	700	700	-
Heat purchase (EfW)	kW	-	2,500	2,500	-
Heat purchase (AD)	kW	-	-	-	1,150
Gas Boiler	kW	15,130	14,200	12,630	15,130
Thermal Storage	m^3	200	200	200	200
Heat production share					
Heat production	GWh/yr	33.6	33.6	33.6	33.6
Gas CHP	%	40.7 %	-	42.9 %	40.7 %
WSHP	%	11.6 %	19.4 %	12.2 %	-
Heat purchase (EfW)	%	-	42.6 %	28.8 %	-
Heat purchase (AD)	%	-	-	-	17.7 %
Gas Boiler	%	2.8 %	38.0 %	16.1 %	41.6 %
CHP electricity					
CHP electricity production	GWh/yr	12.7	-	12.6	12.7
Consumed by EC site	%	4.3 %	-	2.6 %	4.3 %
To Private wire network	%	85.3 %	-	87.3 %	85.3 %
To grid	%	10.4 %	-	10.0 %	10.4 %

Table 6-3. Network 3 - heat and electricity production

Indicative Energy Centre arrangement drawings are shown in Appendix 5 for the options considered.

6.4 Capital costs, operating costs and revenue

A summary breakdown of capital costs is shown in Figure 5-8 with a more detailed breakdown of shown in Appendix 6. In total the costs are estimated at £24m for the hybrid CHP/WSHP option, £22m for the hybrid EfW/WSHP option, £27m for the hybrid CHP/EfW/WSHP option and £24m for the hybrid CHP & AD plant option. It is clear that the capital cost of this network are appreciably higher than the Network 2 scheme. At this stage where costings rely on a range of assumptions the tolerance on capital costs applied is ±20%.

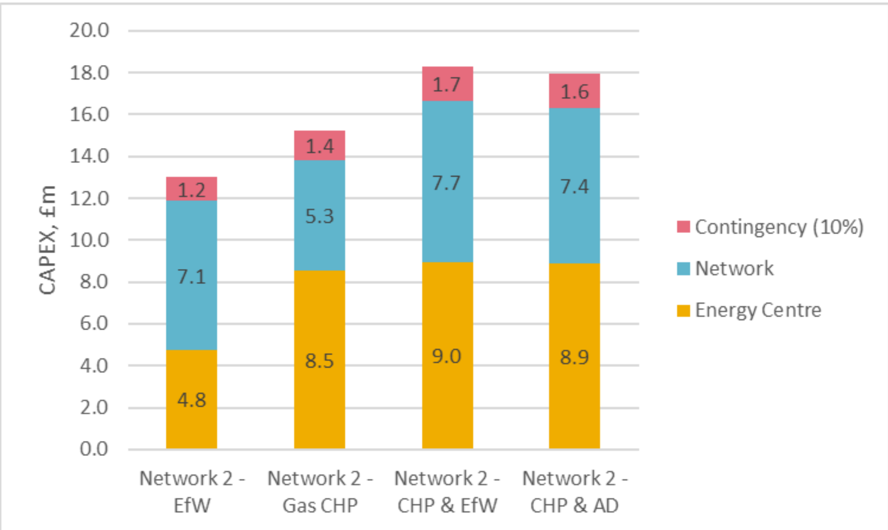

Figure 6-7 Capital cost for Network 3.

The estimated annual revenue and operating costs for the options are shown in Table 6-4, with Appendix 7 and 8 showing key operating cost and revenue assumption, including tariffs/connection fees for each consumer/consumer type.

6.5 Results of Techno-Economic analysis

Economic modelling has been conducted for each heat network option. Results are presented in the figures below, with summary tables in Appendix 9.

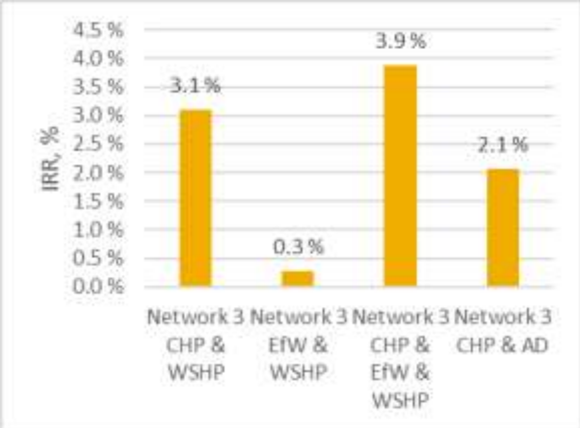

Figure 6-8. Internal rate or return - IRR (25 years) for Network 3.

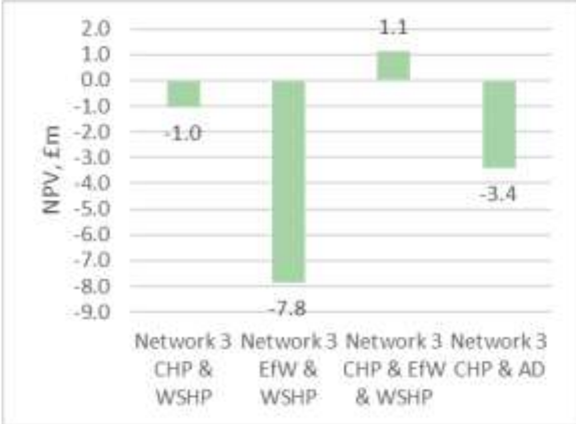

Figure 6-9. Net present value - NPV (25 years @ 3.5%) for Network 3.

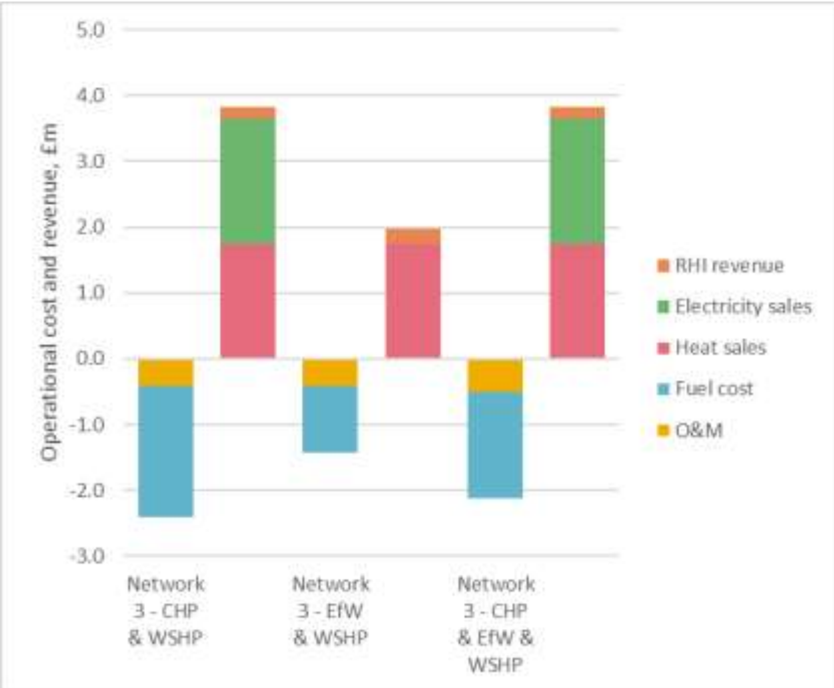

Figure 6-10. Annual operational cost and revenue for Network 3.

A summary of the key economic assessment parameters is presented in Table 5-4 and the discounted cash flow graphs are presented in Figure 6-11.

Techno-economic analysis results					
	Unit	Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP	Gas CHP & AD
Financial					
Total CAPEX (full scheme)	£m	24.4	22.1	27.2	24.0
Total REPEX (full scheme)	£m	10.7	7.0	11.5	10.2
Total OPEX (full scheme)	£m/yr.	2.4	1.4	2.1	2.4
Annual revenue (full scheme)	£m	3.7	2.0	3.7	3.5
Heat tariff to consumers (full scheme)[21]	£/MWh	38.9	38.9	38.9	38.9
Total connection fees	£m	1.4	1.4	1.4	1.4
NPV (25 yr @ 3.5 %)	£m	-1.0	-7.8	1.1	-3.4
IRR (25 yr)	%	3.1 %	0.3 %	3.9 %	2.1 %
Social IRR (25 yr) [22]	%	3.2 %	1.5 %	4.4 %	1.6 %
Bulk heat purchase cost AD EfW	 £/MWh £/MWh	 - -	 - 3.2	 - 3.2	 10.7 -
LCOE (25 yr)	£/MWh	59.3	75.1	54.3	64.8
Minimum grant to achieve 6 % IRR	£m	5.8	10.7	4.9	7.3
Carbon					
CO_2 savings over 25 yr	$ktCO_2$/yr.	50.2	55.3	75.6	52.5
CO_2 savings over 25 yr	%	25.6 %	33.4 %	38.6 %	26.8 %
CO_2 savings per £1,000 grant	tCO_2/£1,000	8.7	5.2	15.5	7.2
Cost of CO_2 savings	£/tCO_2	810	931	492	847

Table 6-4. Techno-economic analysis results for Network.

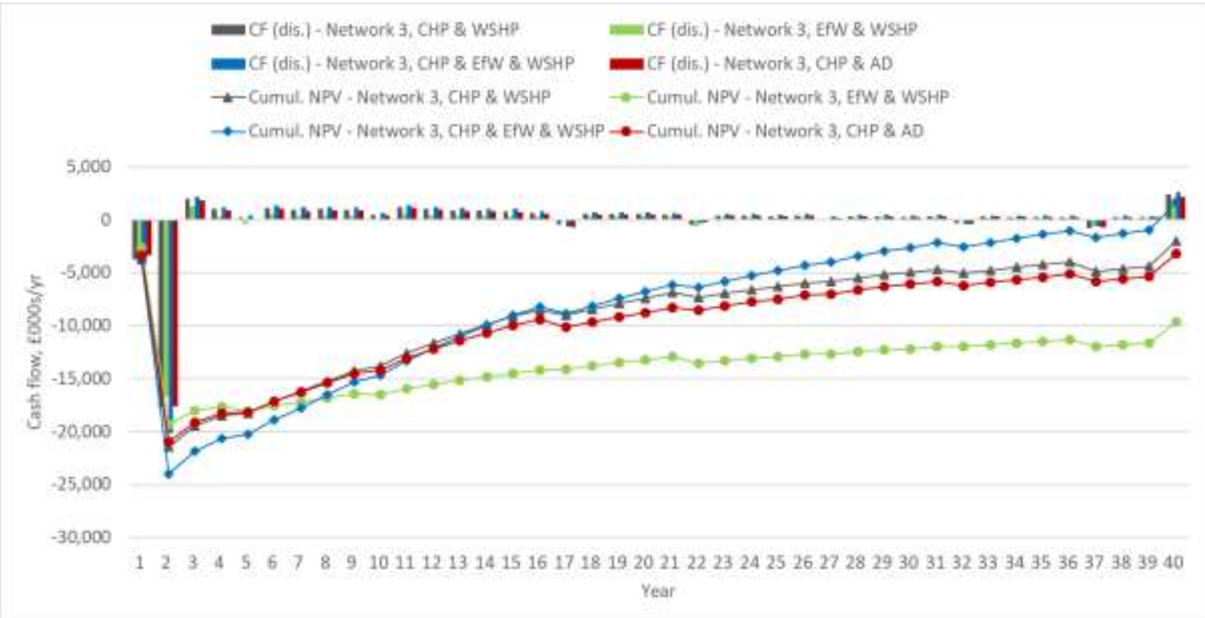

Figure 6-11. Discounted cash flow - Network 3

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[21] *Including variable and fixed heat tariff*

[22] *Social IRR accounts for impacts accrued to the heat network operator and those connected to the networks, as well as to the wider community and society as a whole. The calculation includes net impact on heating costs, carbon emissions and air quality.*

As with Network 2, a variant to the option without CHP was explored assuming bulk sale of power from the EfW plant directly to large consumers (hospital, prisons and IoW College) via private wire. The cost of the bulk power is simply assumed to be equivalent to a 'wholesale' power price (accounting for off- and on-peak variation) and the consumer purchase price is as per the assumption used in the CHP private wire analysis, for each consumer. This improves the 25-year IRR significantly to 4.9%[23], potentially making this the best performance of the options considered. Future work should refine this estimate, in liaison with Amey, whilst also improving certainty around the heat price which will be influenced by the availability of RHI, biogenic fraction of the waste stream and z-factor the heat extraction arrangement).

Within the financial modelling, sensitivities of key parameters have assessed to examine the strength of the economic case for each option. Parameters have only been considered independently although, in reality, individual parameters could change together and have a compound impact (positive or negative); this should be considered in any subsequent investigations. The results are shown in Figure 6-12, Figure 6-13, Figure 6-14 and Figure 6-15.

The figures highlight the impact on IRR (25-year) of variation of a number of sensitivities showing the significance of individual issues. The impact of sensitivities, as would be expected, varies between the options, making it complex to succinctly interpret the results, however, the following appear most significant:

- Change in gas prices (particularly for those with gas CHP), although this, in practice is likely to be mitigated by the fact that increasing gas prices will also reasonably allow adjustment in heat tariff and lessen the impact
- Variable component of the heat tariff
- Capital cost change has a significant impact, particularly on those options with CHP. Cost reductions also appear to have a more significant (positive) impact than cost increases (negative).
- Energy demand: increase in (e.g. new consumers) has similar scale of impact to loss of demand, e.g. revising consumption estimates downwards from the current assessment or loss of consumers.
- Exclusion of RHI revenue for the WSHP option (making the option without CHP return a negative IRR).
- Change in the EfW bulk heat price – whilst the impact is muted where EfW supply is combined with CHP the impact could be significant. The analysis has used a low value of -£4.43/MWh (based on a scenario with RHI and a high z-factor (of 10)) to £12.03/MWh (based on no-RHI and a low z-factor (just over 4)).

[23] *See Appendix 7 & 8 for full assumptions.*

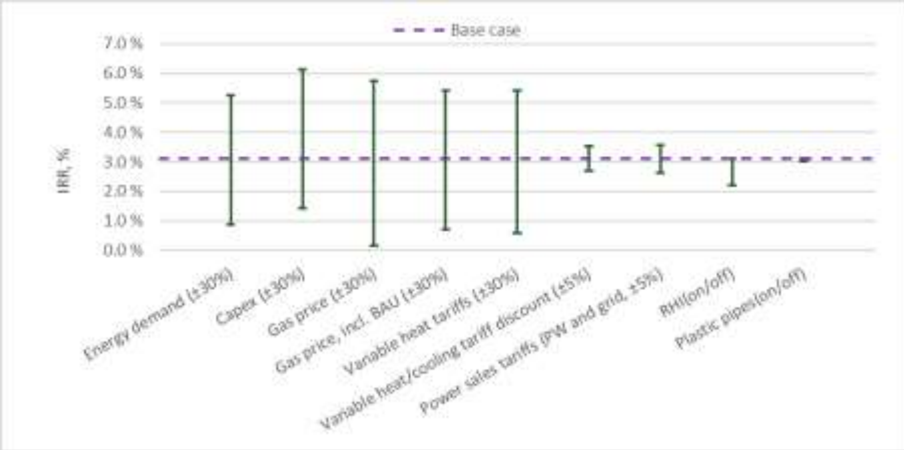

Figure 6-12. IRR sensitivities - Network 3 Newport Harbour, Hospital and HMP IoW (Gas CHP & WSHP) [24]

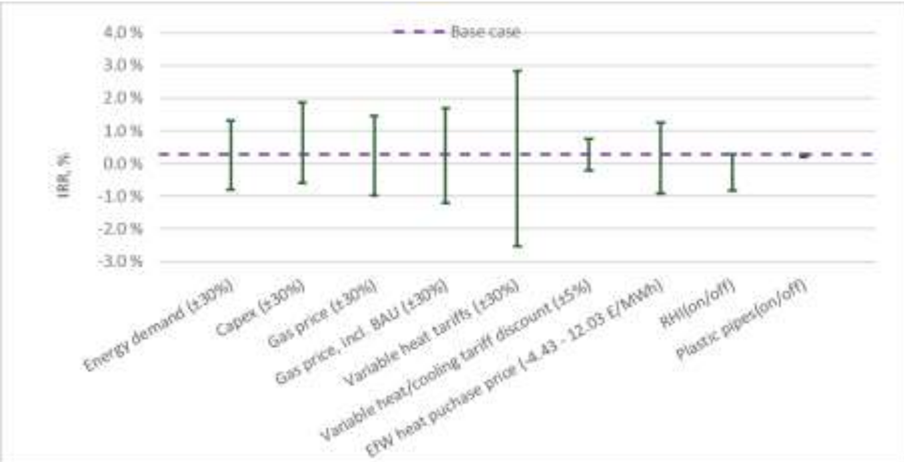

Figure 6-13. IRR sensitivities - Network 3 (EfW & WSHP)[24]

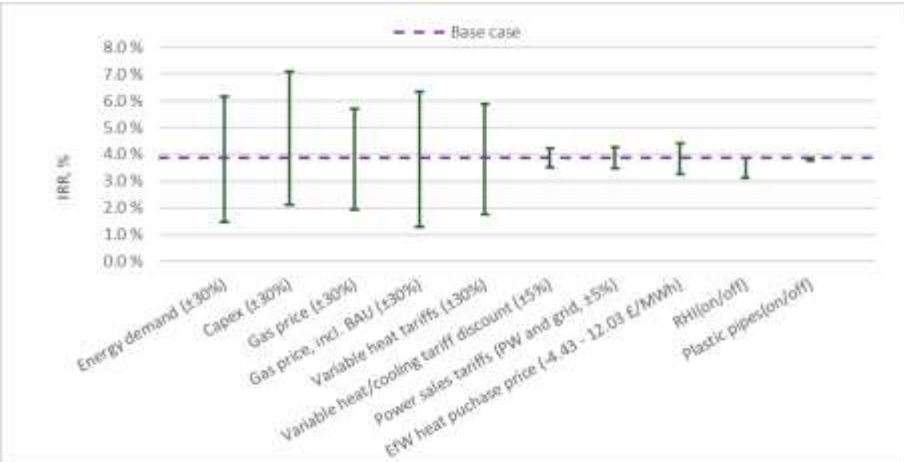

Figure 6-14. IRR sensitivities – Network 3 (Gas CHP & EfW & WSHP) [24]

[24] *"Gas price incl. BAU" considers changing the cost of gas in both the operation of the heat network and the setting on energy tariffs (which are based on counterfactual costs)*

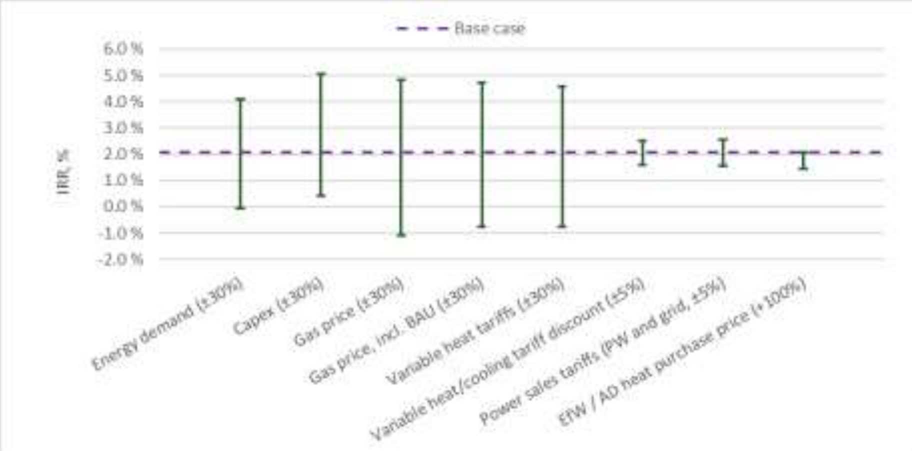

Figure 6-15. IRR sensitivities - Network 3 (Gas CHP & AD) [24]

Grant support

Table 6-5 shows the level of the grant support (e.g. HNIP) that would be required to achieve specific rates of return. A 3-7 % rate of return is assumed to be required for a wholly public funded project and above 10-12% is assumed to be required for a wholly privately funded project. It should be noted that all options achieve the HNIP criteria for funding regarding plant sizing.

As Table 6-5 shows, with the exception of the EfW & WSHP supply option all solutions appear be able to reach a 10% IRR level without going above the requirement for 50% of capex, which is a reasonable starting assumption for the maximum limit set by state-aid rules. Clearly each option needs fairly significant grant support even to achieve 5%. Where public funding requirements for returns are below this then there may be no need for grant support at all.

		3 CHP & WSHP	3 EfW & WSHP	3 CHP & EfW & WSHP	3 CHP & AD
IRR 5.0 %	£m	4.2	9.8	2.8	6.0
	% capex	17.1 %	44.2 %	10.4 %	25.0 %
IRR 7.0 %	£m	7.1	11.4	6.5	8.4
	% capex	29.0 %	51.6 %	24.0 %	34.9 %
IRR 10.0 %	£m	9.7	12.6	9.8	10.4
	% capex	39.6 %	57.1 %	36.2 %	43.6 %

Table 6-5. Gap funding required to reach investment thresholds set out by HNDU – Network 3.

6.6 Techno-economic conclusions

The techno-economic analysis shows reasonable economic performance for all three options involving CHP with IRR (25 year) sitting between 2% and 4%. This would suggest they are close to a case for public investment although they will probably need some grant support. As the grant funding calculation shows, between 11% and 40% of the estimated capital costs would need to be sought from HNIP to make any of the options achieve between 5% and 10% IRR, which would move them towards being commercially fund-able.

It is clear that the economic case for this heat network results in the blending of the poor economic performance of Network 1 and the strong performance of Network 2.

There is marginal difference between the three CHP options (hybrids with other supply technologies). However, there is an appreciable difference in carbon performance with those using heat sourced from the EfW plant seeing a bigger benefit. In all options carbon emissions reductions between 25%

and almost 40% are estimated. In addition this network would give a greater absolute reduction of between 50 and 76 thousand tonnes of carbon (Network 2: 35 to 65 thousand tonnes). Carbon emission reductions are limited where CHP is included, making it important to consider whether low costs power could be sourced for consumers or supply plant, e.g. heat pumps from existing local sources, including the EfW and Black Dog facility.

It is recommended that Network 3 is further considered primarily because it provides the opportunity to maximise carbon savings and establish infrastructure that would enable decarbonisation of further consumers across the town (or at least the northern side) which are likely to be identified over time and the urban expansions planned over the coming decade.

The AD, EFW and WSHP supply points appear credible and deliverable, although greater detail on each is needed and combining with CHP provides good economic results, supporting the initial investment case (whilst limiting carbon savings). All three alongside CHP (and other local power supply) should be further considered as per the recommendations for networks 1 and 2.

In general, the sensitivity analysis shows that project IRR can be significantly affected by a number of key parameters, and this is not untypical of heat network projects. This will require close attention to the design and analysis of the options assuming follow-on development/feasibility work is implemented.

6.6.1 Heat Network benefits

As discussed in section 3.4.4 there are a range of economic and environmental benefits that are estimated to be derived for these heat network options. In summary they are:

1. A general 5% reduction in consumer energy costs (the basis for revenue modelling) and mitigation of future energy cost increases
2. Operational benefits including reduced plant liability and releasing property floor space
3. Reduction in carbon emissions (between 25% and 40% for connected properties - depending on supply technology) and potential to deliver sustained through expansion of switch to lower carbon technologies.
4. Inward investment into the town of between £22m to £27m, depending on option
5. Development of a local energy generation / supply entity
6. Encourage commercial/residential tenant retention in the town

6.6.2 Project risks

As discussed in section 3.4.5 there are a range of project risks that will need to be addressed. An initial risk register has been developed as shown in Appendix 11, which collates the risks of all of the network options, showing generic risks (applicable to all options) and a number of specific risks associated to each heat network identified. Key risks with these network opportunities include:

1. Securing anchor consumers: connection of HMP IoW and the hospital and linking with the development timescales for Newport Harbour (together with existing properties (largely council and education) will drive this opportunity.
2. Development Governance: it will be important that an agency, presumably the council, would need to lead the development process going forward. Ultimately this could become a joint enterprise (with key stakeholders such as MoJ and IWNHST) but as this point it will necessary for the council to drive the next feasibility and the commercial development stages.
3. Energy centre location: it is important that this is secured at the MoJ site proposed with other land being required within the curtilage of the EfW, Black Dog and/or Fairlee WTW sites,

where these contribute to heat supply. For the main primary site, whilst the MoJ site is preferred other locations on the St Marys estate are likely to be possible.

4. Potential network route constraints: see discussions for the under Network 1 and 2
5. Improving / maintaining techno-economic performance: whilst the economic performance has been shown to be reasonable for a number of options, various indicators suggest that the economic case is sensitive to a number of key parameters. It will be important to review and revise the economic assessment in future work to give confidence to stakeholders and, ultimately, to investors (whether public or private). Specific techno-economic improvements are highlighted below. The network options are likely to eligible for HNIP funds because of the scale (and scope to grow) and the carbon savings achievable, which would be a direct solution to improving the economic case.
6. Renewable Heat Incentive revenues: for the WSHP at Fairlee WTW option access to RHI is an important consideration. RHI is due to close in quarter 1, 2021 (with no extension/replacement currently planned) and this would impact the commercial cases (reducing IRR (25 year) by approximately 1%. In any case, where a project relies on the RHI income this will expire after year 20, which is the standard contract term applicable. This may result in adaptation of the operating strategy, reducing WSHP output to utilise only lower cost power (overnight).

6.6.3 Techno-economic improvement opportunities

The opportunities identified for networks 1 and 2 are still relevant here, although with this larger network the solutions that are proposed to be explored for Network 1 as an independent network, particularly the lower temperature strategy becomes less relevant, although a higher temperature heat network feeding the larger consumer, could essentially be “stepped-down” to supply lower temperature, e.g. new development. This would add complexity to the design, construction and operation of the heat network.

6.7 Development recommendations

Network 3 combines Network 1 and 2 consumers. At this early stage of investigation, the network as conceived, appears to be deliverable. It appears to be capable of achieving reasonable commercial performance, but with some grant support required, although this could be limited through further design iterations. Compared to the previous networks, it would deliver benefits to a larger set of consumers, greater economic development support and would quite clearly support the long term objective of decarbonising heat across the town.

There are uncertainties and project development risks that will need to be further considered in any subsequent work, which is recommended. The following risks are considered important:

- Securing anchor consumers
- Securing one or more of the supply options
- Not having the necessary project governance/management arrangements in place to implement the project, including establishing which organisation would take the lead (presumed to be the council)
- Certainty over RHI revenue for the WSHP options
- Need for grant support
- Network routing: this is a general risk for all heat network schemes – land ownership and buried services should be examined to develop the proposed network arrangement

Key development recommendations for these options are as follows, assuming that key stakeholders agree to continue to development and commit the necessary resources (could be part funded by BEIS):

- The council should initiate an approval process to move the opportunity on to a formal project development status
- Establish project governance/management arrangements. This network clearly cuts across the council's objective more than Network 2 because of the inclusion of council consumers (Newport Harbour and existing properties), suggesting that the council should take a leading role. The council may also wish to have an investment and operational role within the scheme. Initially, the council would need to act as a convener (of the key parties – MoJ, IWNHST trust, energy suppliers) and manage/commission the next stages of work (typically 'detailed feasibility' and 'detailed project development').
- Detailed feasibility work: move specific project opportunities towards being a formal investment opportunity it should address key risks, uncertainties and improvement opportunities including:
    - Securing one or more of the supply options: the various supply options will need to be assessed and refined to develop/fix the initial design. Key issues include land allocation, planning permission, contract terms (term, supply liability, price) and capital/operating cost assumptions to revise the financial modelling.
    - Securing the anchor consumers: it will be important to hold further engagement to move toward agreeing formal heads of terms or establishing a partnership agreement. It will also be important to consider the technical/design issues regarding connection and timing risks.
    - Review alternative design options and update existing ones to add value, for example, power sales from the EfW plant, adding addition consumers and addressing RHI risks; and;
    - Review/establish ownership, procurement and funding strategies

General development recommendations (across all network options) are also discussed in section 8.

7 Network 4: Network 3 + urban extensions

7.1 Summary of heat network options

This network considers the expansion of Network 3 to also supply heat to the planned urban extensions to the north and east of Newport over the coming decades. A list of existing and new development consumers is shown in Table 7-1 with further details shown in Appendix 2. The urban extensions are located in two general zones, north and east around HMP IoW and the east of Medina high school. These then naturally associate with Network 1 and Network 2 respectively. The greatest scale of development is identified around the prison zone, with the largest individual site being the development of the former HMP Camp Hill estate. These developments are at an early stage (primarily council planning land allocations) and so lack detail and have inherent uncertainty around quantum and timing of development.

Further investigation in any follow-on work into consumer issues is highlighted under the Network 3 section of the report. For the urban extension it would be important to continue to review emerging plans and develop iteration of the techno-economic analysis discussed here.

Site	Phase	Type	Peak heat (MW)	Heat Load (MWh)	Data Source[25]
St Mary's Hospital - Main Hospital	1	Hospital	4.67	11,354	Metering (NHS)
HMP Parkhurst	1	Prison	2.80	7,074	Metering (MoJ)
HMP Albany	1	Prison	2.17	5,488	Metering (MoJ)
Former HMP Site	2	Residential development	2.35	3,180	New development benchmarking
Land at and adjacent to New Fairlee Farm	2	Residential development	1.87	2,332	New development benchmarking
Newport Harbour	1&2	Mixed-use development	1.47	2,313	New development benchmarking
Medina Leisure Centre & Medina High School	1	Leisure / Education	1.37	1,867	Metering (IoW Council)
Isle of Wight College	1	Education	1.04	1,526	Metering (IoW College)
Land at Horsebridge Hill & Acorn Farm	2	Residential development	0.98	994	New development benchmarking
Land at Noke Common	2	Residential development	0.58	477	New development benchmarking
Newport County Hall and Car Park	1	Offices	0.29	425	Metering (IoW Council)
Newport Police Station	1	Emergency services	0.07	168	DEC
Former Library HQ, Land Adjacent St Mary's Hospital	2	Residential development	0.28	133	New development benchmarking
TOTAL (ALL)			**19.94**	**37,329**	

Table 7-1. Network 4 consumers.

[25] BEES and NEED refers to benchmarking used

Three supply scenarios are examined for Network 4:

- Isle of Wight Waste Recovery Park (EfW) & WSHP at Fairlee WTW
- Gas CHP & WSHP at Fairlee WTW
- Gas CHP & EfW & WSHP at Fairlee WTW

Supply strategies and energy centre locations are described in detail in section 7.3. The results of Network 3 techno-economic analysis (see Table 6-4) show that the Gas CHP/AD hybrid performs less well than the other CHP hybrid options. Since the economic performance of the options (see later) this option was not explored further in Network 4. However, this option (and potentially other arrangements) are still considered as possible options for this network (perhaps with many connecting to support resilience and operation efficiency) and should be further considered in any follow-on work.

Based on review of potential consumers and spatial constraints, a provisional heat network route and energy centre location has been developed (see Figure 4-1).

As an extension of Network 3, the routing decisions and constraints are as per Network 3 together with the need to address reaching the urban extension sites. Internal distribution through the development sites is assumed not be constrained since it will involve relatively low cost 'soft dig' construction. Costing for these elements of the network has been estimated based on numbers of connections (numbers of properties) and the development density.

It is intended to house a principal energy centre (with peaking plant, CHP (where used), controls and ancillary plant) close to the hospital and HMP IoW with one or more of the existing supply points (WSHP at Fairlee WTW, Black Dog heat recovery and Amey EfW heat recovery) acting as satellite bulk heat contributors.

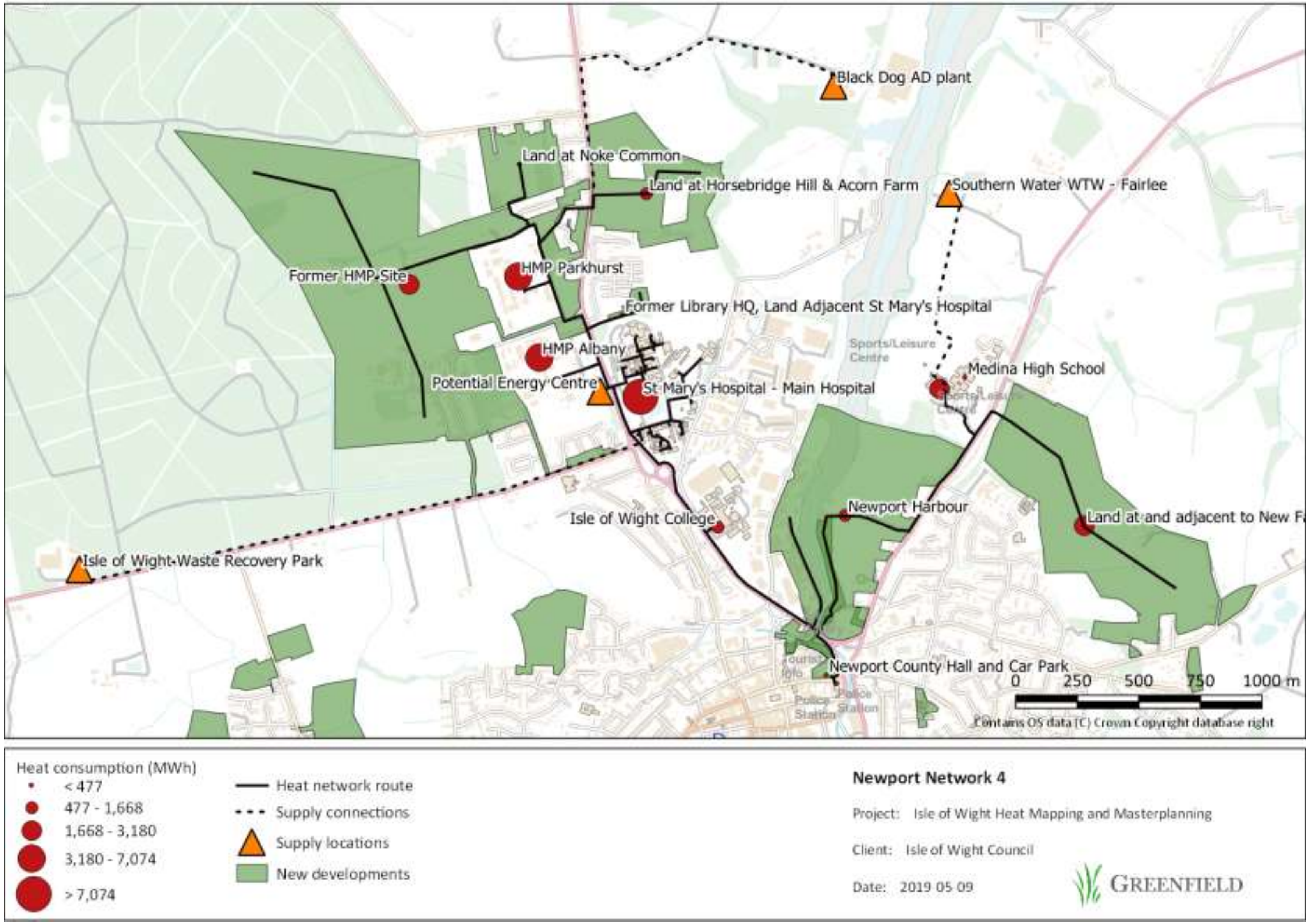

Figure 7-1. Network 4 - heat network and connections.

Key parameters of Network 3 are presented in Table 5-2.

Heat demand and network details				
	Unit	Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP
Demand				
Heat demand	GWh/yr	37.3	37.3	37.
Peak demand	MW	19.9	19.9	19.9
Number of connections Non-residential Residential (dwellings) Total	 No. No. No.	 8 2,935 2,943	 8 2,935 2,943	 8 2,935 2,943
Network				
Network trench length	km	27.1	29.5	29.5
Linear heat density	GWh/yr/km	1.4	1.3	1.3
Main pipe size	DN	400	400	400
Heat losses	%	10 %	10 %	10 %
Design temperatures[26] Flow Return	 °C °C	 90 45-55	 90 45-55	 90 45-55
Soft dig Hard dig Overground	% % %	69 % 28 % 3 %	73 % 24 % 2 %	73 % 24 % 2 %

Table 7-2. Network 4 - heat demand and network details.

7.2 Phasing

Network 4 is an extension of Network 3, and therefore the same timings apply as described in section 6.2. The urban extension developments, as with Newport Harbour, would connect as property phases are completed. As per Network 3 there are no known timing constraints for the supply options with gas CHP being a possible first option, to limit initial development cost. Annual growth in heat demand during the build-out phase is shown in Figure 7-2.

[26] *See Appendix 4 for further detail*

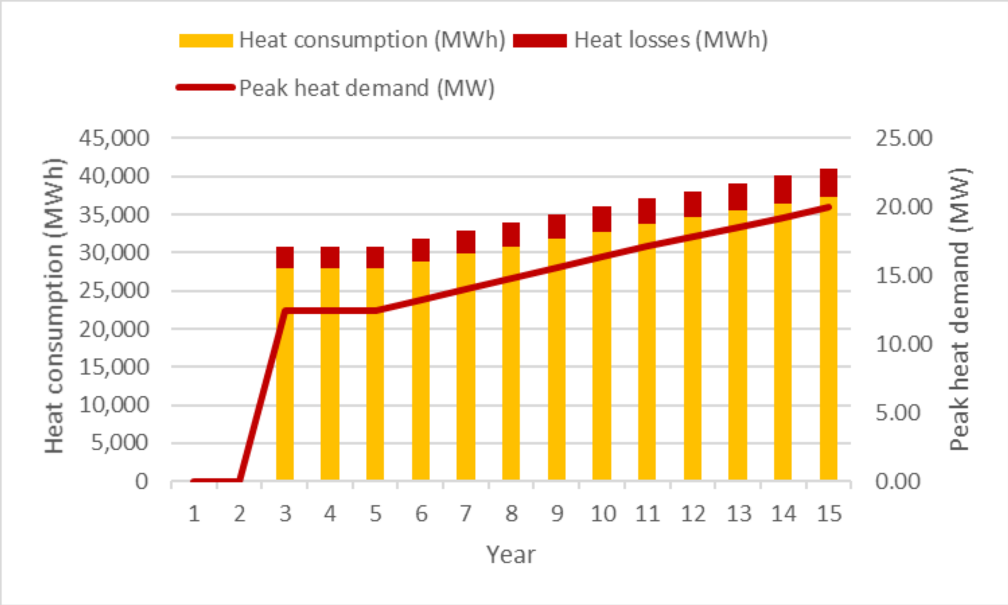

Figure 7-2. Annual heat demand increase – Network 4.

7.3 Energy supply concept design & plant sizing

Baseload production options considered were:

- Gas CHP + WSHP (Fairlee WTW)
- WSHP (Fairlee WTW) + IoW Waste Recovery Park (EfW) heat recovery
- Gas CHP + WSHP (Fairlee WTW) + IoW Waste Recovery Park (EfW) heat recovery

Plant capacity modelling for the options was conducted to determine the economically optimal plant sizing against hourly demand profiles. The following principles/assumptions with key commercial assumptions shown in Appendix 7 were used in the analysis:

- Gas CHP: as per notes for Network 2
- WSHP (Fairlee WTW): as per notes for network 1
- IoW Waste Recovery Park (EfW) heat recovery: as per notes for Network 2
- Gas boilers are dimensioned for back-up and reserve capacity
- Thermal storage sizing is included in the optimisation
- Plant sizes have been explored through hourly modelling of supply strategies accounting for equipment life cycle costs accounting for variable costs and revenues

For the purposes of economic modelling, targeted sizing of the baseload systems was set above the thresholds set by the EU Energy Efficiency Directive (EED) definition of an efficient heat network, which is a requirement for Heat Network Investment Project (HNIP) funding. For all options, which combine CHP and renewable energy or recovered heat sources, the threshold is set at 50% of annual heat supply.

Option 1: Gas CHP + WSHP (Fairlee WTW)

The cost-optimal Gas CHP capacity remains as 1,800 kW since the addition of the urban extension is assumed not to change the Private Wire power demand, although this could be explored. Accounting for the EED supply threshold and the result of optimisation modelling, the recommended WSHP capacity is 1,100 kW with 200 m^3 of thermal storage.

Compared to Network 3, the WSHP capacity is increased for in order to reach the HNIP funding threshold of 50% (from CHP and WSHP) of annual heat supply.

Figure 7-3 shows the modelled load-duration curve for a fully built-out Network 4 with 1,800 kW Gas CHP and 1,100 kW WSHP baseload production and a 200 m^3 thermal storage. Thermal storage is mostly utilised during periods of lower demand as during periods of high heat demand the baseload production units already supply the network at full capacity.

The load duration diagram clearly shows a shallower curve (with a much larger peak demand, due to the short duration requirements for heating and hot water from the largely residential urban extensions) than Network 3. This will tend to worsen the capacity / revenue balance in the scheme.

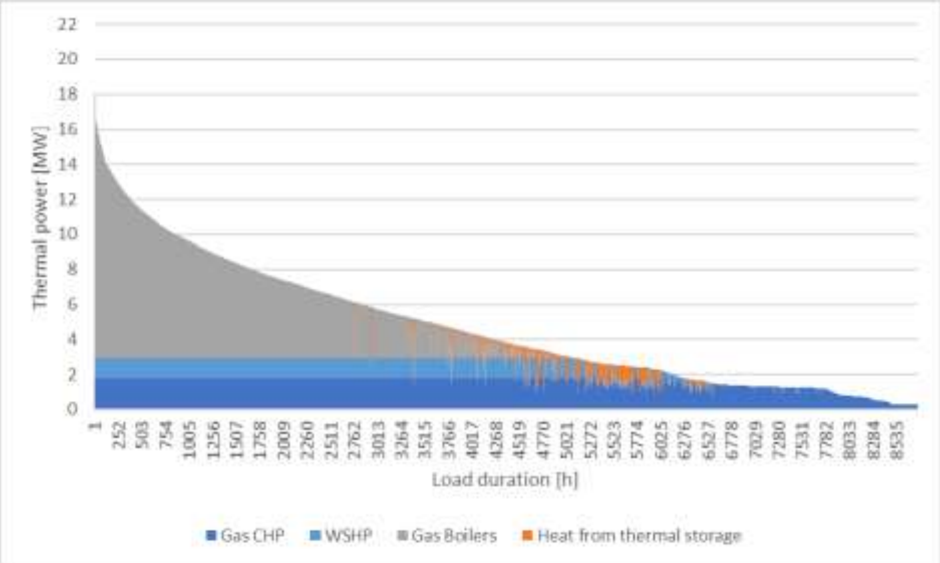

Figure 7-3 Modelled load-duration curve – full Network 4 (Gas CHP and WSHP)

Option 2: WSHP (Fairlee WTW) + IoW EfW heat recovery

The recommended baseload supply capacities for this supply option are 700 kW WSHP and 2,500 kW EfW and 200 m^3 thermal storage.

Figure 7-4 shows the modelled load-duration curve for the fully built-out network.

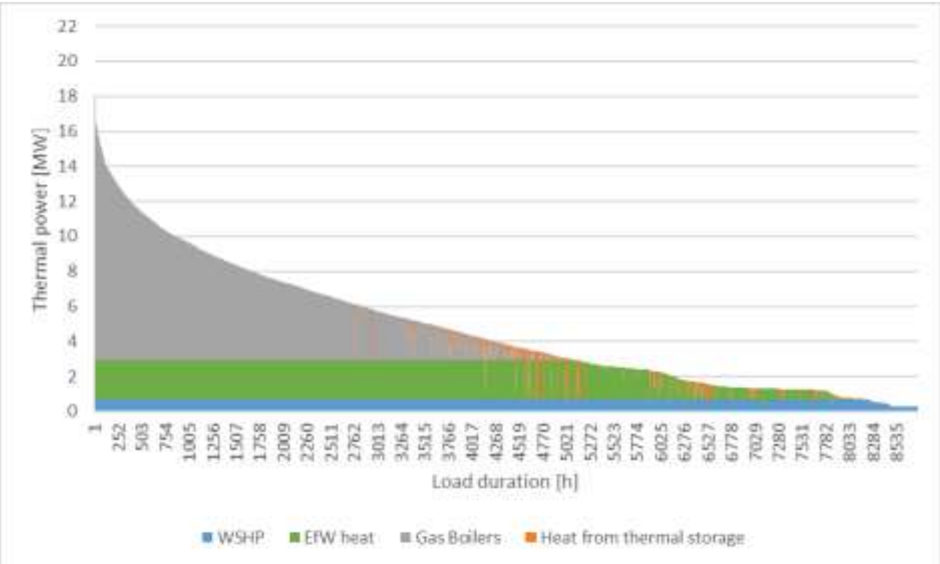

Figure 7-4 Modelled load-duration curve – full Network 4 (WSHP and EfW)

Option 3: Gas CHP + WSHP (Fairlee WTW) + IoW EfW heat recovery

The recommended baseload supply capacities for this supply option are 1,800 kW Gas CHP, 700 kW WSHP, 2,500 kW EfW, with 200 m^3 of thermal storage.

Figure 7-5 shows the modelled load-duration curve for the fully built-out network, showing a much greater contribution from the combined low carbon supply technologies.

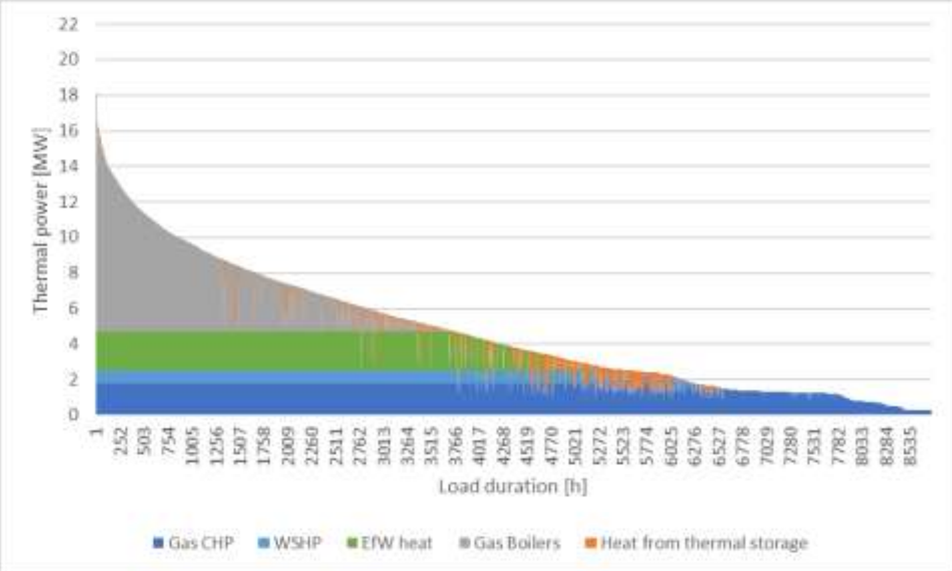

Figure 7-5 Modelled load-duration curve – full Network 4 (Gas CHP, WSHP and EfW)

A summary of the energy modelling results for Network 4 supply options is shown in Table 7-3.

Heat and electricity production				
	Unit	Gas CHP + WSHP	EfW + WSHP	Gas CHP + EfW + WSHP
Supply capacity				
Gas CHP	kW	1,800	-	1,800
WSHP	kW	1,100	700	700
Heat purchase (EfW)	kW	-	2,500	2,500
Heat purchase (AD)	kW	-	-	-
Gas Boiler	kW	21,990	21,700	19,900
Thermal Storage	m^3	200	200	200
Heat production share				
Heat production	GWh/yr	41.4	41.4	41.4
Gas CHP	%	34.5 %	-	34.4 %
WSHP	%	15.8 %	14.5 %	10.7 %
Heat purchase (EfW)	%	-	36.1 %	24.6 %
Gas Boiler	%	49.7 %	49.4 %	30.3 %
CHP electricity				
CHP electricity production	GWh/yr	13.3	-	13.3
Consumed by EC site	%	3.1 %	-	3.1 %
To Private wire network	%	86.2 %	-	86.5 %
To grid	%	10.6 %	-	10.3 %

Table 7-3 Network 4 heat and electricity production.

Indicative Energy Centre arrangement drawings are shown in Appendix 5 for the options considered.

7.4 Capital costs, operating costs and revenue

A summary breakdown of capital costs is shown in Figure 7-6 with a more detailed breakdown of shown in Appendix 6. In total the costs are estimated at £43m for the hybrid CHP/WSHP option, £41m for the hybrid EfW/WSHP option, and, £46m for the hybrid CHP/EfW/WSHP option. At this stage where costings rely on a range of assumptions the tolerance on capital costs applied is ±20%.

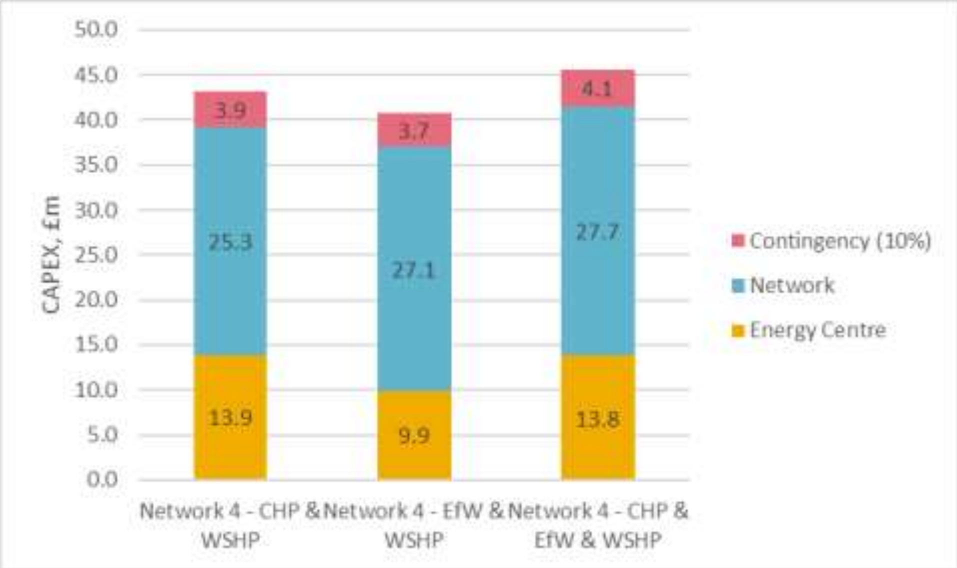

Figure 7-6 Capital cost for Network 4.

The estimated annual revenue and operating costs for the options are shown in Table 7-4, with Appendix 7 and 8 showing key operating cost and revenue assumptions, including tariffs/connection fees for each consumer/consumer type.

7.5 Results of Techno-Economic Analysis

Economic modelling has been conducted for each heat network option. Results are presented in the figures below, with summary tables in Appendix 9.

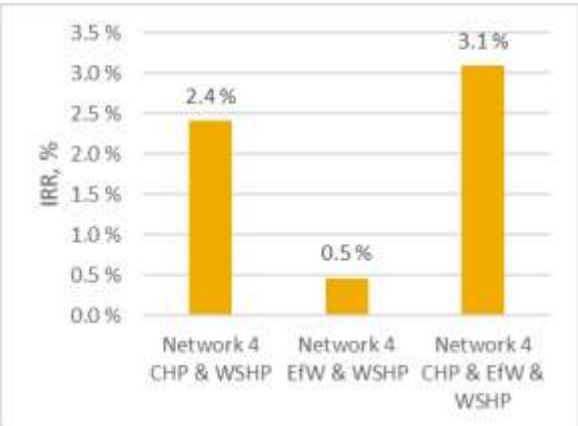

Figure 7-7. Internal rate or return - IRR (25 years) for Network 4.

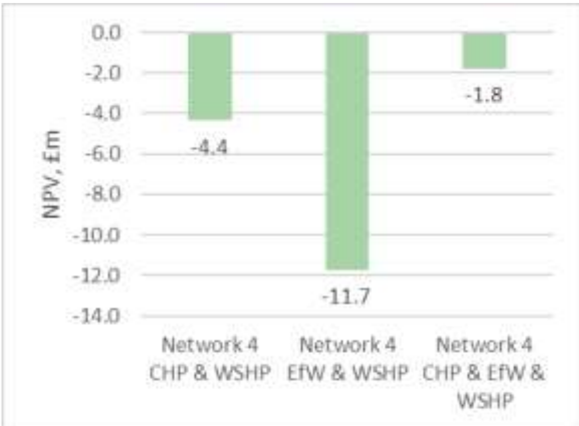

Figure 7-8. Net present value - NPV (25 years @ 3.5%) for Network 4.

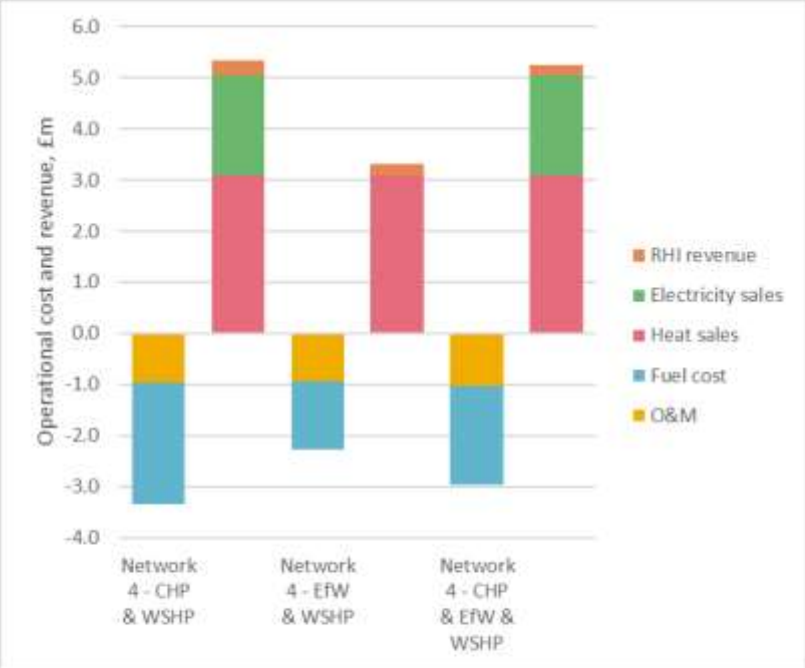

Figure 7-9. Annual operational costs and revenue - Network 4.

A summary of the key economic assessment parameters is presented in Table 7-4 and representations of the discounted cash flow graphs are presented in Figure 7-10.

Techno-economic analysis results				
	Unit	Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP
Financial				
Total CAPEX (to full build out)	£m	43.2	40.7	45.6
Total REPEX (full scheme)	£m	16.2	12.3	16.7
Total OPEX (full scheme)	£m/yr.	3.3	2.3	3.0
Annual revenue (full scheme)	£m	5.2	3.3	5.1
Heat tariff to consumers (full scheme)[27]	£/MWh	61.2	61.2	61.2
Total connection fees	£m	5.3	5.3	5.3
NPV (25 yr @ 3.5 %)	£m	-4.4	-11.7	-1.8
IRR (25 yr)	%	2.4 %	0.5 %	3.1 %
Social IRR (25 yr) [28]	%	1.6 %	0.2 %	2.7 %
Bulk heat purchase cost EfW		-	3.2	3.2
LCOE (25 yr)	£/MWh	89.5	104.1	84.4
Minimum grant to achieve 6 % IRR	£m	10.9	16.2	9.6
Carbon				
CO_2 savings over 25 yr	$ktCO_2$/yr.	60.1	59.3	78.3
CO_2 savings over 25 yr	%	26.6 %	30.4 %	34.6 %
CO_2 savings per £1,000 grant	tCO_2/£1,000	5.5	3.7	8.1
Cost of CO_2 savings	£/tCO_2	1,201	1,418	870

Table 7-4. Techno-economic analysis results for Network 4.

[27] *Including variable and fixed heat tariff*
[28] *Social IRR accounts for impacts accrued to the heat network operator and those connected to the networks, as well as to the wider community and society as a whole. The calculation includes net impact on heating costs, carbon emissions and air quality.*

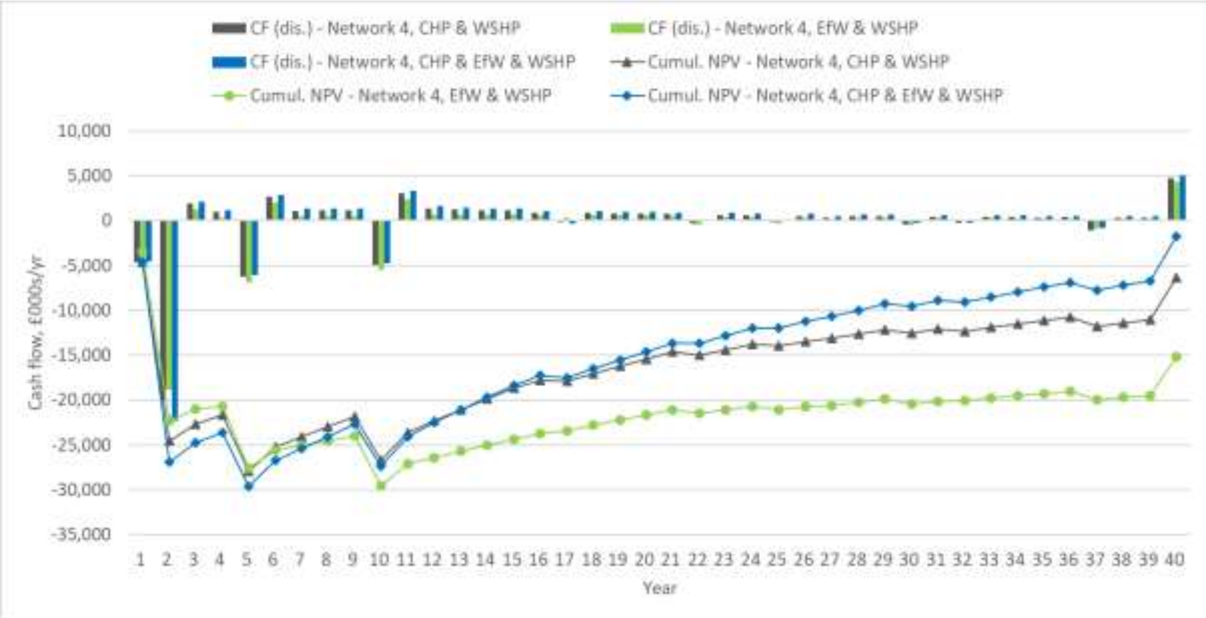

Figure 7-10. Discounted cash flow for Network 4

As with networks 2 and 3, a variant to the option without CHP was explored assuming bulk sale of power from the EfW plant directly to large consumers (hospital, prisons and IoW College) via private wire. The cost of the bulk power is simply assumed to be equivalent to a 'wholesale' power price (accounting for off- and on-peak variation) and the consumer purchase price is as per the assumption used in the CHP private wire analysis, for each consumer. This improves the 25-year IRR significantly to 4.7%[29], potentially making this the best performance of the options considered. Future work should refine this analysis, in liaison with Amey, whilst also improving certainty around the heat price which will be influenced by the availability of RHI, biogenic fraction of the waste stream and z-factor the heat extraction arrangement).

Within the financial modelling, sensitivities of key parameters have been assessed to examine the strength of the economic case for each option. Parameters have only been considered independently although, in reality, individual parameters could change together and have a compound impact (positive or negative); this should be considered in any subsequent investigations. The results are shown in Figure 7-11 to Figure 7-13.

The figures highlight the impact on IRR (25-year) of variation of a number of sensitivities showing the significance of individual issues. The impact of sensitivities, as would be expected, varies between the options, making it complex to succinctly interpret the results, however, the following appear most significant, with the greatest variability being associated with those with CHP included:

- Change in gas prices (particularly for those with gas CHP), although this, in practice is likely to be mitigated by the fact that increasing gas prices will also reasonably allow adjustment in heat tariff and lessen the impact
- Variable component of the heat tariff
- Capital cost change has a significant impact, particularly on those options with CHP. Cost reductions also appear to have a more significant (positive) impact than cost increases (negative).

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[29] *See Appendix 7 & 8 for full assumptions.*

- Energy demand: increase in (e.g. new consumers) has similar scale of impact to loss of demand, e.g. revising consumption estimates downwards from the current assessment or loss of consumers
- Exclusion of RHI revenue for the WSHP option (making the option without CHP return a negative IRR)
- Change in the EfW bulk heat price – whilst the impact is muted where EfW supply is combined with CHP the impact could be significant. The analysis has used a low value of -£4.43/MWh (based on a scenario with RHI and a high z-factor (of 10)) to £12.03/MWh (based on no-RHI and a low z-factor (just over 4)).

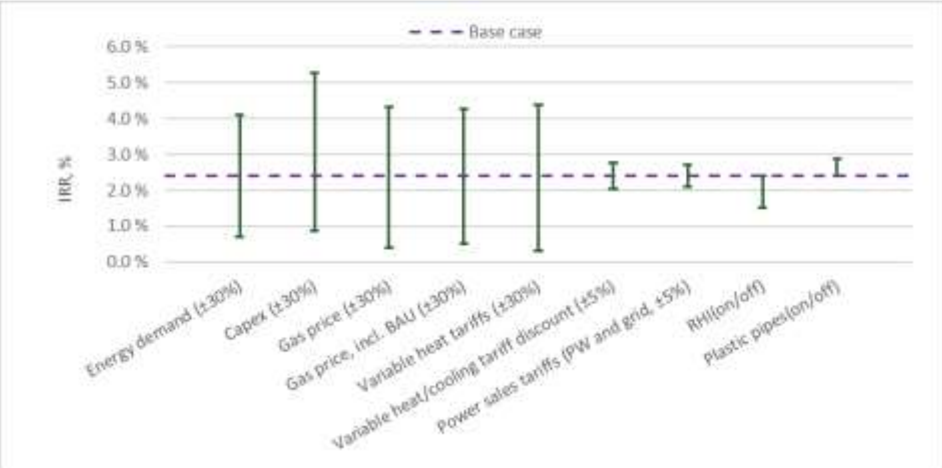


Figure 7-11. IRR sensitivities Network 4 (Gas CHP & WSHP) [30]

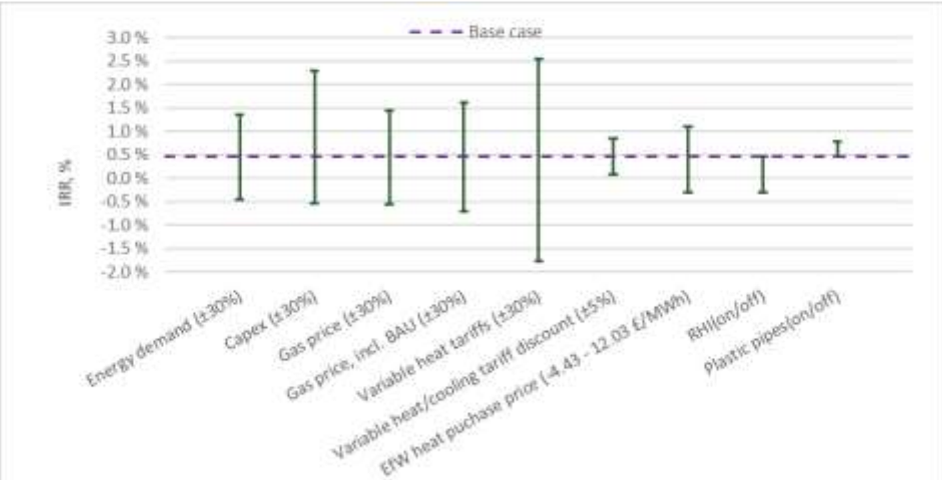


Figure 7-12. IRR sensitivities Network 4 (EfW & WSHP)[30]

[30] *"Gas price incl. BAU" considers changing the cost of gas in both the operation of the heat network and the setting on energy tariffs (which are based on counterfactual costs)*

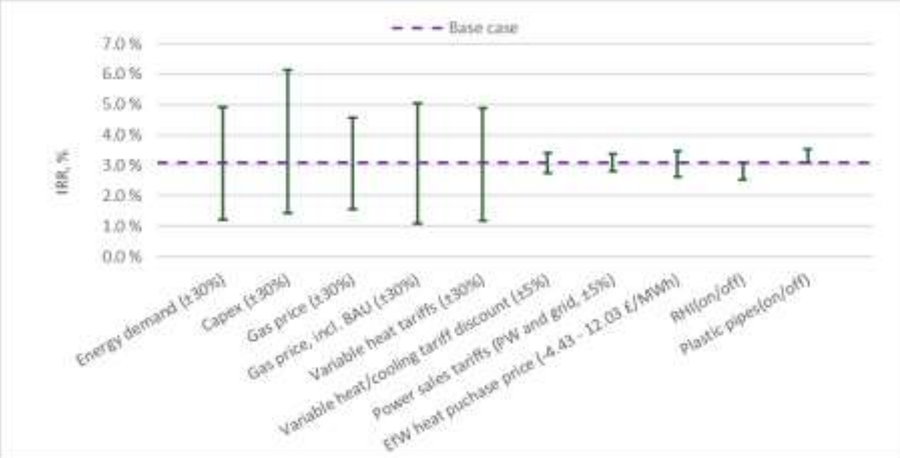


Figure 7-13. IRR sensitivities Network 4 (Gas CHP & EfW & WSHP)[30]

Grant support

Table 7-5 shows the level of the grant support (e.g. HNIP) that would be required to achieve specific rates of return. A 3-7 % rate of return is assumed to be required for a wholly public funded project and above 10-12% is assumed to be required for a wholly privately funded project. It should be noted that all options achieve the HNIP criteria for funding regarding plant sizing.

As Table 7-5 shows, with the exception of the EfW & WSHP supply option, all options appear be able to reach a 10% IRR level without going above the requirement for 50% of capex, which is a reasonable starting assumption for the maximum limit set by state-aid rules. Clearly each option needs fairly significant grant support even to achieve 5% (from 16% to 20% of capital cost). Where public funding requirements for returns are below this then there may be no need for grant support at all. It is considered that all options would be eligible for HNIP funding.

		4 CHP & WSHP	4 EfW & WSHP	4 CHP & EfW & WSHP
IRR 5.0 %	£m	8.7	14.8	7.0
	% capex	20.2 %	36.2 %	15.4 %
IRR 7.0 %	£m	12.6	17.2	11.7
	% capex	29.1 %	42.2 %	25.6 %
IRR 10.0 %	£m	15.6	18.8	15.5
	% capex	36.2 %	46.1 %	34.0 %

Table 7-5. Gap funding required to reach investment thresholds – Network 4.

7.6 Techno-economic conclusions

The techno-economic analysis shows reasonable economic performance for all three options are modest, sitting between 2% and 3%, which is very similar to the Network 3 results. This would suggest they are close to a case for public investment although will probably need grant support. As the grant funding calculation shows between 16% and 47% of the estimated capital costs would need to be sought from HNIP to make any of the options achieve between 5% and 10% IRR, which would move them towards being commercially fund-able.

There is marginal difference between the three options in economic terms. There is also only a relatively small variation in carbon performance with the options varying between 27% and 35% with a greater absolute benefit of between 60 to 78 thousand tonnes of carbon saved (Network 2: 50 to 76 thousand tonnes). Carbon emission reductions are limited by the inclusion of the CHP, making it important to consider whether low cost power could be sourced for consumers or supply plant, e.g. heat pumps from existing local sources, including the EfW and Black Dog facility.

It is recommended that Network 4 is further considered primarily because it provides the opportunity to supply heat network infrastructure to the major urban extensions which will lead to a significant increase in carbon emission unless a low carbon solution is made available. It is noted that the solution for Network 4 requires Network 3 to be implemented, and implemented in time for the design and planning process of the development sites to be include a heat network supply solution.

As per Network 3 EFW and WSHP supply points appear credible and deliverable, although greater detail on each is needed and combining with CHP provides good economic results, supporting the initial investment case (whilst limiting carbon savings). As discussed earlier, heat recovery from the Black Dog AD plant could also be considered (its likely to led to marginal reduction in IRR, based on the current input assumptions). All three alongside CHP (and other local power supply) should be further considered as per the recommendations for Networks 4.

In general, the sensitivity analysis shows that project IRR can be significantly affected by a number of key parameters, and this is not untypical of heat network project. This will require close attention to the design and analysis of the options assuming follow-on development/feasibility work is implemented.

7.6.1 Heat Network benefits

As discussed in section 3.4.4 there are a range of economic and environmental benefits that are estimated to be derived for these heat network options. In summary they are:

1. A general 5% reduction in consumer energy costs (the basis for revenue modelling) and mitigation of future energy cost increases
2. Operational benefits including reduced plant liability and releasing property floor space
3. Reduction in carbon emissions (between 27% and 35% for connected properties - depending on supply technology) and potential to deliver sustained through expansion of switch to lower carbon technologies.
4. Inward investment into the town of between £41m to £46m, depending on option
5. Development of a local energy generation / supply entity
6. Existing IoW planning policy (DM1) requires any residential development over 250 properties to incorporate a heat network solution, where feasible, hence the development of area-wide heat network solution would be very supportive to developer to achieve this obligation
7. Encourage commercial/residential tenant retention in the town

7.6.2 Project risks and techno-economic improvements opportunities

Project risks

As discussed in section 3.4.5 there are a range of project risks that will need to be addressed. An initial risk register has been developed as shown in Appendix 11, which collates the risks all of the network options, showing generic risks (applicable to all options) and a number of specific risks associated with each heat network identified.

The key risks for Network 4 are the same as Network 3 with the additional risk around securing the urban extension as prospective consumers. Whilst there is a planning obligation (DM1) for a heat network solution this will need to be enforced through development control.

The urban extensions are located in two general zones, north and east around HMP IoW and the east of Medina high school. The developments are at an early stage (primarily council planning land allocation) and so lack detail and have inherent uncertainty around quantum and timing of development. Further investigation in any follow-on work into consumer issues is highlighted under the Network 3 section of the report. For the urban extension it would be important to continue to review emerging plans and develop iterations of the techno-economic analysis discussed here.

The risks associated with delivering network infrastructure to the curtilage of the development sites (thereafter risks is assumed to be low) will also need to be resolved.

Techno-economic improvement opportunities

The opportunities identified for networks 3 (and 1 and 2) are still relevant here. However, as a very large network, the solutions proposed to be explored for Network 1, if this was to implement as independent of Network 2, particularly the lower temperature strategy, becomes less relevant. This is not to say that a higher temperature heat network (i.e. Network 2) could not be possible. The main network could essentially be "stepped-down" to supply lower temperatures, e.g. new development in Network 4 where low temperatures may offer efficiency benefits (whilst also adding complexity to the design, construction and operation).

7.7 Development recommendations

Network 4 focuses on extensions to Network 3 to supply a number of major, largely residential urban extensions. At this early stage of investigation, the network as conceived, appears to be deliverable, although it relies on the implementation of Network 3 (or Network 1 or Network 2 to enable partial expansion of these). Similar to Network 3, this network appears to be capable of achieving reasonable commercial performance, but with some grant support required, although this could be limited through further design iterations. Compared to the previous networks it would deliver benefit to an even larger set of consumers, greater economic development support and would quite clearly support the long term objective of decarbonising heat across the town.

There are numerous uncertainties and project development risks that will need to be further considered in any subsequent investigation, which is recommended. Whilst the network is much larger in scale (geographic, number of consumers, and, network and supply sizing) there are no new specific risks, other than to secure the new development are foreseen.

Key development recommendations are the same as Network 3, and assume that key stakeholders agree to continue the development and commit the necessary resources (could be part-funded by BEIS). The key recommended tasks are repeated here for convenience:

- The council should initiate an approval process to move the opportunity on to a formal project development status
- Establish project governance/management arrangements. The council is best placed to lead the development primarily because of the multiple stakeholders. The council may also wish to have an investment and operational role within the scheme. Initially, the council would need to act as a convener (of the key parties – MoJ, IWNHST trust, property developers and energy suppliers) and manage/commission the next stages of work (typically 'detailed feasibility' and 'detailed project development').
- Detailed feasibility work: to move specific project opportunities towards being a formal investment opportunity it should address key risks, uncertainties and improvement opportunities including (see network 3 for further detail):
    - Securing one or more of the supply options
    - Securing the anchor consumers
    - Review alternative design options and update existing ones to add value
    - Review/establish ownership, procurement and funding strategies

General development recommendations (across all network options) are also discussed in section 8.

8 Development recommendations (across all heat network opportunities)

As highlighted in the individual heat network sections of the report the development of the three larger networks (2,3 and 4) is recommended. If Network 1: Newport Harbour is to be implemented the economic case would need to be further developed but this may drive it toward being based on a low temperature strategy (and may not deliver a commercially viable scheme). As a consequence this may further negatively impact economic performance of Networks 2, 3 and 4.

Rationalising the opportunities for heat networks in North Newport it is recommended:

1. The council should initiate an approval process to move all or some of the network options and supply variants on to a formal project development status

2. That detailed feasibility is commissioned to provide greater confidence in the preferred options:
    a. exploring key consumers connections
    b. exploring supply issues (to secure preferred options)
    c. exploring network and related risks
    d. engaging with key stakeholders (existing "anchor" consumers, property developers and operators of the potential supply operators)
    e. examining ownership, procurement and funding (post-feasibility) strategies[31]
    f. developing project delivery plan (s)

3. The council resolves with stakeholders how to establish a robust project management/governance arrangement, which, for the larger networks would lead to working partnerships. This process is best led by the council in Networks 1, 3, and 4 but in Network 2 it may be suitable for one of the key consumers (IWNHST or MoJ) to lead the process

   Initially, the council would need to act as a convener (of the key parties – MoJ, IWNHST trust, property developers and energy suppliers) and manage/commission the next stages of work (typically 'detailed feasibility' and 'detailed project development').

[31] *Various choices existing, including a publicly owned/operated heat network, a public joint venture, a private-public joint venture or various options for private ownership/operation, including a concessions contract arrangement*

Appendix 1. Energy mapping

Heat mapping methodology

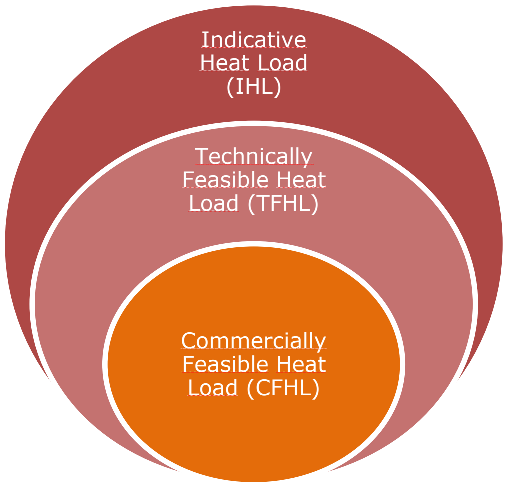
The heat mapping is conducted by utilising data from various sources including:

- Primary consumption data for existing consumers (replacing benchmarked data), where it was made available by stakeholders
- ERIC (NHS facilities)
- Filed EPC and DEC records
- Isle of Wight Strategic Housing Land Availability Assessment
- Development site planning documents
- Open source information (e.g. Google Maps)

Significant consumers were identified in the Newport Heat Mapping report (Greenfield, December 2018). Additional demands were identified in the area by engagement with the local authority. Where actual metered data or filed EPC and DEC records were not available, benchmarking analysis was used to estimate heat, electricity and cooling loads. The benchmarking methodology is described in the sections below.

Identifying appropriate loads

The figure below illustrates the various classifications of the energy load assessments that are used. Typically, the first, Indicative Heat Load (IHL) is determined from current energy use to provide heat, e.g. gas used in a boiler to provide heat. Where available, actual consumption information is used to determine the heat load. If actual consumption information is not available, then benchmarking is conducted, or where this is not possible, then other secondary data such as data from Energy Performance Certificates (EPCs) or Display Energy Certificates (DECs) could be used. Benchmarking and use of secondary data brings inaccuracies and uncertainty, and so metered data is always preferable but is frequently unavailable, particularly during early stage investigations.



The second classification is Technically Feasible Heat Load (TFHL) which is arrived at by adjusting IHL to account for non-displaceable loads, i.e. those that cannot be substituted by a heat network using hot water. Reasons could include that energy is required in the form of steam or at temperatures that are unsuited to a hot water network. At an early stage of analysis, this level of detail would typically only be considered for major consumers.

The final classification is Commercially Feasible Heat Load (CFHL), which is determined by excluding those loads for which supply from a heat network supply is unlikely to be commercial viable, e.g. an existing low-cost supply is available, or the cost of the transmission pipework required would be excessive. Commercial issues might also include phasing of the replacement of existing plant, the relative cost of connection, the loss of other potential revenues, e.g. from power generation where local CHP is being considered. CFHL is the thermal load that would ideally be modelled to determine the overall load required within a heat network. It is not always possible, for all prospective consumers, particularly at early stages of feasibility, to arrive at reasonable estimates for CFHL and this can subsequently be dealt with through risk and sensitivity analyses.

The methodologies used to analyse the heat loads of different building categories are presented in the following sections.

Existing buildings

Metered consumption

Where available, actual consumption information is used to determine the heat load. Actual consumption data varies from half-hourly/hourly, monthly or annual level data.

The consumption data, typically gas consumption data, was used to calculate the heat demand under the assumption of thermal efficiency of 80% for traditional boiler systems across the whole data set.

If the consumption data was available at monthly or annual level, the data was time-profiled against assumed building occupation hours and heating degree days, to arrive at hourly consumption profiles.

Benchmarking

Annual consumption for all energy consumption is estimated through benchmarks based on property use, type of building, estimated internal floor area and number of dwellings. In order to reflect the energy performance of modern buildings, where applicable, good practice values from published benchmarks such as BEES and NEED for existing properties. Benchmark assessments are weather-corrected against local degree-days to match the number of annual heating degree days in the local area.

The BEES benchmarks define heating, hot water, cooling and electricity demands. NEED benchmarks define gas and electricity consumption per dwelling (the data can be sorted to by e.g. property type and property age). A typical boiler efficiency of 80% is then applied to arrive at a heat consumption estimate.

Annual heating demand was then also time-profiled against assumed building occupation hours and heating degree days based on external temperature variations in the local area. For occupied periods a heating degree day reference temperature of 15.5°C is assumed and during unoccupied hours 10.5°C. The analysis is used to generate estimated peak demands and consumption profiles for hot water and heating.

Hourly electricity demand profiles are generally calculated by applying typical winter (October-April) and summer (May-September) billing profiles for non-domestic buildings to the annual consumption data. Where electricity consumption demand profiles for a particular type of building is available then these were applied.

New development

Future energy demand has been estimated and profiled (on an hourly basis) for new development. A variety of planning, master planning and design-stage information has been used. The methodology for the analysis is as follows:

1. Sites have been split out into the different building use types (space types), so that each consumption type may be modelled separately.
2. Energy consumption benchmarks have been applied to each space type, using an appropriate benchmark. This calculation is done within an in-house energy demand modelling tool.
3. The total heat and electricity demand for the site are then mapped onto an hourly energy demand profile, using an energy profiling tool which incorporates energy demand profiles for different use types.
4. The total demand and demand profiles have been adjusted to account for degree day variations.

The following energy consumption benchmarks have been utilised:

1. BEES benchmark data was used to model the energy demand of the commercial use areas.
2. Building Regulations 2013 standards were applied to model benchmark data used to examine residential development.
3. NEED provides primary heat benchmarks for dwellings. A boiler efficiency of 80% was assumed to convert this figure into heat demand.
4. Existing hourly energy demand profiles have been used based on space type.
5. Heating benchmarks were adjusted according to any variation in Degree Days between the site and the UK average. A base temperature of 15.5ºC was assumed for heating.

Appendix 2. Prospective consumers

Schedule of prospective consumers

Site	Peak heat (MW)	Heat Load (MWh)	Power Load[32] (MWh)	Data Source[33]
St Mary's Hospital - Main Hospital	2.35	11,354	6,478	Metering (NHS)
HMP Parkhurst	2.80	7,074	1,446	Metering (MoJ)
HMP Albany	2.17	5,488	2,293	
Former HMP Site	2.35	3,180		New development benchmarking
Land at and adjacent to New Fairlee Farm (development)	1.87	2,332		
Newport Harbour (development)	1.47	2,313		
Medina Leisure Centre & Medina High School[34]	1.43	2,264		Metering (IoW Council)
Isle of Wight College	1.04	1,526	1,836	
Land at Horsebridge Hill & Acorn Farm (development)	0.98	994		New development benchmarking
Land at Noke Common (development)	0.58	477		
Newport County Hall and Car Park	0.29	425		Metering (IoW Council)
Newport Police Station	0.07	168		DEC
Former Library HQ, Land Adjacent St Mary's Hospital	0.28	133		New development benchmarking
TOTAL (ALL)	**17.70**	**37,727**	**12,053**	

Consumer notes

St Mary's Hospital (Isle of Wight NHS Trust)

St Mary's Hospital is a 477-bed acute hospital campus (see site plan below) located to the north of on Median Road. It is operated by the Isle of Wight NHS Trust.

In addition individual boiler (some supply a number of properties) the Hospital has an existing 300 kWe CHP installation used in a tri-generation application in within the main building. At circa 10 years old the existing plant, which is owned by the Trust, is coming towards the end of its useful life.

The Hospital provided metered consumption data for gas and power and information relating to the location of existing boiler plant. The Trust confirmed an interest in exploring a connection to a district energy system to reduce energy cost and carbon emissions. The hospital requires a high degree of resilience with respect to energy supply and presently this includes back-up power generation partly supplied by the CHP plant (although this is due to switch to stand-alone generators in 2019) and dual-fuel boiler plant. The trust confirmed that energy supply from a heat network solution would not, in principle, require an energy centre to be located on the campus, although it was considered that sufficient space could probably be found on the site. The heat network supply arrangements, however, would need to demonstrate sufficient resilience to be acceptable (alongside other performance and commercial requirements).

[32] *Connected to private wire network*

[33] *BEES and NEED refers to benchmarking used*

[34] *Gas-fired CHP, also supplies Medina High School*

HMP Isle of Wight

The Ministry of Justice (MoJ) provided energy consumption data for the HMP Isle of Wight (made up of two prison campuses HMP Albany and HMP Parkhurst) from 2014-18. The average heat consumption over the period was 6.9 GWh for HMP Albany and 8.8 GWh for HMP Parkhurst.

The MoJ has confirmed an interest in further considering both heat and power supply from a heat network system and identified that land to the east of HMP Albany (which is in close proximity to St Mary's hospital) may be available for the siting of an energy centre, where this is required.

HMP Camp Hill, to the west of HMP Albany has been closed and the site is likely to be redeveloped for housing. This site has been included with the other urban extension developments in the Network 4 analysis.

Isle of Wight College

The Isle of Wight training college is a general further education college (GFE). The college operates with a broad curriculum to reflect the needs of the island community. The College is the island's major provider of further education and training for some 8,000 learners and has built more accommodation over the past five years. It is also a Centre of Vocational Excellence (CoVE) in four areas; care, hospitality, marine engineering and early years.

The college site consists of five main buildings, which are assumed to be heated by gas boilers. The college provided annual metered data for gas and power.

Newport Harbour development

Newport Harbour is a mixed-use development aiming to regenerate the Harbour area on the shores of River Medina.

The development masterplan is currently being revised and in the absence of this the prior masterplan from 2017[35] has been utilised. Out of the three options presented in this study, the central option, in terms of the extent of development, was selected for use for the heat network analysis. This assumes the development would consist of terraced housing, apartments, shops and restaurants, workshops/studios, hotels, market and community facilities. In total a 41,236 m^2 of new commercial floorspace and 216 new residential units is assumed.

A map and schedule of development are shown below.

[35] *Newport Harbour Feasibility Study, Ash Sakula Achitects, Imagine Places and 31 Ten (June 2017)*

New Buildings GEA

Type	Ground	First	Second	Third	Fourth	Fifth	Total Area (sq m)
Terraced houses	7,333	7,333	5,745				20,411
Apartments	795	2,360	2,360				5,515
Shops and restaurants	3,280						3,280
Workshops/studios	830	2,430	2,430				5,690
Community facilities	1,985	1,985					3,970
Hotels	525	525	525				1,575
Markets	795						795
						Total	**41,236**

Residential Units

Type	Terraced	Apartment	Total No. of Units
East	95	56	151
West	11	9	20
Town	35	10	45
		Total	**216**

Parking Spaces

Type	Covered	External	Total No. of Units
East		20	20
West		0	0
Town		10	10
		Total	**30**

Notes

External parking in the East and town will be for residential use

Does not include existing carparks around Premier Inn and Council Office

All areas are gross external areas in sq m

Newport land allocations – urban extensions include in the Network 4 analysis

Based on land allocations and forecasted housing construction estimates from Isle of Wight Council planning service (draft Island Planning Strategy consultation document) estimates of thermal energy demand has been developed, using benchmarks from recent housing developments as shown in the table below.

Site	Dwellings	Modelled heat consumption (MWh)
117 Medina Avenue	12	32
Test Centre site, 23 Medina Avenue	6	16
Various land adjacent to and east of Carrisbrooke College	175	464
Land at Horsebridge Hill & Acorn Farm	375	994
Land west of Sylvan Drive	200	530
Land off Gunville Road (east)	40	106
Land off Gunville Road, (west)	20	53
Land at Noke Common	180	477
Former Library HQ, Land Adjacent St Mary's Hospital	50	133
Land off Broadwood Lane	150	398
Former HMP Site	1200	3,180
Land at Morey's	100	265
Land at and adjacent to New Fairlee Farm,	880	2,332
Barton School Site, Green Street	25	66
part OS Parcel 5627 off Pan Lane, east of St. Georges Way and directly south of Asda, Newport, Isle Of Wight	7	19
Land at Landscape Lane	10	27
Land at Fairlee Road, Hillside	15	40
Total	**3,445**	**9,129**

Land allocations in Newport

Appendix 3. Supply technology descriptions

Gas CHP

Combined heat and power (CHP) systems capture the heat released during power generation, resulting in reduced energy losses and increased energy efficiency. Typical technology in small mixed used heating systems (<5 MW) and medium size (<20 MW) district heating systems are reciprocating gas-fired engine CHP systems. Overall efficiency in such systems is in the range of 80 to 90% with power to heat factor at 90 to 110%.

Gas fired CHP is a proven technology able to deliver short-term carbon savings and also provide both heat and power to district energy networks. Electricity can be distributed via a grid connection or by private wire to local customers. Key to good economic performance is identifying private wire opportunities to enable power to be sold at (near to) the retail electricity price (rather than the grid wholesale price).

Another aspect of achieving good economic performance is ensuring the gas CHP capacity is appropriately dimensioned. Capital and operating costs are relatively high and CHP plant is not suited to modulation (turning down) and as a consequence, utilisation (or load factor) needs to high to generate sufficient value from energy supply whilst minimising maintenance costs. Typically, gas CHP will met a baseload supply, operating for a minimum of 5,000 hours per year, with gas boilers/thermal storage are providing top up and back up.

Energy centre location and utility connections (gas and electricity) is also important factor as utility connections can add significant capital costs.

A well-designed gas CHP can modestly reduce carbon emissions due to its higher efficiency compared to the alternative case of conventional gas boiler and grid electricity produced mostly by large distant "power only" power stations. District heating CHP technology is appropriate today from a carbon perspective but would deliver reduced savings if the grid sourced electricity decarbonises in the future (as predicted), which leads to the need to replace or supplement the technology overtime with lower carbon technologies, if carbon saving is a primary objective.

Heat recovery from Energy from Waste facility at Forest Road

The option refers to the extraction of heat from Isle of Wight Waste Recovery Park options which is an Advanced Thermal Treatment (ATT) plant that is presently being refurbished/updated. It is located at the existing Household Waste and Recycling Centre (HWRC) at Forest Park Industrial Estate. The location plan of the site is shown below.

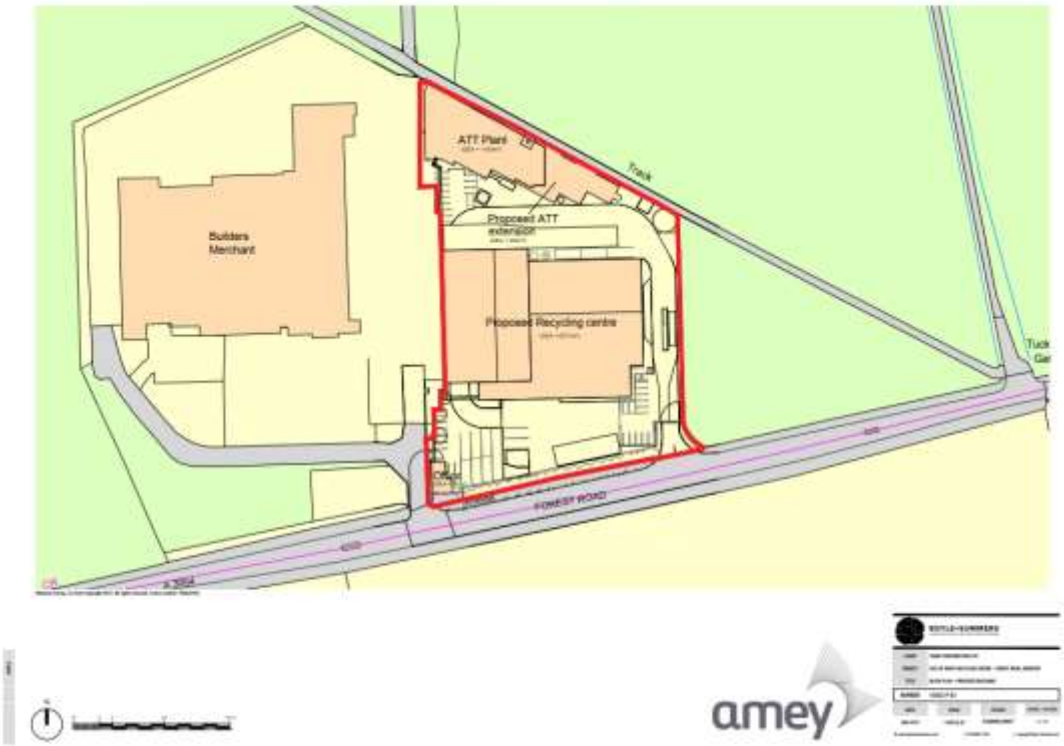


Figure - Location plan of the Isle of Wight Waste Recovery Park.

The upgraded ATT plant will include power generation via steam turbines with a 3.3 MW_e peak electrical output with approx. 3.0 MW_e electricity export capacity (300kWe parasitic load). The ATT facility is designed to be 'CHP-Ready' with a tapping point located on the turbine, a turbine bleed, from which steam can be extracted to provide heat at any time in the future. Amey have suggested a possible heat output capacity in the region of 2.5MW_{th}. The plant is planned to operate 7,800 hours per year which indicates an export potential of 19.5 GWh/yr. Amey were unable to confirm costs of bulk heat supply which could vary depending on which part of the process it is extracted from and the impact on power generation, which could zero in the case where lower temperature "waste" heat is extracted. They were also unable to confirm estimates of capital cost for installation of heat extraction equipment study. Costs have therefore been taken from recently published research work (see Appendix 7) and capital costs of the plant have been estimated by Greenfield Nordic. Both present material uncertainties within the financial and plant sizing modelling which should be further considered in the follow on work.

Heat recovery from Black Dog Anaerobic Digestion plant at Stag Lane

The Black Dog Anaerobic Digestion plant is a German MT-Energie designed and built facility incorporating a main digester, post digester and a storage tank. The plant produces approx. 95,000 m^3 of biogas per week which powers CHP units with gas engines from 60 tonnes of feed per day (Maize, Grass and dry materials).

The plant consists of 2 no. CHP units, the first a 2G German unit producing 500KW power and heat and an AB Italian CHP unit which generates 637KW of power and a similar amount of heat. Exportable heat is estimated be approx. 1-1.15 MW based on hot water at around 85 °C. The CHP plant operates 24/7, with stops for planned maintenance every 2,000 hours.

Water-Source Heat Pumps

Water source heat pumps operate by taking heat from the water, upgrading to useable temperatures through an electrically driven heat pump system so that it can be fed into a building or local heat networks. The WSHP system will include a heat pump unit (or units) and a water pumping system which might be integrated in the WSHP heat pump energy centre or be a separate pumping station close to the water source. Water abstraction and discharge pipes are required in both cases.

COP (Coefficient of Performance) of the heat pump is mainly dependent on the temperature difference between the lowest and highest temperature in the system. If abstracted water temperature is 10 degrees and it is discharged at 5 °C and district heating flow temperature is 75 ˚C the highest temperature difference in the system is 70 °C. In the above case COP might reach the level of 2.5 to 3.0. If assuming that COP is 2.75 it means that one (1) part of electricity is consumed to produce 2.75 parts of thermal energy.

Using water source heat pumps would achieve savings in CO_2 emissions and also gain financial support in the form of Renewable Heat Incentive (RHI); current rates for all capacities for WSHP and GSHPs are: tier 1, £95.6 /MWh and tier 2, £28.5/MWh.

Technically, when looking at the feasibility of implementing a heat pump into a specific river or canal the two most important characteristics are water temperature and flow rates.

Ground-Source Heat Pumps

Ground-source heat pumps (GSHPs) are a well-established technology that can economically heat buildings in most locations by absorbing heat from the ground and/or ground water.

The system consists of a heat pump system (heat pump units and ancillary equipment including pumps, heat exchangers, pipes etc.) and a ground heat exchanger system or groundwater boreholes.

The type of ground source heat exchangers can be divided into two main groups which are shallow (1.0–2.5 m) horizontal heat exchangers and deep (15–200 m) vertical systems. Shallow horizontal heat exchangers are common for residential installations as their investment cost is lower compared to deep vertical systems. Due to the relatively low temperature of shallow ground layers during the heating season, efficiency is relatively low. Deep vertical systems are not dependent on the top layer of the ground as a source of heat, and the nature of its seasonally varying temperature, rather it relies on migration of heat from surrounding deeper geology, where the temperature is almost constant during the year. As a consequence, they are more efficient without necessarily being more expensive to install.

A vertical closed loop field is composed of pipes that run vertically in the ground. This would consist of and array of boreholes, commonly filled with bentonite grout surrounding the pipe to provide a good thermal connection to the surrounding soil or rock to improve the heat transfer. The conductivity will influence system performance.

In some cases, an open-loop system, which utilises groundwater abstracted from an aquifer may be possible. Groundwater is directly abstracted and pumped through the heat exchanger (evaporator) inside the heat pump, and water is returned (discharged) through a separate injection well back to the aquifer, meaning zero net abstraction. Abstraction and discharge or groundwater would require Environment Agency licensing, for a flow rates greater than 20 l/s. Groundwater systems are suitable where there is near-surface bedrock and is typically not suitable in locations where the geology is mostly clay, silt, or sand.

Further analysis on both open-loop GSHP and closed-loop GSHP potential for Ryde and Newport networks was conducted based on a hydrology/geology report by British Geological Survey (BGS) for a specific location at the Nicholson Road development site in Ryde. It is broadly anticipated that the findings here also apply to Newport. Based on the report's findings, both open-loop and closed-loop GSHP were deemed unsuitable for the area and thus excluded as a supply option.

Bedrock in the area is mostly various types of clay or sand, which means low ground thermal conductivity and poor performance for closed-loop systems. Poor thermal performance directly increases the GSHP systems £/kW cost as more boreholes or deeper boreholes are needed to generate the amount of heat demanded. Furthermore, the sandy bedrock can potentially cause issues (based on logs from previous borehole drilling in the area) during drilling/installation of the ground-loop collectors, which further increases investment costs for the GSHP system.

An open-loop GSHP was also deemed unsuitable based on the BGS report. Potential water yield from the main aquifer in the area is very low; the best yield identified from any previously drilled borehole in the area is just 9 l/s (for a 10 hr period) and to achieve a constant flow rate to support a heat network would mean extracting at the rate lower than the maximum identified. The BGS report also identified that boreholes in the area have experienced decline in yield over time due to clogging caused by the fine-grained sand. Sand screens and filter packs would be required to be installed to the borehole to minimise clogging effects, increasing the installation costs. Drilling costs are also increased due to the sandy ground type. Multiple boreholes are needed for any significantly sized open-loop system and careful siting of the boreholes is required to minimise any hydraulic and thermal interference effects.

In this study, were the GSHPs option possible then it would be assumed industrial-scale solutions based on centrifugal compressor units would be used. COP of the heat pump is typically at the level of 2.5 to 3.0, depending on the ground loop's and heat network's temperature levels.

Ground source heat pumps are characterised by high capital costs. Capital costs of boreholes with ground loop systems are typically between 20–30% of the total capital costs of GWHP's but this is dependent on local geological conditions. Land contamination can restrict the pipe location.

Renewable Heat Incentive (RHI) tariff payments are available for ground source heat pumps. In addition, waste heat can also be used to replenish ground heat, e.g. from cooling systems, with the full output of a heat pump receiving RHI payments where the waste heat contributes up to one third of the overall thermal input into heat pump, i.e. two thirds would need to come directly from the ground.

Gas Boilers

Gas fired boilers are common generation plant for individual heating systems as well as for centralised district heating. Gas is a fossil-based energy source that has low capital costs and flexibility to be used at different operating temperatures and it reacts quickly in load variations. Gas boilers are often used as back-up and peak boilers in district heating systems alongside combined heat and power baseload generation plants.

Heat Storage Systems

In addition to the energy supply options considered above, heat storage can be a useful addition to a heat network. The optimum use of the capacity mix can be enhanced by including heat storage which is used to even out momentary demand variations and most importantly, can increase the use of base load capacity, maximising carbon reduction and use of the least-cost supply option. During periods of low heat demand (e.g. during night periods and at weekends) the excess base-load capacity can be used to 'charge' the heat storage and correspondingly, during high heat demand the storage 'discharges' partially replacing peak supply plant (gas boilers).

In addition, heat storage brings other operational benefits by reducing the need of short-term modulation of heat production from CHP, heat pumps or boiler systems; this helps to ensure higher efficiency and will also reduce the maintenance needs. Other operational benefits also include production optimisation with energy price hourly variations. This concerns mainly on Gas CHPs and heat pumps; CHP electricity generation can be scheduled at the times when electricity price is high and WSHP when electricity price is low, respectively.

Appendix 4. Heat network pipe dimensions, operating assumption and costs

In this study, the district heating network layout and pipework has been optimised and dimensioned using TERMIS district heating/cooling hydraulic modelling software. The design parameters used for dimensioning are presented in the table below.

Parameter	Value	Source
Maximum design temperature Maximum operating temperature	140°C 120°C	HVAC TR/20, 2003
Upper dimensioning supply temperature – Flow (plant outlet)	90°C 85°C (AD) 80°C (heat pumps)	HNCP[36], BEIS report: Assessment of the costs and performance of HNs (Bulk schemes, max value), supplier data
Lower dimensioning temperature – Return (consumer HIU)	55°C 45°C (new developments)	HNCP
Maximum design gauge pressure	16.0 bar	HVAC TR/20, 2003
Static return pressure	3.0 bar	Greenfield experience from prior projects
Pressure loss guideline to be used in design Main lines Branches	 100 Pa/m 250 Pa/m	 London Heat Network Manual London Heat Network Manual
Minimum pressure difference at consumer HIU	60 kPa	HNCP
Pipe series	2	Greenfield analysis

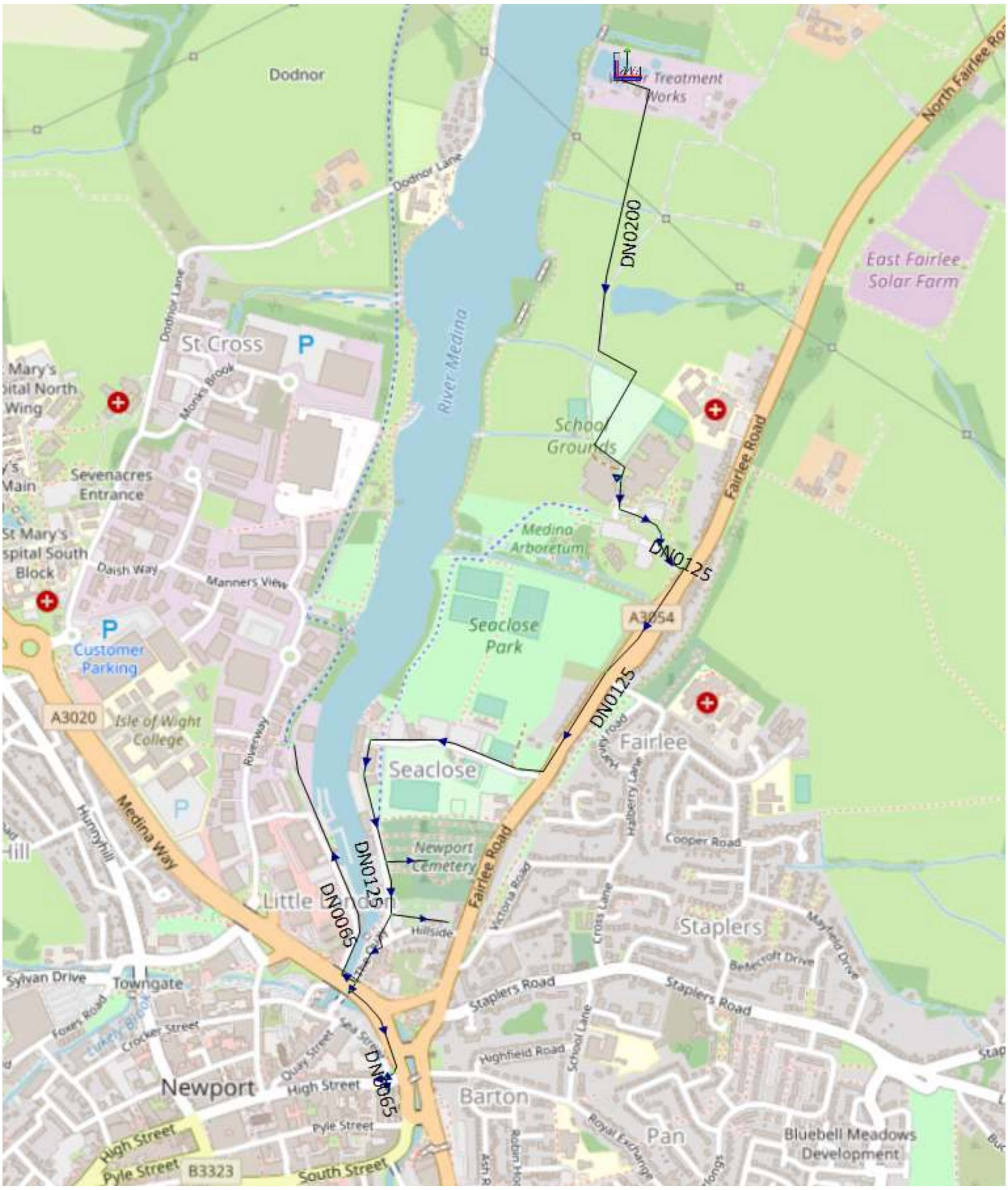
Design parameter assumptions used for hydraulic modelling of the heat network.

The Heat Networks proposed are dimensioned with a source (or flow) temperature of 90°C at peak demand. It is proposed that the network would operate on a variable flow and variable temperature basis, with changes in both responding to the instantaneous consumption needs. Higher loads will require greater water flow (controlled at the 'consumer substations' or 'Heat Interface Unit') and higher source (often called 'flow') temperatures.

The flow temperature would typically reside around 80-85°C until an outdoor temperature of below 0-5°C occurs. With colder weather, the flow temperature is gradually increased towards the maximum temperature. Return temperature is dependent on correct/optimum design and operation of consumer substations and building heating systems, varying normally between 45-55°C.

Pipe dimensions and capital cost breakdowns are presented in the tables below for all examined network options.

[36] *Heat Networks Code of Practice*



Network 1 Newport Harbour+ consumer zone (WSHP) pipe dimensions.

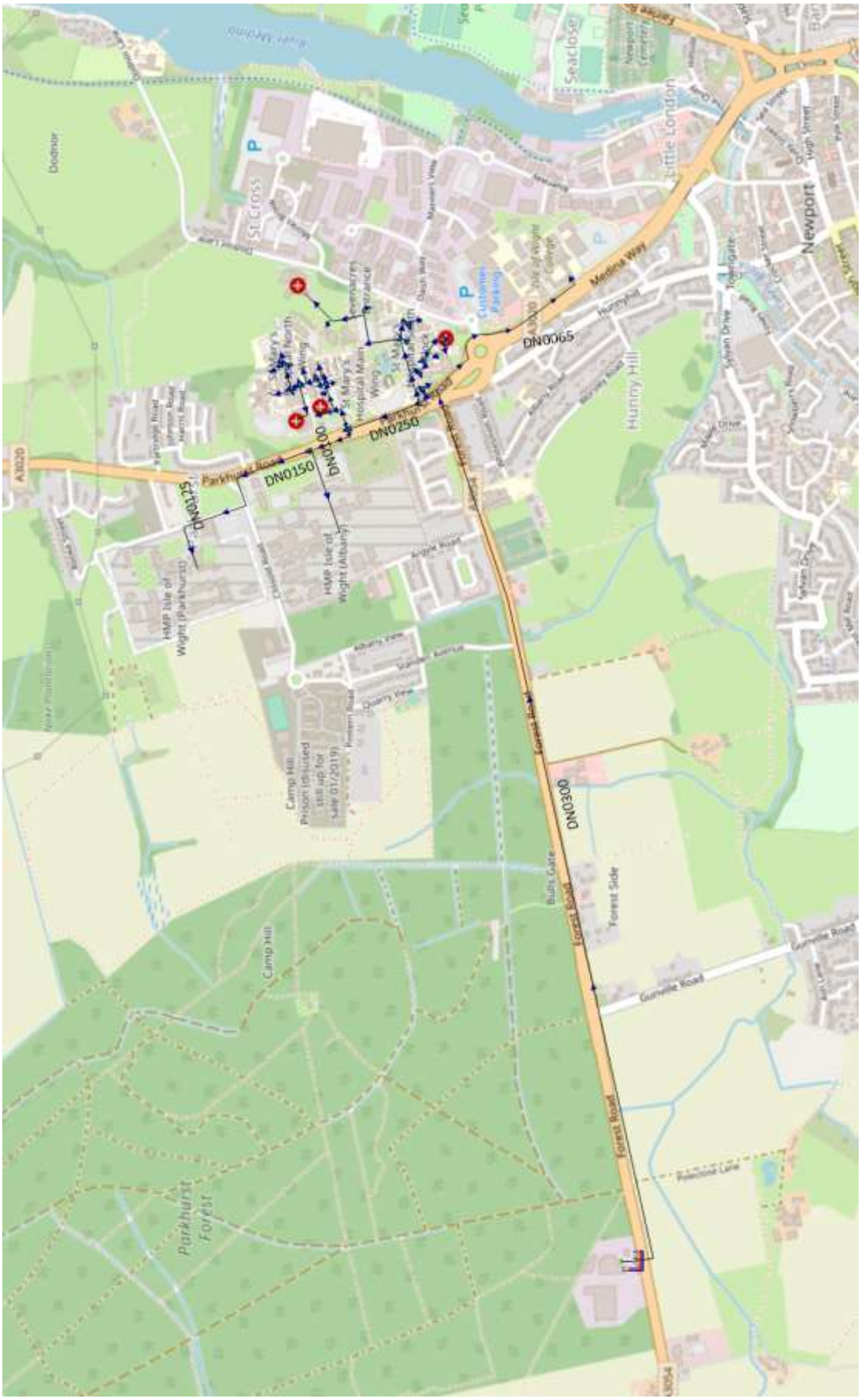
	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,080	252.7	260.8	513.5
DN25	-	-	-	-
DN32	20	4.9	12.4	17.3
DN40	-	-	-	-
DN50	-	-	-	-
DN65	940	301.0	461.9	762.9
DN80	-	-	-	-
DN100	270	113.0	195.3	308.3
DN125	1,306	595.3	802.8	1,398.1
DN150	-	-	-	-
DN200	948	538.7	531.0	1,069.7
DN250	-	-	-	-
Subtotal	4,565	1,805.6	2,264.1	4,069.7
Constraint mitigation				26.0
Contingency (10%)		180.6	226.4	409.6
Total	4,565	1,986.1	2,490.5	4,505.3

Network 1 Newport Harbour+ consumer zone (WSHP) pipe dimensions and capital costs.

Network 1 Newport Harbour+ consumer zone (AD plant) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,080	252.7	260.8	513.5
DN25	-	-	-	-
DN32	20	4.9	12.4	17.3
DN40	-	-	-	-
DN50	-	-	-	-
DN65	940	301.0	461.9	762.9
DN80	-	-	-	-
DN100	270	113.0	195.3	308.3
DN125	1,306	595.3	802.8	1,398.1
DN150	-	-	-	-
DN200	948	538.7	531.0	1,069.7
DN250	-	-	-	-
Subtotal	4,565	1,805.6	2,264.1	4,069.7
Constraint mitigation				26.0
Contingency (10%)		180.6	226.4	409.6
Total	4,565	1,986.1	2,490.5	4,505.3

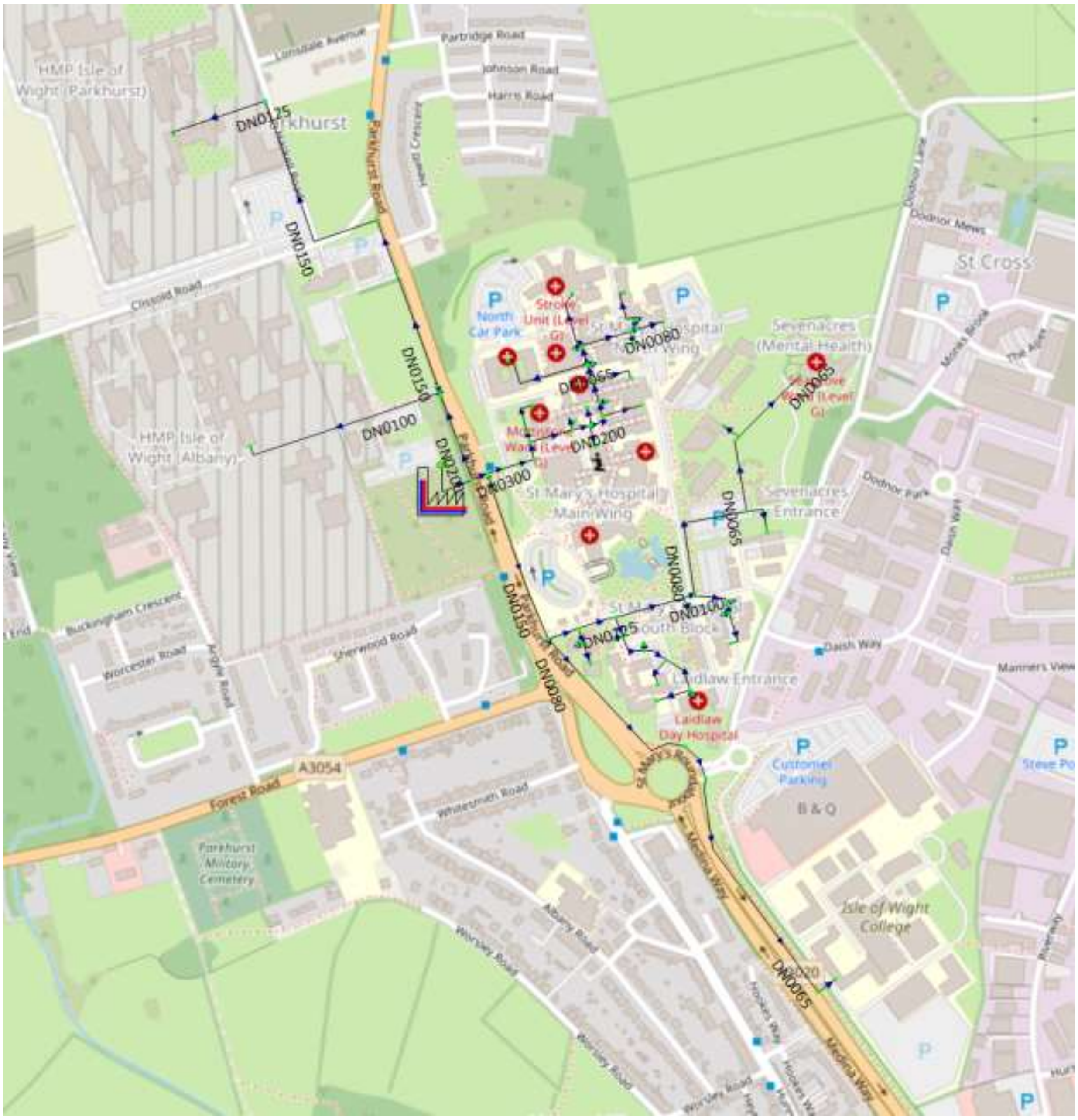
Network 1 Newport Harbour+ consumer zone (AD plant) pipe dimensions and capital costs.



Network 2 Hospital and HMP IoW zone (EfW) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	56	13.2	20.7	33.9
DN25	147	34.5	71.0	105.4
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	282	84.7	160.6	245.3
DN65	938	300.1	453.9	754.0
DN80	297	102.2	148.4	250.6
DN100	318	132.8	228.8	361.5
DN125	2,721	1,239.8	1,459.0	2,698.9
DN150	513	266.9	332.8	599.7
DN200	455	258.3	332.4	590.8
DN250	19	12.1	15.5	27.6
DN300	37	24.2	22.3	46.5
Subtotal	5,965	2,520.1	3,342.8	5,862.9
Constraint mitigation				-
Contingency (10%)		252.0	334.3	586.3
Total	5,965	2,772.2	3,677.1	6,449.2

Network 2 Hospital and HMP IoW zone (EfW) pipe dimensions and capital costs.



Network 2 Hospital and HMP IoW zone (Gas CHP) pipe dimensions.

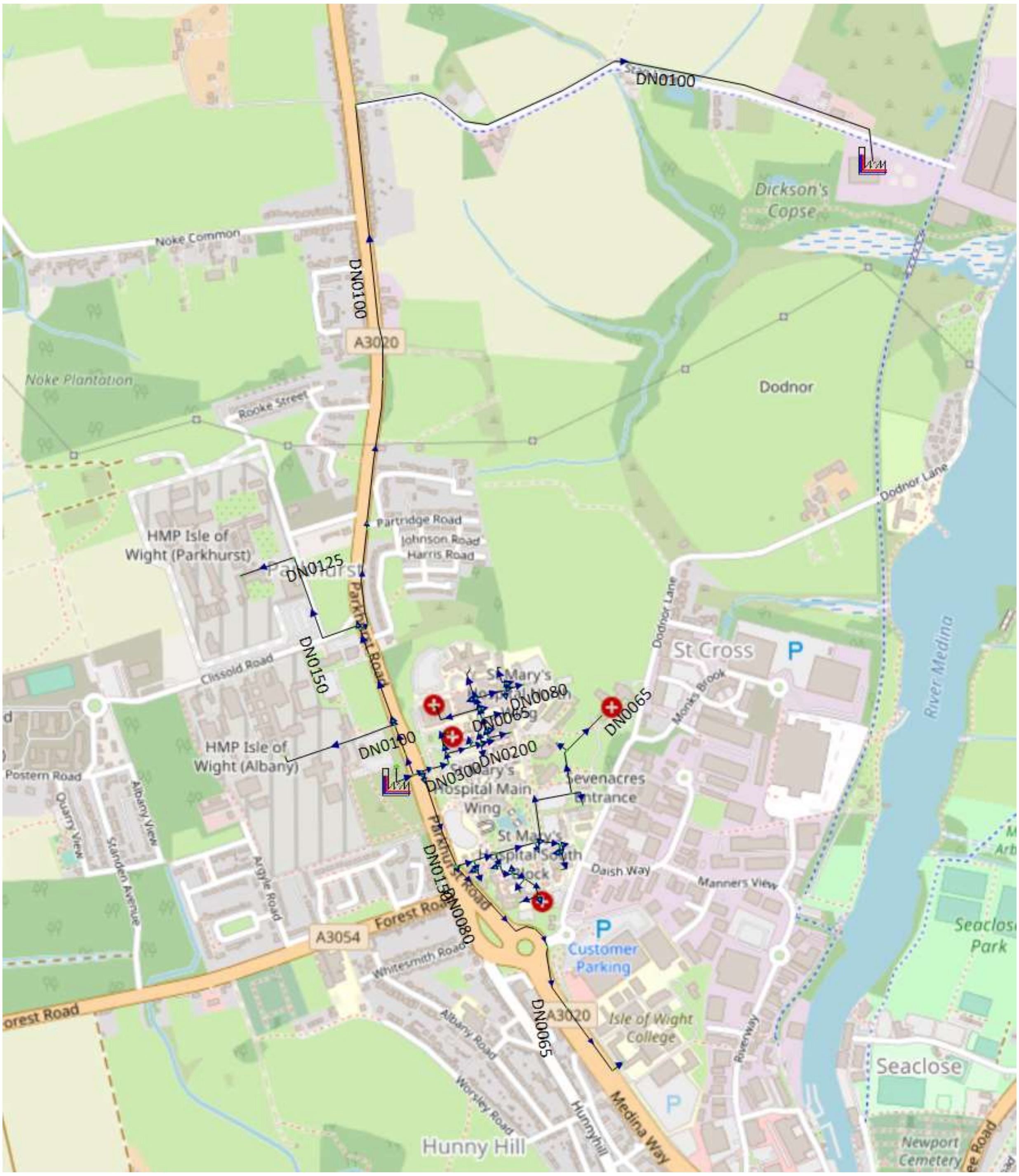
	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	56	13.2	20.7	33.9
DN25	147	34.5	71.0	105.4
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	282	84.7	160.6	245.3
DN65	938	300.1	453.9	754.0
DN80	355	122.0	176.6	298.6
DN100	318	132.8	228.8	361.5
DN125	329	149.8	195.0	344.8
DN150	657	341.6	454.1	795.6
DN200	253	144.0	173.2	317.2
DN250	19	12.1	15.5	27.6
DN300	37	24.2	22.3	46.5
Subtotal	3,573	1,410.3	2,069.0	3,479.2
Constraint mitigation				-
Contingency (10%)		141.0	206.9	347.9
Total	3,573	1,551.3	2,275.8	3,827.1

Network 2 Hospital and HMP IoW zone (Gas CHP) pipe dimensions and capital costs.

Network 2 Hospital and HMP IoW zone (Gas CHP & EfW) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	56	13.2	20.7	33.9
DN25	147	34.5	71.0	105.4
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	282	84.7	160.6	245.3
DN65	938	300.1	453.9	754.0
DN80	297	102.2	148.4	250.6
DN100	318	132.8	228.8	361.5
DN125	2,721	1,239.8	1,459.0	2,698.9
DN150	513	266.9	332.8	599.7
DN200	455	258.3	332.4	590.8
DN250	19	12.1	15.5	27.6
DN300	37	24.2	22.3	46.5
Subtotal	5,965	2,520.1	3,342.8	5,862.9
Constraint mitigation				-
Contingency (10%)		252.0	334.3	586.3
Total	5,965	2,772.2	3,677.1	6,449.2

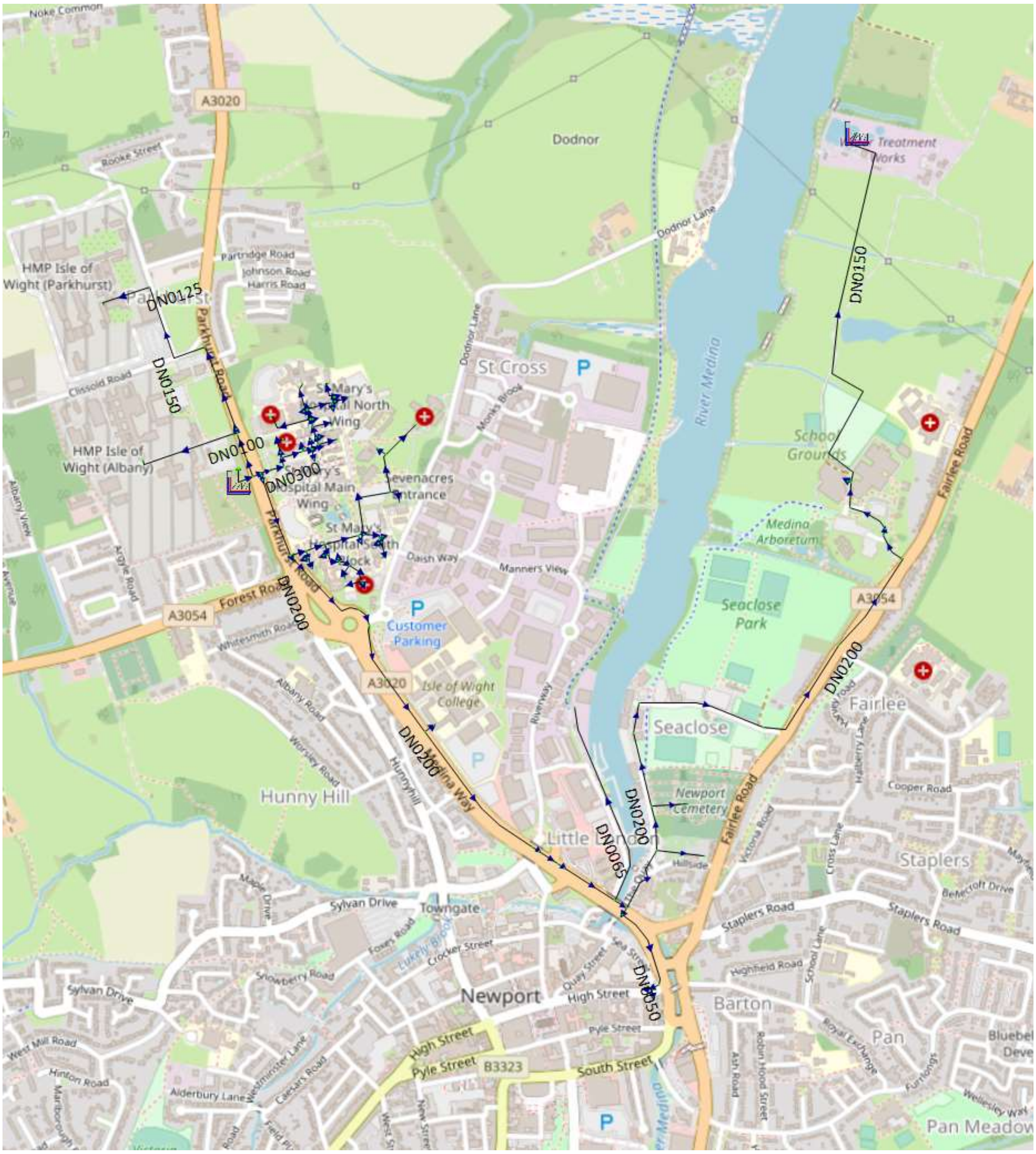
Network 2 Hospital and HMP IoW zone (Gas CHP & EfW) pipe dimensions and capital costs.



Network 2 Hospital and HMP IoW zone (Gas CHP & AD) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	56	13.2	20.7	33.9
DN25	147	34.5	71.0	105.4
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	282	84.7	160.6	245.3
DN65	938	300.1	453.9	754.0
DN80	355	122.0	176.6	298.6
DN100	2,522	1,053.6	1,441.1	2,494.7
DN125	329	149.8	195.0	344.8
DN150	657	341.6	454.1	795.6
DN200	253	144.0	173.2	317.2
DN250	19	12.1	15.5	27.6
DN300	37	24.2	22.3	46.5
Subtotal	5,777	2,331.1	3,281.3	5,612.4
Constraint mitigation				-
Contingency (10%)		233.1	328.1	561.2
Total	5,777	2,564.2	3,609.4	6,173.6

Network 2 Hospital and HMP IoW zone (Gas CHP & AD) pipe dimensions and capital costs.



Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (Gas CHP & WSHP) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,136	265.9	281.5	547.4
DN25	167	39.0	80.8	119.9
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	633	189.9	329.0	518.9
DN65	1,009	322.9	477.3	800.2
DN80	297	102.2	148.4	250.6
DN100	327	136.4	235.1	371.5
DN125	329	149.8	195.0	344.8
DN150	1,404	730.0	807.1	1,537.1
DN200	2,988	1,697.5	1,924.1	3,621.5
DN250	201	129.7	164.3	294.1
DN300	55	36.7	38.2	74.9
Subtotal	8,728	3,851.3	4,778.3	8,629.6
Constraint mitigation				26.0
Contingency (10%)		385.1	477.8	865.6
Total	8,728	4,236.5	5,256.1	9,521.2

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (Gas CHP & WSHP) pipe dimensions and capital costs.

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (EfW & WSHP) pipe dimensions.

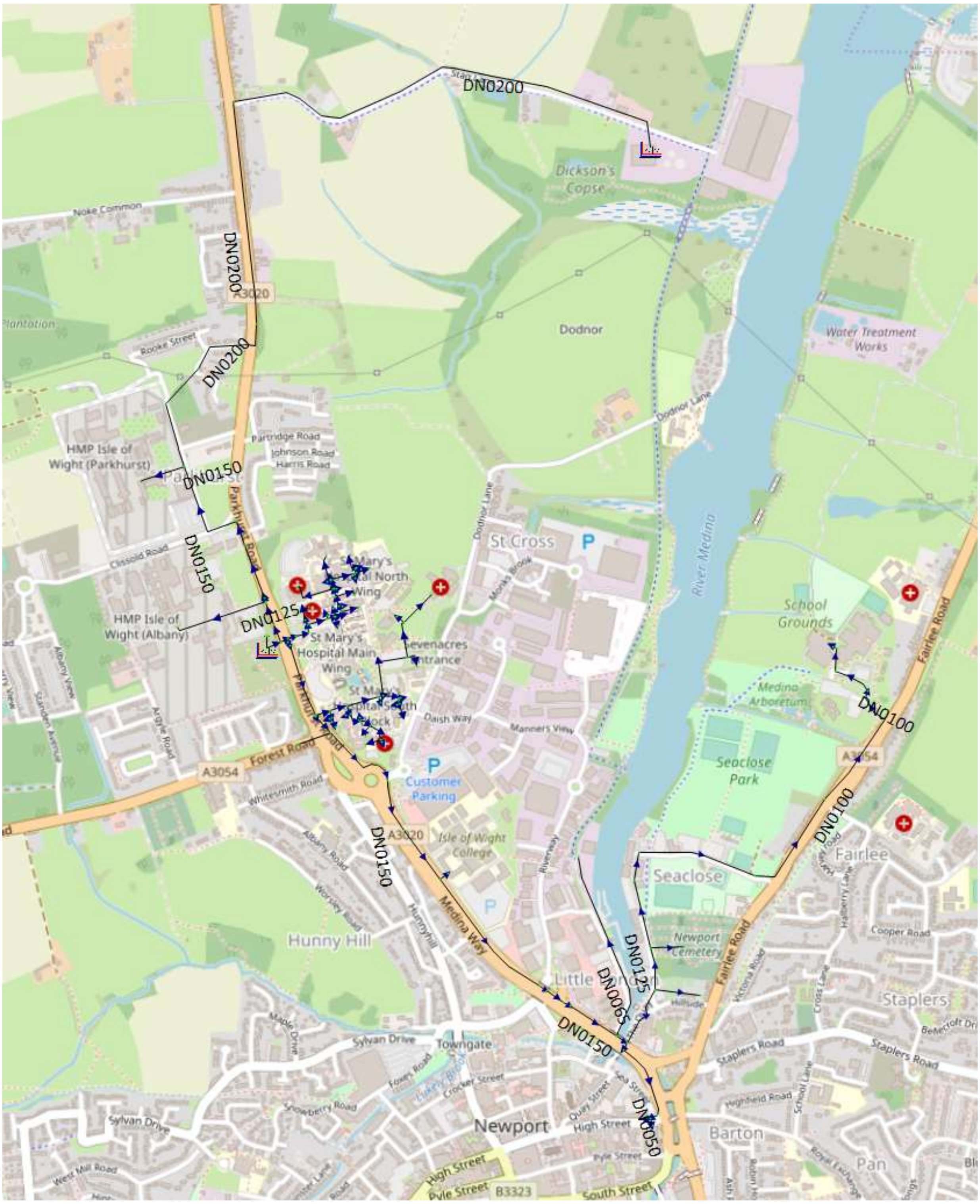
	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,136	265.9	281.5	547.4
DN25	167	39.0	80.8	119.9
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	633	189.9	329.0	518.9
DN65	1,009	322.9	477.3	800.2
DN80	297	102.2	148.4	250.6
DN100	327	136.4	235.1	371.5
DN125	2,721	1,239.8	1,459.0	2,698.9
DN150	1,404	730.0	807.1	1,537.1
DN200	2,930	1,664.7	1,891.5	3,556.2
DN250	259	166.9	198.6	365.5
DN300	19	12.4	15.9	28.4
DN400	37	27.4	23.4	50.7
Subtotal	11,120	4,948.9	6,045.0	10,993.9
Constraint mitigation				26.0
Contingency (10%)		494.9	604.5	1,102.0
Total	11,120	5,443.8	6,649.5	12,121.9

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (EfW & WSHP) pipe dimensions and capital costs.

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (EfW & Gas CHP & WSHP) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,136	265.9	281.5	547.4
DN25	167	39.0	80.8	119.9
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	633	189.9	329.0	518.9
DN65	1,009	322.9	477.3	800.2
DN80	297	102.2	148.4	250.6
DN100	327	136.4	235.1	371.5
DN125	2,721	1,239.8	1,459.0	2,698.9
DN150	1,404	730.0	807.1	1,537.1
DN200	2,930	1,664.7	1,891.5	3,556.2
DN250	259	166.9	198.6	365.5
DN300	19	12.4	15.9	28.4
DN400	37	27.4	23.4	50.7
Subtotal	11,120	4,948.9	6,045.0	10,993.9
Constraint mitigation				26.0
Contingency (10%)		494.9	604.5	1,102.0
Total	11,120	5,443.8	6,649.5	12,121.9

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (EfW & Gas CHP & WSHP) pipe dimensions and capital costs.



Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (Gas CHP & AD) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	1,136	265.9	281.5	547.4
DN25	167	39.0	80.8	119.9
DN32	17	4.3	8.9	13.1
DN40	165	47.0	88.4	135.5
DN50	633	189.9	329.0	518.9
DN65	1,009	322.9	477.3	800.2
DN80	297	102.2	148.4	250.6
DN100	1,225	511.6	704.9	1,216.6
DN125	916	417.2	635.3	1,052.5
DN150	1,705	886.4	1,014.0	1,900.4
DN200	2,755	1,565.3	1,867.2	3,432.5
DN250	19	12.1	15.5	27.6
DN300	37	24.2	22.3	46.5
DN400	-	-	-	-
Subtotal	10,080	4,388.2	5,673.7	10,061.9
Constraint mitigation				26.0
Contingency (10%)		438.8	567.4	1,008.8
Total	10,080	4,827.0	6,241.1	11,096.7

Network 3 Newport Harbour+ consumer zone + Hospital and HMP IoW zone (Gas CHP & AD) pipe dimensions and capital costs.

Network 4 Newport Harbour+ consumer zone + Hospital and HMP IoW zone + urban extension (Gas CHP & WSHP) pipe dimensions.

	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	14,505	3,394.2	3,503.0	6,897.1
DN25	120	28.0	52.4	80.4
DN32	104	25.9	61.6	87.5
DN40	188	53.7	82.3	136.0
DN50	801	240.4	408.9	649.3
DN65	1,353	432.8	683.0	1,115.8
DN80	1,026	352.8	490.5	843.3
DN100	2,289	956.1	1,236.1	2,192.2
DN125	1,797	818.9	1,048.6	1,867.5
DN150	1,220	634.2	671.2	1,305.4
DN200	3,443	1,956.3	2,240.2	4,196.5
DN250	201	129.7	164.3	294.1
DN300	19	12.4	15.9	28.4
DN400	37	27.4	23.4	50.7
Subtotal	27,101	9,062.8	10,681.3	19,744.1
Constraint mitigation				26.0
Contingency (10%)		906.3	1,068.1	1,977.0
Total	27,101	9,969.1	11,749.4	21,747.1

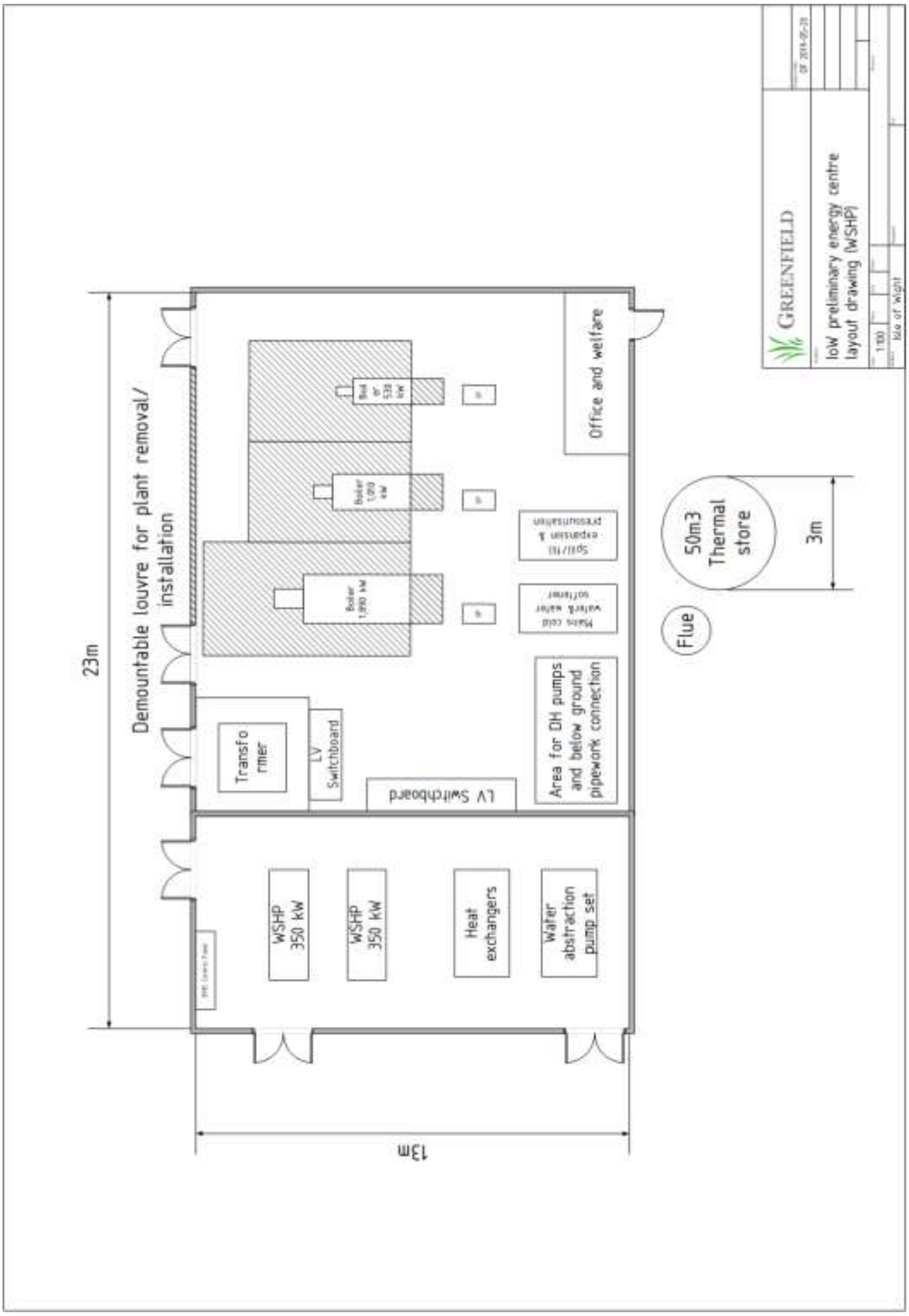
Network 4 Newport Harbour+ consumer zone + Hospital and HMP IoW zone + urban extension (Gas CHP & WSHP) pipe dimensions and capital costs.

Network 4 Newport Harbour+ consumer zone + Hospital and HMP IoW zone + urban extension (EfW & WSHP) pipe dimensions.

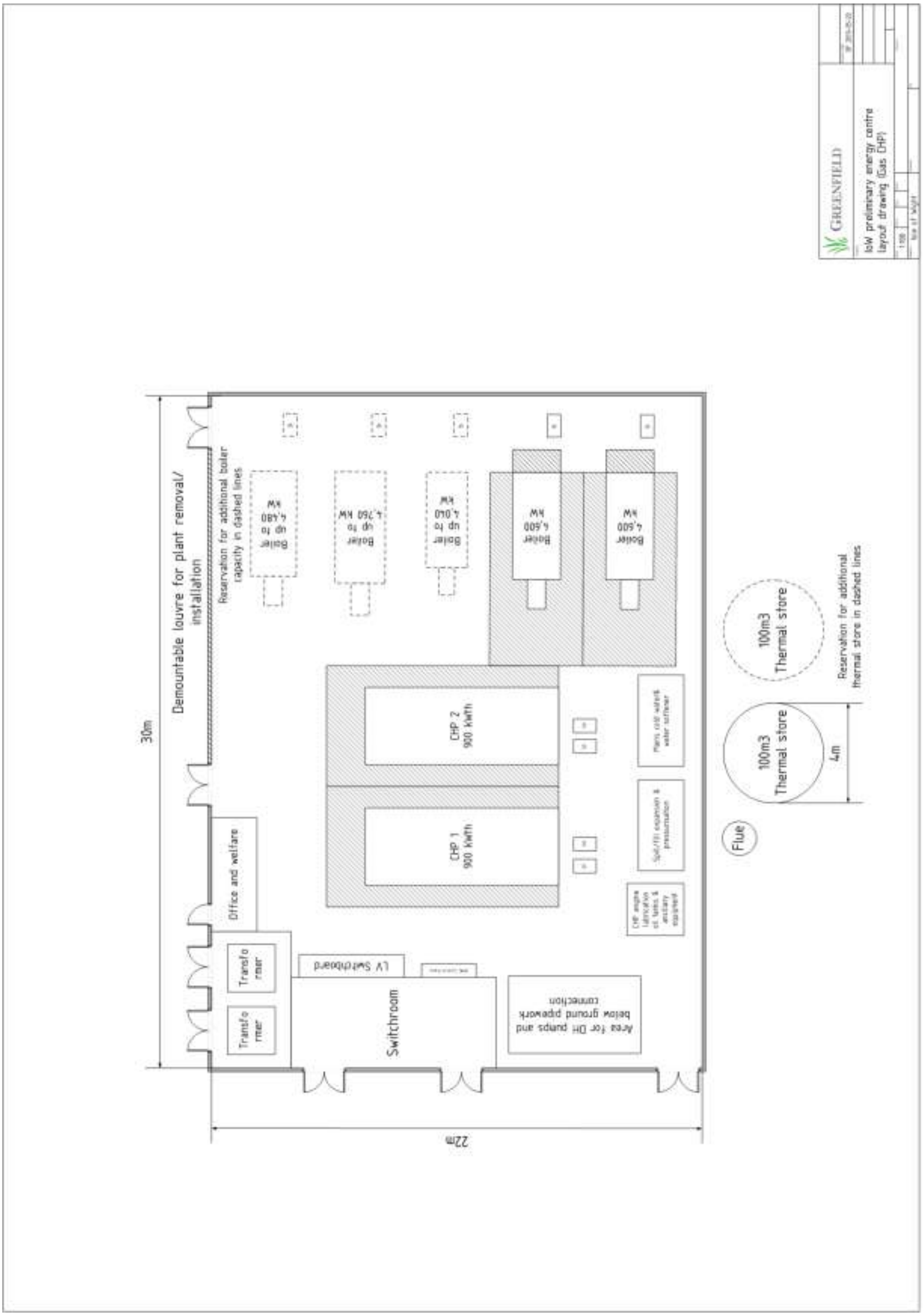
	Trench length (m)	Pipe only supply and installation cost (£k)	Trenching and civils cost (£k)	Total cost (£k)
DN20	14,505	3,394.2	3,503.0	6,897.1
DN25	120	28.0	52.4	80.4
DN32	104	25.9	61.6	87.5
DN40	188	53.7	82.3	136.0
DN50	801	240.4	408.9	649.3
DN65	1,353	432.8	683.0	1,115.8
DN80	1,026	352.8	490.5	843.3
DN100	2,289	956.1	1,236.1	2,192.2
DN125	4,190	1,908.9	2,312.6	4,221.5
DN150	1,220	634.2	671.2	1,305.4
DN200	3,386	1,923.5	2,207.6	4,131.1
DN250	259	166.9	198.6	365.5
DN300	19	12.4	15.9	28.4
DN400	37	27.4	23.4	50.7
Subtotal	29,494	10,157.2	11,947.0	22,104.2
Constraint mitigation				26.0
Contingency (10%)		1,015.7	1,194.7	2,213.0
Total	29,494	11,173.0	13,141.7	24,343.2

Network 4 Newport Harbour+ consumer zone + Hospital and HMP IoW zone + urban extension (EfW & WSHP) pipe dimensions and capital costs.

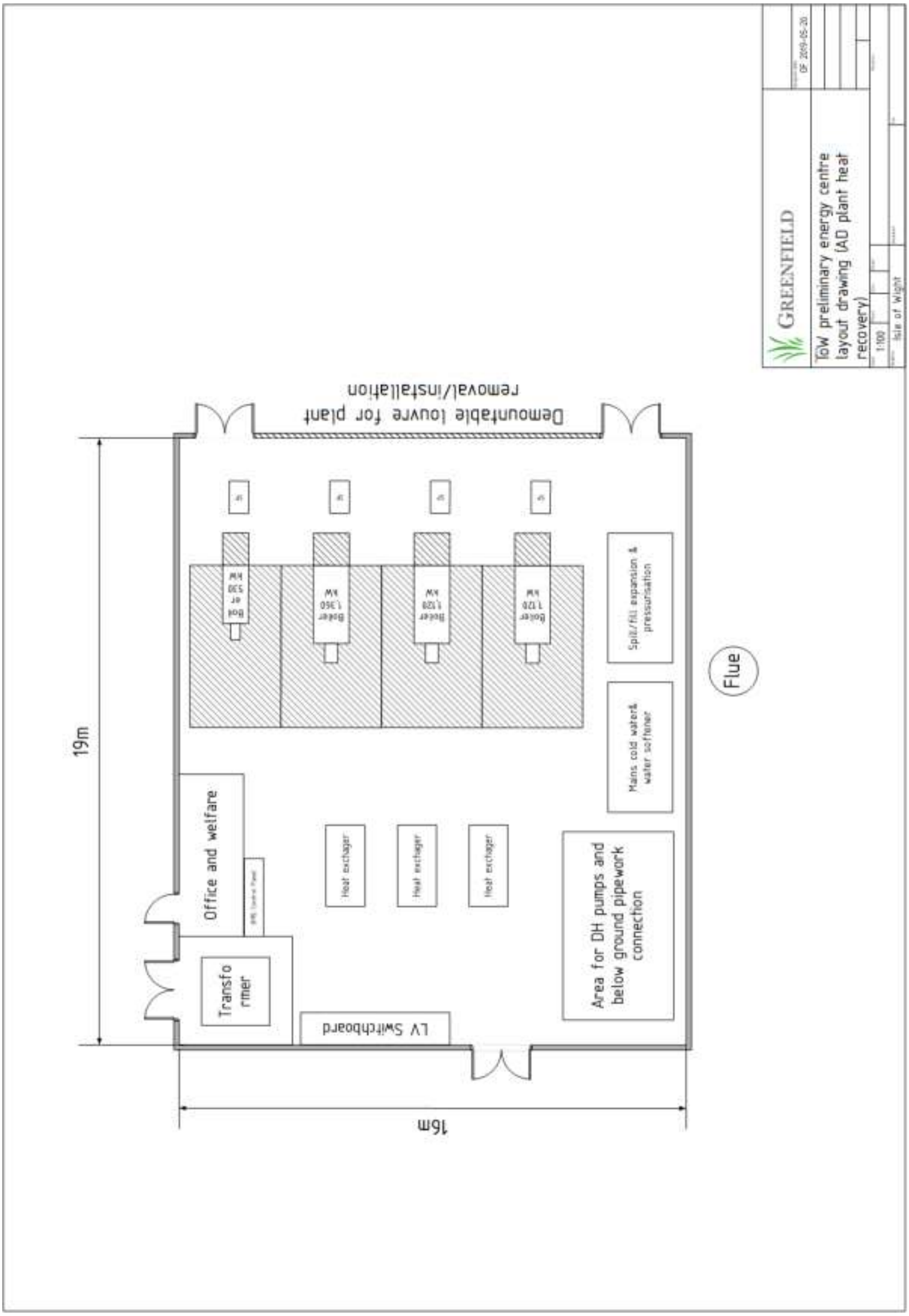
Appendix 5. Preliminary Energy Centre layouts



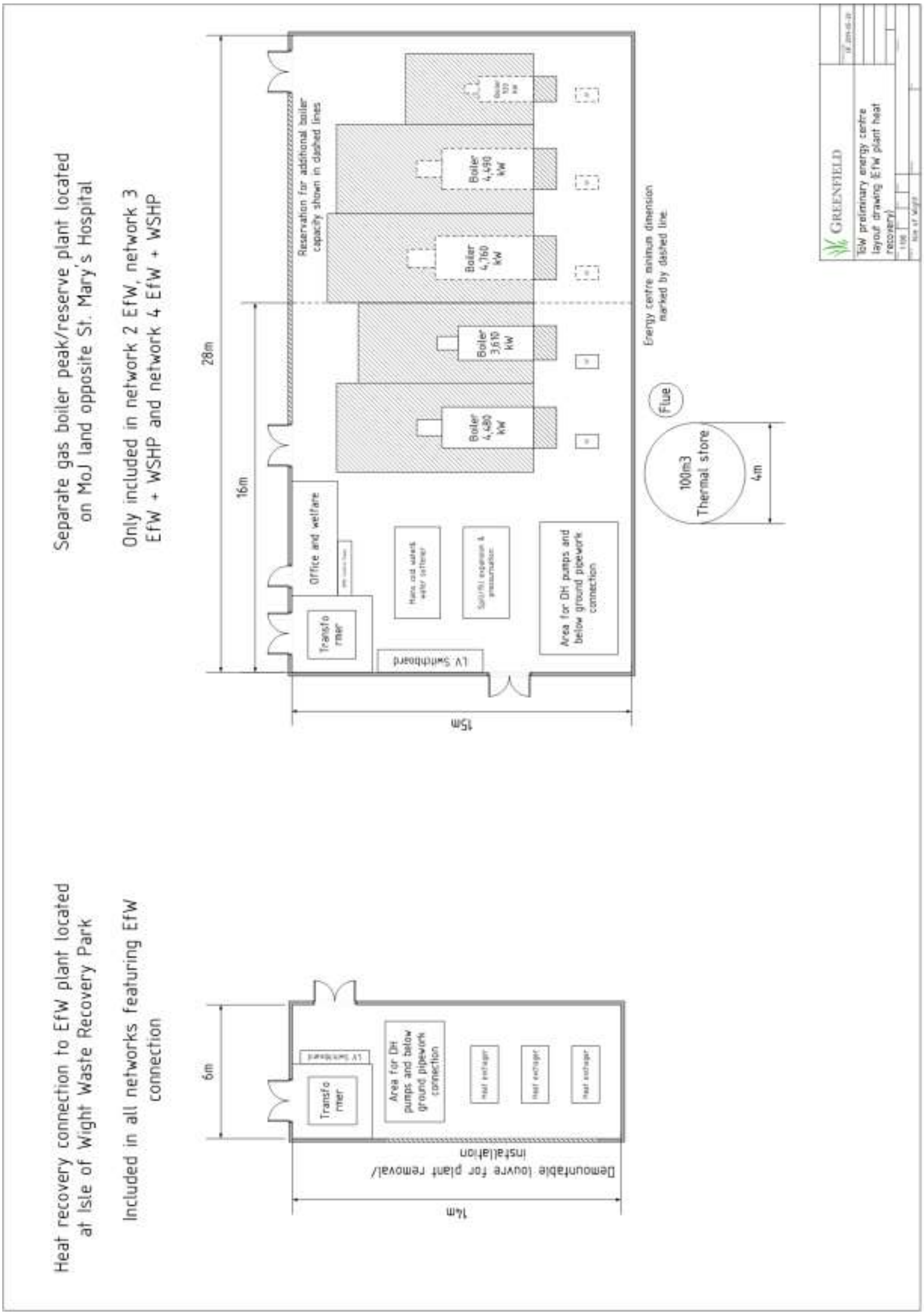
Preliminary layout drawing for the Newport WSHP energy centre.



Preliminary layout drawing for the Newport Gas CHP energy centre.



Preliminary layout drawing for the Newport Black Dog AD plant (heat recovery) energy centre.



Preliminary layout drawing for the Isle of Wight Waste Recovery Park EfW plant (heat recovery) connection and peak/reserve boiler plant.

Appendix 6. Capital costs (EC and network)

Newport – Network 1

Investment costs			
Network		1	1
Baseload supply technology		WSHP	AD
Total investment costs	£k	8,326	8,660
DH Network (steel)	£k	4,096	5,214
Heat substations, HIUs & metering		526	526
Private wire network		0	0
Energy Centres		1,987	1,300
Utility connections (gas, power, water, drainage, telecoms)		107	107
Heat Store		139	0
Development costs[37]		714	524
Contingency (10%)		757	989

Capital costs breakdown – Newport Network 1.

[37] *Including detailed engineering costs, professional fees, project management, and project development*

Energy Centre cost breakdown			
Network		**1**	**1**
Baseload supply technology		**WSHP**	**AD plant heat purchase**
Land	£k	-	-
Energy Centre Building (shell and core) plus civils	£k	491	491
Energy generating technology costs	£k	649	375
CHP units	£k	-	-
Water-Source Heat Pumps	£k	529	-
AD plant	£k	-	230
Gas Boilers	£k	120	145
Energy Centre items, or refurbishment of existing plant areas, as applicable	£k	-	-
Thermal storage	£k	139	-
Electrical export switchgear and transformers	£k	169	-
Gas connection	£k	45	45
Electrical connections (export by Private Wire or export to grid)	£k	-	-
Water connection	£k	30	30
Drainage connection	£k	30	30
Telecoms connection	£k	2	2
Other Energy Centre capex (e.g. piping, valves, pumps, water treatment, cabling, electrical panels, etc.)	£k	677	434
Energy centre subtotal (exc. thermal store and connections)	**£k**	**1,987**	**1,300**
Energy centre subtotal (inc. thermal store and connections)	**£k**	**2,233**	**1,407**
Detailed engineering costs	£k	335	211
Professional fees	£k	112	70
Project Management	£k	67	42
Project Development	£k	200	200
Contingency (10%)	£k	295	193
Energy Centre total	**£k**	**3,241**	**2,124**

Energy Centre cost breakdown for Newport Network 1.

Newport – Network 2

Investment costs					
Network		2	2	2	2
Baseload supply technology		EfW	Gas CHP	Gas CHP & EfW	Gas CHP & AD
Total investment costs	£k	13,051	15,224	18,310	17,950
DH Network (steel)	£k	5,863	3,479	5,863	5,612
Heat substations, HIUs & metering		1,240	1,240	1,240	1,240
Private wire network		0	583	583	583
Energy Centres		3,349	5,808	5,923	5,861
Utility connections (gas, power, water, drainage, telecoms)		107	719	719	719
Heat Store		250	250	483	483
Development costs[38]		1,055	1,761	1,835	1,820
Contingency (10%)		1,186	1,384	1,665	1,632

Capital costs breakdown – Newport Network 2.

[38] *Including detailed engineering costs, professional fees, project management, and project development*

Energy Centre cost breakdown					
Network		**2**	**2**	**2**	**2**
Baseload supply technology		**EfW**	**Gas CHP**	**Gas CHP + EfW**	**Gas CHP + AD plant**
Land	£k	-	-	-	-
Energy Centre Building (shell and core) plus civils	£k	1,309	1,607	1,309	1,470
Energy generating technology costs	£k	885	2,156	2,568	2,345
CHP units	£k	-	1,746	1,746	1,746
Water-Source Heat Pumps	£k	-	-	-	-
EfW	£k	500	-	500	-
AD plant	£k	-	-	-	230
Gas Boilers	£k	385	410	322	369
Energy Centre items, or refurbishment of existing plant areas, as applicable	£k	-	-	-	-
Thermal storage	£k	260	260	465	465
Electrical export switchgear and transformers	£k	-	628	628	628
Gas connection	£k	45	45	45	45
Electrical connections (export by Private Wire or export to grid)	£k	-	612	612	612
Water connection	£k	30	30	30	30
Drainage connection	£k	30	30	30	30
Telecoms connection	£k	2	2	2	2
Other Energy Centre capex (e.g. piping, valves, pumps, water treatment, cabling, electrical panels, etc.)	£k	1,155	1,418	1,418	1,418
Energy centre subtotal (exc. thermal store and connections)	**£k**	**3,349**	**5,808**	**5,923**	**5,861**
Energy centre subtotal (inc. thermal store and connections)	**£k**	**3,716**	**6,787**	**7,107**	**7,045**
Detailed engineering costs	£k	557	1,018	1,066	1,057
Professional fees	£k	186	339	355	352
Project Management	£k	111	204	213	211
Project Development	£k	200	200	200	200
Contingency (10%)	£k	477	855	894	886
Energy Centre total	**£k**	**5,248**	**9,403**	**9,835**	**9,751**

Energy Centre cost breakdown for Newport Network 2.

Newport – Network 3

Investment costs					
Network		3	3	3	3
Baseload supply technology		Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP	Gas CHP & AD
Total investment costs	£k	24,425	22,146	27,181	23,955
DH Network (steel)	£k	8,656	11,020	11,020	10,088
Heat substations, HIUs & metering		1,628	1,628	1,628	1,628
Private wire network		583	0	583	583
Energy Centres		7,794	5,336	7,909	6,866
Utility connections (gas, power, water, drainage, telecoms)		781	107	781	719
Heat Store		483	483	483	483
Development costs[39]		2,279	1,559	2,306	1,993
Contingency (10%)		2,220	2,013	2,471	2,178

Capital costs breakdown – Newport Network 3.

[39] *Including detailed engineering costs, professional fees, project management, and project development*

Energy Centre cost breakdown					
Network		**3**	**3**	**3**	**3**
Baseload supply technology		**Gas CHP + WSHP**	**EfW + WSHP**	**Gas CHP + EfW + WSHP**	**Gas CHP + AD plant**
Land	£k	-	-	-	-
Energy Centre Building (shell and core) plus civils	£k	2,098	1,800	1,800	1,961
Energy generating technology costs	£k	2,805	1,534	3,217	2,490
CHP units	£k	1,746	-	1,746	1,746
Water-Source Heat Pumps	£k	529	529	529	-
EfW	£k	-	500	500	-
AD plant	£k	-	-	-	230
Gas Boilers	£k	530	505	442	514
Energy Centre items, or refurbishment of existing plant areas, as applicable	£k	-	-	-	-
Thermal storage	£k	465	465	465	465
Electrical export switchgear and transformers	£k	797	169	797	628
Gas connection	£k	45	45	45	45
Electrical connections (export by Private Wire or export to grid)	£k	612	-	612	612
Water connection	£k	61	30	61	30
Drainage connection	£k	61	30	61	30
Telecoms connection	£k	3	2	3	2
Other Energy Centre capex (e.g. piping, valves, pumps, water treatment, cabling, electrical panels, etc.)	£k	2,095	1,832	2,095	1,787
Energy centre subtotal (exc. thermal store and connections)	**£k**	**7,794**	**5,336**	**7,909**	**6,866**
Energy centre subtotal (inc. thermal store and connections)	**£k**	**9,040**	**5,908**	**9,155**	**8,050**
Detailed engineering costs	£k	1,356	886	1,373	1,208
Professional fees	£k	452	295	458	403
Project Management	£k	271	177	275	242
Project Development	£k	200	200	200	200
Contingency (10%)	£k	1,132	747	1,146	1,010
Energy Centre total	**£k**	**12,452**	**8,213**	**12,607**	**11,112**

Energy Centre cost breakdown for Newport Network 3.

Newport – Network 4

Investment costs				
Network		3	3	3
Baseload supply technology		Gas CHP & WSHP	EfW & WSHP	Gas CHP & EfW & WSHP
Total investment costs	£k	43,166	40,734	45,639
DH Network (steel)	£k	19,770	22,130	22,130
Heat substations, HIUs & metering		4,985	4,985	4,985
Private wire network		583	0	583
Energy Centres		9,881	7,313	9,790
Utility connections (gas, power, water, drainage, telecoms)		781	107	781
Heat Store		483	483	483
Development costs[40]		2,759	2,013	2,738
Contingency (10%)		3,924	3,703	4,149

Capital costs breakdown – Newport Network 4.

[40] *Including detailed engineering costs, professional fees, project management, and project development*

Energy Centre cost breakdown				
Network		**4**	**4**	**4**
Baseload supply technology		**Gas CHP + WSHP**	**EfW + WSHP**	**Gas CHP + EfW + WSHP**
Land	£k	-	-	-
Energy Centre Building (shell and core) plus civils	£k	2,962	2,664	2,664
Energy generating technology costs	£k	3,347	1,788	3,471
CHP units	£k	1,746	-	1,746
Water-Source Heat Pumps	£k	832	529	529
EfW	£k	-	500	500
AD plant	£k	-	-	-
Gas Boilers	£k	770	759	696
Energy Centre items, or refurbishment of existing plant areas, as applicable	£k	-	-	-
Thermal storage	£k	465	465	465
Electrical export switchgear and transformers	£k	893	265	797
Gas connection	£k	45	45	45
Electrical connections (export by Private Wire or export to grid)	£k	612	-	612
Water connection	£k	61	30	61
Drainage connection	£k	61	30	61
Telecoms connection	£k	3	2	3
Other Energy Centre capex (e.g. piping, valves, pumps, water treatment, cabling, electrical panels, etc.)	£k	2,678	2,595	2,857
Energy centre subtotal (exc. thermal store and connections)	**£k**	**9,881**	**7,312**	**9,790**
Energy centre subtotal (inc. thermal store and connections)	**£k**	**11,127**	**7,884**	**11,036**
Detailed engineering costs	£k	1,669	1,183	1,655
Professional fees	£k	556	394	552
Project Management	£k	334	237	331
Project Development	£k	200	200	200
Contingency (10%)	£k	1,389	990	1,377
Energy Centre total	**£k**	**15,275**	**10,888**	**15,151**

Energy Centre cost breakdown for Newport Network 4.

Appendix 7. Operational costs assumptions

			Source:
Fuel costs – gas	£/MWh	24.9–42.1	BEIS QEP: Tables Annex, September 2018, non-domestic, very small to medium, excl. VAT, incl. CCL
Fuel costs – electricity (for heat pumps and energy centre)	£/MWh	113.8–144.4	BEIS QEP: Tables Annex, September 2018, non-domestic, small to large, excl. VAT, incl. CCL
Fuel costs - biomass	£/MWh	30.0	LHV basis, biomass supplier quote
Heat purchase price from EfW	£/MWh	3.15	Greenfield analysis based Amey z-factor, estimated biomass fraction and RHI. Sensitivity range used in based on z-factor variance of the 4 to 10 and exclusion/inclusion of RHI
Heat purchase price from AD plant	£/MWh	10.7	Greenfield analysis and experience from prior projects
Metering and billing cost	£/consumer/yr	90	Quote from heat network operator
Network management ("Account Manager")	£/yr	18,000	Quote from heat network operator
Utility costs and overheads (water, data, etc.)	£/yr	1,500	Greenfield experience from prior projects
Insurance		0.1% of CAPEX	Quote from heat network operator
Heat Trust	£/dwelling	4.5	Quote from heat network operator

Operational cost assumptions.

			Source:
Variable costs			
Gas CHP variable	£/MWh$_{fuel}$	2.43	Analysis based on plant maintenance costs based on operating hours
WSHP variable	£/MWh$_{fuel}$	3.00	
GSHP variable	£/MWh$_{fuel}$	3.00	
Biomass variable	£/MWh$_{fuel}$	2.00	
Gas boiler variable	£/MWh$_{fuel}$	1.25	
Annual fixed costs			
Gas CHP		3.5 % of CAPEX	Analysis based on plant maintenance costs based on operating hours
WSHP		3.5 % of CAPEX	
GSHP		3.5 % of CAPEX	
Biomass		3.5 % of CAPEX	
Gas boiler		2.0 % of CAPEX	
Other energy centre equipment		1.0 % of CAPEX	
Heat network fixed maintenance	£/m, trench	1.3	Greenfield experience from prior projects
Heat network replacement/repair	%-of HN capex/yr	0.5%	
Substation & HIU servicing	£/unit/yr	50	Quote from heat network operator

Maintenance cost assumptions.

			Source:
Gas boilers lifetime	*yrs*	25	Greenfield experience from prior projects
Gas CHP lifetime	*yrs*	15	
Biomass HOB lifetime	*yrs*	15	
WSHP lifetime	*yrs*	20	
GSHP lifetime	*yrs*	15	
Other energy centre equipment lifetime	*yrs*	35	
Heat network, steel lifetime	*yrs*	50	
Heat network, plastic lifetime	*yrs*	40	
Substations & HIUs lifetime	*yrs*	20	
REPEX		70% of Balance of Plant original CAPEX	

REPEX / lifetime assumptions.

Appendix 8. Revenue assumptions

In terms of revenues (or income) for the heat network, consumer tariffs are based on a 5% reduction of a calculated counterfactual cost, i.e. cost of the alternative energy supply solution (assumed to be building-level gas boilers in all properties and grid supplied power). Tariffs will vary between consumer types, with domestic consumers paying more (per unit of energy delivered) than commercial properties, as per counterfactual costs. Connection fees would also be levied against each property when it connects to the network and this is assumed to be a 5% reduction of the calculated counterfactual cost of installing gas boilers. On this basis, connection fees would vary based on the heat capacity required by each consumer. In total connection fees are estimated that just over £500k.

Revenue is assumed to be available from the Renewable Heat Incentive (RHI) for the renewable energy options (heat pumps), although it should be noted that the current RHI programme is due to close in Q1 2021 and a replacement or extension has yet to be proposed (a financial sensitivity has been modelled with the exclusion of RHI).

All heat and power sales prices to consumers are based on the consumers' counterfactual energy costs. Heat and power sales tariff components include a 5% discount to incentivise the consumers to connect to the heat network.

The heat sales tariff has been split to three components; energy fee, fixed annual fee, and connection fee. The energy fee is estimated based on counterfactual gas cost and applying the appropriate BEIS retail gas price projection. The fixed annual fee accounts for counterfactual boiler O&M costs, replacements and residual value.

Boiler maintenance costs, life expectancy, and replacement costs reflect the centralised gas boiler solution and are based on the Heat Trust Heat Cost Calculator and boiler manufacturer data.

	Unit rate for gas	Annual boiler O&M costs	Annual boiler replacement costs (based on 15 yrs)	Variable heat tariff (inc. 5% discount)	Fixed heat tariff inc. (5% discount)	Connection fee (inc. 5% discount)
	£/MWh	£/kW	£/kW	£/MWh	£/kW	£/kW
HMP IoW	24.9	9.9	2.9	30.9	12.3	85.5
IoW College	25.6	9.9	2.9	31.8	12.3	85.5
Hospital	24.9	9.9	2.9	30.9	12.3	85.5
IoW Council	25.6	9.9	2.9	31.8	12.3	85.5
Non-resi developments (Newport Harbour)	25.6	9.9	2.9	31.8	12.3	85.5

Heat sales tariffs non-residential consumers.

	Unit rate for gas	Annual boiler O&M costs	Annual boiler replacement costs (based on 15 yrs)	Variable heat tariff (inc. 5% discount)	Fixed heat tariff inc. (5% discount)	Connection fee (inc. 5% discount)
	£/MWh	£/dwelling	£/dwelling	£/MWh	£/dwelling	£/dwelling
Residential, flats	44.1	205.3	77.8	54.7	272.2	1,451.6
Residential, houses	44.1	205.3	77.8	54.7	272.2	1,451.6

Heat sales tariffs residential consumers.

Power revenues, within gas CHP options, is based upon sales of power to the consumers at a 5% discount to their recently billed costs, accounting time-of-day changes in their tariff.

			Source
Electricity sales (grid)	£/MWh	45.1	BEIS (electricity wholesale, reference scenario) Price is inflated annually according to BEIS predictions
Electricity sales (private wire)	£/MWh	148.6 (peak) / 102.3 (off-peak)	QEP, inc. 5% discount. Price is inflated annually according to BEIS predictions

Power revenue assumptions.

Details on RHI revenue assumptions are shown in the table below.

		Rate	Term	Source
Heat pumps Tier 1 (15 % of heat load) Tier 2 (85 % of heat load)	 £/MWh £/MWh	 95.6 28.5	20 years	Office of Gas and Electricity Markets: Tariffs and payments: Non-Domestic RHI
Biomass (> 1 MWth) Tier 1 (35 % of heat load) Tier 2 (65 % of heat load)	 £/MWh £/MWh	 31.1 21.8		

RHI revenue assumptions.

Appendix 9. Detailed financial modelling results

Newport – Network 1

Project viability		1 WSHP	1 AD
NPV @ Discount rate:	3.5 %		
25 yr	£k	-5,477	-6,772
30 yr		-6,146	-7,185
40 yr		-7,221	-7,678
LCOE (heat consumption) @ Discount rate:	3.5 %		
25 yr	£/MWh	164.5	185.5
30 yr		156.6	169.6
40 yr		148.9	152.9
IRR			
25 yr	%	-3.5 %	-2.7 %
30 yr		-4.0 %	-2.6 %
40 yr		-5.9 %	-2.4 %
MIRR			
25 yr	%	-1.6 %	-1.3 %
30 yr		-1.4 %	-0.9 %
40 yr		-1.1 %	-0.1 %
Simple Payback (yr)	yr	NA	NA
Discounted Payback (yr) @ Discount rate:	3.5 %	NA	NA
Economic viability (including socio-economic benefits)			
NPV @ Discount rate:	3.5 %		
25 yr	£k	-5,123	-6,300
30 yr		-5,245	-5,983
40 yr		-5,362	-5,391
IRR			
25 yr	%	-2.9 %	-2.2 %
30 yr		-3.6 %	-1.6 %
40 yr		NA	-0.4 %
Simple Payback (yr)	yr	NA	NA

Detailed financial modelling results.

Gap funding required to reach		1 WSHP	1 AD
IRR 5.0 %	£m	5.7	7.2
	% capex	68.4 %	66.3 %
IRR 7.0 %	£m	5.8	7.5
	% capex	69.7 %	69.1 %
IRR 10.0 %	£m	5.7	7.6
	% capex	69.0 %	70.0 %

Gap funding required to reach investment thresholds set out by HNDU.

Newport – Network 2

Project viability		2 EfW	2 CHP	2 CHP & EfW	2 CHP & AD
NPV @ Discount rate:	3.5 %				
25 yr	£k	-1,616	4,076	6,605	3,875
30 yr		-1,767	4,330	7,300	4,175
40 yr		-1,836	4,840	8,522	4,790
LCOE (heat consumption) @ Discount rate:	3.5 %				
25 yr	£/MWh	58.3	42.9	36.1	43.5
30 yr		55.7	40.7	33.0	40.6
40 yr		53.7	40.4	31.9	39.6
IRR					
25 yr	%	2.4 %	6.0 %	6.7 %	5.5 %
30 yr		2.4 %	5.9 %	6.7 %	5.4 %
40 yr		2.5 %	6.0 %	6.8 %	5.5 %
MIRR					
25 yr	%	2.8 %	4.5 %	4.8 %	4.3 %
30 yr		2.9 %	4.3 %	4.7 %	4.2 %
40 yr		3.0 %	4.1 %	4.4 %	4.0 %
Simple Payback (yr)	yr	29.1	13.8	13.3	14.7
Discounted Payback (yr) @ Discount rate:	3.5 %	NA	22.9	19.4	25.1
Economic viability (including socio-economic benefits)					
NPV @ Discount rate:	3.5 %				
25 yr	£k	521	3,658	8,100	4,829
30 yr		1,976	5,033	10,675	6,813
40 yr		4,349	6,175	13,743	8,999
IRR					
25 yr	%	3.8 %	5.6 %	7.2 %	5.8 %
30 yr		4.6 %	6.2 %	7.8 %	6.4 %
40 yr		5.5 %	6.5 %	8.2 %	6.9 %
Simple Payback (yr)	yr	21.6	14.4	13.1	14.6

Detailed financial modelling results.

Gap funding required to reach		2 EfW	2 CHP	2 CHP & EfW	2 CHP & AD
IRR 5.0 %	£m	3.3	-	-	-
	% capex	25.3 %	-	-	-
IRR 7.0 %	£m	4.8	1.2	0.5	2.2
	% capex	36.9 %	8.0 %	2.5 %	12.1 %
IRR 10.0 %	£m	6.1	3.7	3.7	4.9
	% capex	46.8 %	24.1 %	20.4 %	27.4 %

Gap funding required to reach investment thresholds set out by HNDU.

Newport – Network 3

Project viability		3 CHP & WSHP	3 EfW & WSHP	3 CHP & EfW & WSHP	3 CHP & AD
NPV @ Discount rate:	3.5 %				
25 yr	£k	-1,024	-7,837	1,138	-3,406
30 yr		-1,550	-8,707	1,200	-3,460
40 yr		-2,035	-9,680	1,649	-3,233
LCOE (heat consumption) @ Discount rate:	3.5 %				
25 yr	£/MWh	59.3	75.1	54.3	64.8
30 yr		56.5	71.5	50.3	61.2
40 yr		55.3	68.3	48.1	59.0
IRR					
25 yr	%	3.1 %	0.3 %	3.9 %	2.1 %
30 yr		2.9 %	0.2 %	3.9 %	2.2 %
40 yr		2.8 %	0.1 %	4.0 %	2.4 %
MIRR					
25 yr	%	3.2 %	1.4 %	3.6 %	2.7 %
30 yr		3.2 %	1.5 %	3.6 %	2.8 %
40 yr		3.2 %	1.8 %	3.6 %	3.0 %
Simple Payback (yr)	yr	25.5	NA	22.0	28.2
Discounted Payback (yr) @ Discount rate:	3.5 %	NA	NA	NA	NA
Economic viability (including socio-economic benefits)					
NPV @ Discount rate:	3.5 %				
25 yr	£k	-858	-5,071	2,854	-4,774
30 yr		562	-3,735	5,353	-3,337
40 yr		1,894	-1,530	8,271	-2,262
IRR					
25 yr	%	3.2 %	1.5 %	4.4 %	1.6 %
30 yr		3.7 %	2.1 %	5.1 %	2.3 %
40 yr		4.1 %	3.0 %	5.6 %	2.8 %
Simple Payback (yr)	yr	23.9	32.6	18.8	29.7

Detailed financial modelling results.

Gap funding required to reach		3 CHP & WSHP	3 EfW & WSHP	3 CHP & EfW & WSHP	3 CHP & AD
IRR 5.0 %	£m	4.2	9.8	2.8	6.0
	% capex	17.1 %	44.2 %	10.4 %	25.0 %
IRR 7.0 %	£m	7.1	11.4	6.5	8.4
	% capex	29.0 %	51.6 %	24.0 %	34.9 %
IRR 10.0 %	£m	9.7	12.6	9.8	10.4
	% capex	39.6 %	57.1 %	36.2 %	43.6 %

Gap funding required to reach investment thresholds set out by HNDU.

Newport – Network 4

Project viability		4 CHP & WSHP	4 EfW & WSHP	4 CHP & EfW & WSHP
NPV @ Discount rate:	3.5 %			
25 yr	£k	-4,351	-11,726	-1,802
30 yr		-5,554	-13,493	-2,187
40 yr		-6,365	-15,145	-1,721
LCOE (heat consumption) @ Discount rate:	3.5 %			
25 yr	£/MWh	89.5	104.1	84.4
30 yr		86.1	100.4	79.9
40 yr		82.9	95.8	75.5
IRR				
25 yr	%	2.4 %	0.5 %	3.1 %
30 yr		2.2 %	0.3 %	3.0 %
40 yr		2.2 %	0.3 %	3.2 %
MIRR				
25 yr	%	2.8 %	1.6 %	3.2 %
30 yr		2.8 %	1.7 %	3.2 %
40 yr		2.9 %	2.0 %	3.3 %
Simple Payback (yr)	yr	34.8	NA	27.0
Discounted Payback (yr) @ Discount rate:	3.5 %	NA	NA	NA
Economic viability (including socio-economic benefits)				
NPV @ Discount rate:	3.5 %			
25 yr	£k	-7,269	-12,383	-3,632
30 yr		-5,816	-11,116	-1,068
40 yr		-3,375	-7,907	2,926
IRR				
25 yr	%	1.6 %	0.2 %	2.7 %
30 yr		2.1 %	0.7 %	3.3 %
40 yr		2.8 %	1.8 %	4.0 %
Simple Payback (yr)	yr	39.8	NA	27.4

Detailed financial modelling results.

Gap funding required to reach		4 CHP & WSHP	4 EfW & WSHP	4 CHP & EfW & WSHP
IRR 5.0 %	£m	8.7	14.8	7.0
	% capex	20.2 %	36.2 %	15.4 %
IRR 7.0 %	£m	12.6	17.2	11.7
	% capex	29.1 %	42.2 %	25.6 %
IRR 10.0 %	£m	15.6	18.8	15.5
	% capex	36.2 %	46.1 %	34.0 %

Gap funding required to reach investment thresholds set out by HNDU.

Appendix 10. Carbon reduction analysis

CO_2 emissions have been calculated for the preferred energy supply solutions taking account of the efficacy of the various supply plant, system losses and parasitic consumption, e.g. pumping and the impact of displacing grid supplied power in the CHP options. Carbon factors have been applied to each supply option and then this has been compared against a ‘business as usual’ scenario for each property that assumed to be connected to the network. The ‘business as usual’ scenario assumes gas boilers supply all existing and new buildings. Typical assumptions for boiler efficiencies have been applied. All buildings are assumed to be supplied with grid power. Where power generation is included in the supply mix, e.g. with CHP plant, carbon savings associated to power supply is attributed to the heat supply to enable comparison between heat networks. The emission factors for gas, biomass and grid supplied electricity shown in the table below have been used.

Emission Factors		
Gas[41]	tCO_2 / MWh	0.205
Biomass	tCO_2 / MWh	0.039
Energy from Waste	tCO_2 / MWh	0.100
Grid Electricity (2018)[42]	tCO_2 / MWh	0.313

CO_2 emissions for each heat network option and for the ‘business as usual’ solution is calculated based on static 2018 factors. Subsequently the report goes on to show the impact of accounting for future projections for carbon emissions as estimated by HM Treasury[43], whilst also taking account of the specific carbon reductions that can be attributed to decentralised power generation from CHP as estimated by BEIS[44]. It is important to account for this since the carbon factor for electricity is forecast to significantly change over coming decades as the UK government seeks to decarbonise power supply, which would reduce the carbon benefits of locally generated electricity (when relative to grid power). The changes in electricity carbon factor predicted requires significant transformation of the UK power supply system which relies on major investment into new nuclear power, renewables and other low carbon technologies. Whilst it cannot be said with certainty that the rate of change predicted will be achieved it is a risk for a heat network scheme using CHP (whether gas, fuel cell or biomass) for baseload supply. Where carbon reduction is a key objective and stakeholders wish to apply the government’s future grid carbon factors projections then the lower figures should be utilised to interpret the analysis results.

From a long-term perspective, it should be noted that supply technology can vary within a heat network; this is one of its key advantage. This may mean it acceptable for stakeholders to initially adopt more cost-effective technologies even where they do not deliver significant carbon savings because the implementation of the network infrastructure then enables lower carbon technologies to be introduced at later, perhaps at which point they will be more cost effective.

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[41] *BEIS: “Government emission conversion factors for greenhouse gas company reporting” (August 2017)*
[42] *BEIS: “Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal” (January 2018)*
[43] *"Grid Average, consumption-based" emission factor for electricity has been used from Valuation of energy use and greenhouse gas (GHG) emissions - supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government, HM Treasury, January 2018.*
[44] *“CHP exporting” and “CHP onsite” emission factors have been used from Emission factors for electricity displaced by gas CHP, Bespoke natural gas CHP analysis, Department of Energy & Climate Change, December 2015.*

Appendix 11. Initial risk register

Version	Date	Notes
0.1	28/5/19	First issue

Key: Risk phase	
Project Development (PD)	Risks occurring prior to construction
Construction (C)	Risks occurring during construction
Operational & Mngt (O)	Risks occurring during operation period
Key: Risk theme	
Project Development	Risks associated due to scheme management (project development and construction phases)
Demand	Risk of loads to materialise or loads are lost over time, e.g. construction delays, efficiency programme, errors in initial analysis
Supply	Risk of out of insufficient generation and other EC and network failures/limitations of the required supply of energy
Financial/Commercial	Risks of increases in operational costs and depressed revenues beyond business case modelling assumptions, e.g. interest rate hike, inflation, reduced reference fuel costs
Regulatory	Risk with of legislative change (during development and operation), e.g. change in planning requirements, emissions standards, customer protection

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
Demand	**PD, C**	**All**	**Demand for heat and power is lower than expected due to not being able to sign up consumers**	At this stage there is limited certainty over consumers connections (no MOUs/HOTs/contracts in place). The impact of losing consumers can be significant but some are more important than others (scales and proximity to others). Loss of consumers could be for a range of reasons, including (1) the scheme not being able to provide an attractive offer to stakeholders (site operators, end-consumers, developers) or (2) because the scheme is not available when required (although few require early connection)	4	4	16	1. Liaise with key stakeholders as scheme move through feasibility to investable proposition 2. Ideally establish MoU/HoTs with key consumers in near future 3. Refine understanding of programme / milestone issues and adjust scheme phasing and consider temporary solutions, where necessary 4. Revise scheme design based on secured consumers (allowing for expansion capacity)
Supply	**PD**	**Newport**	**Energy Centre location**	Location options are dependent on supply technology (CHP, EfW, AD, WSHP or combination) and the access to land/building facilities. Without securing this, the project will not proceed. Space would need to be found on the Hospital or MoJ sites to house the CHP plant (indicative location has been discussed with stakeholders). In case of the EfW, AD and Fairlee Water Treatment Works (WTW), space would need to be found on the sites to house an energy centre.	4	4	16	1. Explore site options with stakeholders (including NHS, MoJ, IoW Waste Recovery Park, Black Dog AD, and Southern Water) 2. Develop solutions for all options to provide fall-back solutions until such as point as its necessary to make a decision of the supply option
Supply	**PD**	**Newport**	**Supply from EfW facility**	Obvious potential exists for the export of thermal energy from the Isle of Wight Waste Recovery Park EfW facility but the economic case for investment in the on-site upgrades would need to be made based on secure incomes from heat (and possibly power) sales. Presently there is little certainty around this. Also, mutually beneficial terms would need to be struck between the EfW and (future) heat network operators.	5	3	15	1. Explore business case with Isle of Wight Waste Recovery Park EfW

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
Supply	**PD**	**Newport**	**Supply from Black Dog AD facility**	Obvious potential exists for the export of thermal energy from the Black Dog AD facility but the economic case for investment in the on-site upgrades would need to be made based on secure incomes from heat sales. Mutually beneficial terms would need to be struck between the Black Dog AD and (future) heat network operators.	5	3	15	1. Explore business case with Black Dog AD
Project Development	**PD, C**	**All**	**Development skills / resources (to deal with feasibility investment planning, project/contract management, technical appraisal)**	There is no present capacity and capability to act as an informed client to contract to market (feasibility, install & operate). Not resolving this will lead to the non-delivery and/or unintended consequences of poor delivery where it is attempted without sufficient resource.	4	3	12	Once there is a "live" project with good stakeholder support and appointed lead entity: 1. Formalise / Initiate project and establish project management structure and agreements between project champion and key stakeholders 2. Conduct skills audit 3. Work with / secure funding from HNDU for the follow-on investigation work 3. Recruit key resources (some will be external) 4. Up-skill decision makers and internal managers
Regulatory	**PD, C**	**All**	**Planning + consenting**	Energy Centres will need to planning permission and regulatory approvals	4	3	12	Once indicative scheme is established liaise with planners to review key information required and adaptations that may support a positive outcome
Supply	**O**	**All**	**Poor reliability and performance of consumer heat supply**	Poor design, construction or operational standards leading to poor service and/or non-service at times and a loss of trust in the system which could result in disconnections. The masterplanning stage has developed early-stage indicative design solutions but care will need to be taken to conduct design, installation and operation in compliance with the National Heat Code of Practice (and subsidiary guidance).	4	3	12	1. Apply best practice design, construction and operational standards, e.g. UK Code of Practice 2. Ensure specification meets longevity standards required 3. Ensure scheme revenues are sufficient to support O&M and meeting re-investment requirements

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
								4. Transfer risks and incentives to operator to maintain optimal performance 5. Give careful consideration for interfaces between design, build and operation
Supply	**PD**	**All - Renewable supply options only**	**No access to RHI**	RHI is due to close by end of Q1 2021 and as such these heat network options will not be able to access it. It may be replaced or extended but this has not been confirmed by government	4	3	12	1 Develop solutions (technical/financial) in subsequent work that limit reliance on RHI
Supply	**PD**	**Newport / CHP (only) option - Network 2 only**	**Not meeting the Energy Efficiency Directive definition of efficient district heating (and consequent inability to claim HNIP)**	Presently the CHP solution for this network does not the achieve the EED definition (greater than 75% of delivered energy). It is therefore not eligible for the HNIP funds. With a strong rate of return is presently assumed that it would not be need. If it were, i.e. the investment threshold exceeds the anticipated returns it will be necessary to reconfigure the scheme by increasing CHP capacity (difficult based on current knowledge of the power/heat demand profiles) of the introduction of a complimentary renewable energy source, e.g. waste heat.	3	4	12	1 Continue to review financial performance through project development 2. Agree investment return threshold with funder/stakeholders 3. Redesign network solution where HNIP funding is required
Demand	**PD, C**	**Newport**	**Loss of any of the large consumers (hospital, prisons, IoW College)**	Either due to lack of the engagement or commercial/technical reasons, e.g. existing contract arrangement or lacking commercial justification, the consumers may choose not to connect, in which case the conceived network would be very different and possibly nothing to commercially support it within this location	5	2	10	1. Hold discussions with consumers to explore rationale and constraints to involvement 2. Explore alternative consumers to replace them if they are to be excluded
Supply	**PD**	**Newport**	**Access to water abstraction from Southern Water WTW**	Potential exists for water abstraction and heat recovery from the Southern Water WTW pumping station using heat pumps but the commercial basis of that needs to be explored with the operator. Mutually	3	3	9	1. Explore business case with Southern Water

Risk theme	**Phase: PD, C, O**	**Network / option relevance**	**Risk name**	**Risk description (and mitigation)**	**I**	**L**	**RV**	**Proposed action**
				beneficial terms would need to be struck between the site operator and (future) heat network operators.				
Demand	**PD, O**	**All**	**Demand for heat is lower than expected, due to poor data or change in consumption profiles**	Heat demand data for most properties is based on metered consumption data so provide high confidence. Other data, particularly in the new developments, is based on benchmarking and realised energy demand could be lower or higher than expected. Energy demands may also change over time as buildings are updated / operated differently. For example, refurbishment.	4	2	8	1. Highlight data weaknesses and seek to improve over time 2. Update consumption estimates (and update scheme design) as new data becomes available (at least at key decision points during the scheme development process) 3. Use new data to revise scheme design prior to project investment 4. Address consumption changes through operational management
Supply	**PD**	**All**	**Energy Centre utility constraints**	Technical or commercial constraint to connect energy centre servicing infrastructure, e.g. gas and power connections	4	2	8	1. examine connection issues with DNOs once EC sizing is completed
Financial/Commercial	**C**	**All**	**Overspend on capital budget**	Failure to deliver project within the estimated capital costs and contingency. Likelihood is low since costs have been benchmarked against major UK suppliers and a 10% contingency is added. However, there are risks such as greater construction and construction management costs for the network infrastructure and energy centre options.	4	2	8	1. Use effective project management framework/process 2. Produce clear specification of requirements and systematically de-risk 3. Use PM and advisers with experience of heat networks 4. Pass on risks, e.g. Design, Build & Operate council 5. Manage budget, making adjustments to capital allocation and finding balancing cost reduction, as necessary

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
Supply	**C, O**	**All**	**Energy Centre & network: Poor end-consumer service delivery**	Poor service provision leads to user dissatisfaction and in worst case to disconnection	4	2	8	1. Ensure design, construction and commissioning are of a high standard and at least compliance against Code of Practice 2. Provide effective operational management, including annual consumer satisfaction surveys 3. Structure incomes/profits to management performance 4. Establish arbitration solution, e.g. Heat Trust or council operated scheme
Supply	**O**	**All**	**Energy Centre and network: Inadequate maintenance**	Poor maintenance could lead to system failures which will cause dissatisfaction and increased costs	4	2	8	1. Ensure design, construction and commissioning are of a high standard and at least compliance against the Heat Network Code of Practice 2. Design in effective monitoring and management capabilities 3. Provide effective asset management and ensure sufficient budget (O&M and repex) for planned and un-planned maintenance / replacement 4. Structure O&M contracts to performance
Demand	**C**	**All**	**Construction delays**	This refers to delays once a detailed construction plan is resolved which is likely to be linked to consumer and/or supply plant milestones. Delays may cause commercial impact but in the worst-case result in loss of supply option and/or consumers	3	2	6	1. Develop realistic programme 2. Implement effective project management and risk appraisal to predict constraints 3. Explore risks with stakeholders and development joint mitigation plans
Financial/Commercial	**PD**	**All**	**Availability of appropriate investment**	A heat network scheme involves significant capital expenditure, which will be compensated by long term returns. Funding is required to be secured from amongst key stakeholders or external investors. At this early stage investment strategies are not in place; this is a task that will require further investigation as it proceeds through subsequent development stages.	2	3	6	1.Explore options as the specific network schemes develop

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
				Options include 3rd party network ownership, public debt (PWLB, soft loan or grant support (e.g. HNIP, LEP/EU funds)) and private debt/equity and will depend on the nature of the project structure.				
Financial/Commercial	**O**	**All**	**Operating costs and revenues outside business case tolerances**	O&M costs exceed and/or revenues fall short, of the modelling tolerances. Modelling has been conducted on a conservative basis and so as are considered reasonable at this point.	3	2	6	1. Conduct independent due diligence 2. Monitoring costs and revenues during operation and develop operational responses 3. Pass risks on to operators, where possible
Financial/Commercial	**PD, O**	**All**	**Energy prices (general) vary on the medium/long-terms basis**	The financial modelling uses long terms price forecasts from BEIS and so retain inherent uncertainty, although there is a clear trend towards increasing energy costs over time. Changing energy prices will both affect costs of energy supply and the operation of the heat network, e.g. pumping and operation of heat pumps, but will also affect consumer tariffs since these will either be linked to UK energy or consumer price indices. These will typically act against one another to mitigate overall impact.	3	2	6	1. Carefully negotiate energy centre fuel/electricity contracts 2. Establish heat supply contracts that link tariffs to energy/consumer indices 3. Adjust business case accordingly
Supply	**PD, C**	**All**	**General network route constraints**	Various highway and junction constraints and existing buried services will present route constraint issues. These are likely to be surmountable but solutions will need to be developed.	2	3	6	1. Liaise with owner/operators of existing utility infrastructure 2. Survey other network constraints 3. Develop engineering solutions and examine capital costs impact
Supply	**C**	**All**	**Runs beyond programme**	Construction delays leading to possible cost increases and potentially missing deadlines for the new consumer connections and/or supply	3	2	6	1. Use project management framework/process 2. Use experienced PM

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
Supply	PD, C	Newport	**Network route constraints - crossing River Medina**	Consumers are located on both sides of River Medina. Crossing the river is required to connect: 1) both sides of the Newport Harbour development which is located on both sides of the river 2) the hospital and prison area with the Newport Harbour area. The Medina Way road bridge offers an existing crossing opportunity as the heat network pipes can be mounted on the underside or sides of the concrete structure of the bridge. Should this not be possible, an alternative is to install the pipes in a trench construction at the bottom of the river itself, or underneath the river using directional drilling.	2	3	6	1. Liaise with owner/operators of land and existing utility infrastructure, including Canals and Rivers Trust and council highways department 2. Identify options and complete review to identify preferred solution (with fall-back) 3. Use this to inform the design of the proposed network such that it is future-proofed for future expansion
Supply	O	All	**Future proofing network capacity**	A decision will need to be made regarding the sizing of the network infrastructure and the energy centre(s) based on a assumed demand, which clearly could increase overtime. Whilst there is significant capacity within the proposed network to allow for expansion, it is finite and major demand growth could exceed capacity. However, it important to avoid oversizing as this results in greater construction costs and if underutilised it will limit system efficiency (greater losses) and higher supply costs.	2	2	4	1. Make decision for initial network sizing based on reasoned opinion of future expansion strategies. 2. Continue to review as network design evolves
Regulatory	PD, O	All	**National legislation introduces new costs, e.g. taxation**	New carbon taxation of the heat network may add additional costs.	2	2	4	1. Due diligence against the possible changes 2. Make operational adjustments as required
Regulatory	PD, O	All	**Heat supply becomes regulated**	Currently unregulated, the supply of heat can be treated as any unregulated services. This is unlikely to be a major issue since heat sales are internal or to as part of the tenant arrangements.	2	2	4	1. Review implications in further detail as scheme progresses

Risk theme	Phase: PD, C, O	Network / option relevance	Risk name	Risk description (and mitigation)	I	L	RV	Proposed action
Supply	**PD**	**All**	**Air quality im-pacts of energy centre(s) (per-ceived and real)**	Air quality impact may lead to regulatory constraints or may create public concern against development. Careful site selection and selection of appropriate plant with NOx and other emission mitigation systems are likely to address concerns, particularly as a heat network will displace emission relative to less efficient building-level boiler plant.	3	1	3	1 On next iteration of energy centre design, review this issue further

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