OTTERPOOL PARK

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DOCUMENTS SUBMITTED IN SUPPORT

OP5 APPENDIX 4.9 – **ENERGY STRATEGY**

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August 2022

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OTTERPOOL PARK

Energy Strategy

AUGUST 2022

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1 Executive Summary

1.1.1 The vision for Otterpool Park is to be a progressive and innovative development, embracing the opportunities from changes in policy, low carbon technologies and the energy market. This Energy Strategy has been developed to ensure that Otterpool Park is well placed to exploit new technology and commercial arrangements and provides the opportunity to deliver sustainable, low carbon, and cost-effective homes, businesses, and communities across the whole development lifecycle.

1.1.2 The document has been prepared in support of an Outline Planning Application that seeks permission for a new garden settlement accommodating up to 8,500 homes (Use Classes C2 and C3) and Use Class E, F, B2, C1, Sui Generis development with related infrastructure, highway works, green and blue infrastructure, with access, appearance, landscaping, layout and scale matters to be reserved.

1.1.3 The proposed Otterpool Park development would be constructed in phases, completing in approximately 2041/2042. The proposed 8,500 residential dwellings proposed (at a ratio of approximately 70/30 houses to flats). The development would also include commercial and retail space, schools, health care facilities, community spaces, sports facilities, and a hotel. This Energy Strategy also confirms that the identified approach and infrastructure would be suitable for the development of 10,000 dwellings of the fully occupied wider Framework Masterplan.

1.1.4 This Energy Strategy will be updated as part of the tiered planning application approach comprising of this Tier 1 Energy Strategy (at Outline Planning), Tier 2 (at detailed masterplans and design codes), and Tier 3 (Reserved Matters Applications). It is anticipated that these updates will be secured through planning condition.

1.1.5 This Tier 1 Energy Strategy has been prepared for the Outline Planning Application and sets the long-term framework, ambition, and boundaries for future operation within the context that there will be significant changes in future policy, technology and best practice guidelines over the proposed Development build out timeline. This document therefore sets out the overall site wide approach for energy and key commitments that the development will deliver. This document will be updated periodically to reflect changes in national policy/regulations.

1.1.6 There is a commitment to provide an Energy Strategy with each relevant Tier 2 submission which demonstrates how the commitments in the Tier 1 Energy Strategy are being taken forward into the Energy Strategy for that Tier 2 area of land. The Strategy for each Phase Level Masterplan will set out the overall approach towards energy and sustainability matters for that phase having regard to national and local planning policy adopted at that time, with the consideration also given to any supplementary guidance and relevant legislation.

1.1.7 There is also a commitment to develop an Energy Statement with each relevant Tier 3 reserved matters application which will need to confirm how the proposed development is consistent with the Tier 1 and Tier 2 Energy Strategy commitments.

1.1.8 The Tier 2 and Tier 3 Energy documents will set out the overall approach towards energy and carbon for that phase with regard to national and local planning policy adopted at that time, and consideration also given to any supplementary guidance and relevant legislation whilst providing an opportunity to update solutions and commitments taking account of new technologies and opportunities in the energy market.

1.1.9 This Tier 1 Energy Strategy provides a framework for the path to net-zero carbon by 2030. The Tier 2 and Tier 3 level Energy Strategies will set out how the commitments in this

Tier 1 Energy Strategy will be delivered or exceeded, and any further relevant measures that are identified in the development of these applications.

1.1.10 Outlined below are commitments in the Tier 1 Energy Strategy framework and how these will be incorporated into future Tier 2 and Tier 3 Energy Strategies/ Statements:

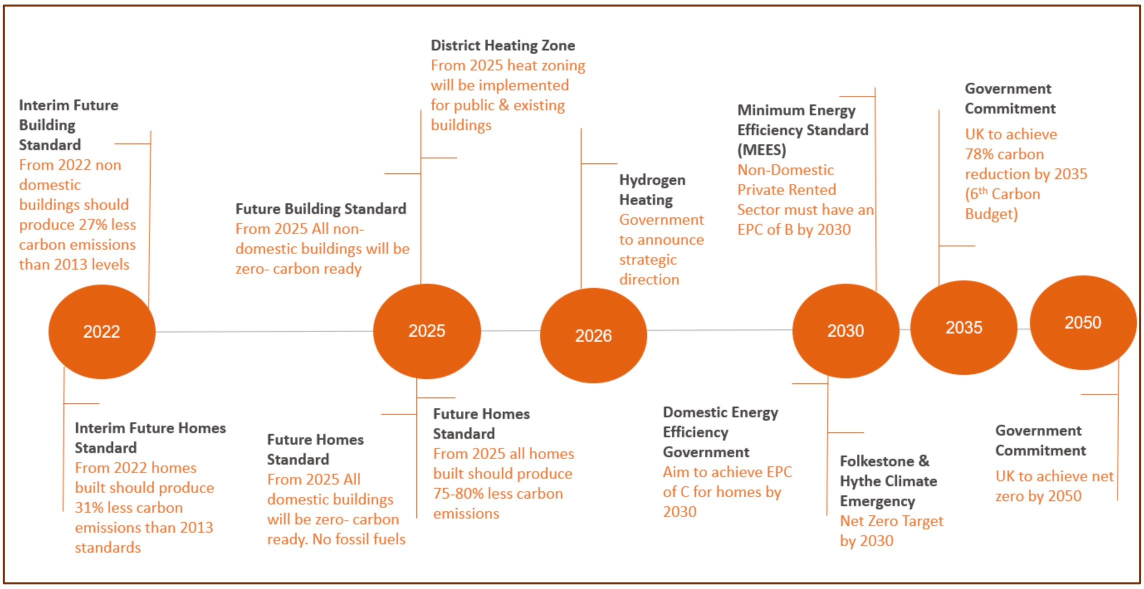
- Future Energy Strategies to be submitted at Tier 2 and Tier 3 will adhere to the operational Energy Hierarchy (Be Lean, Be Clean, Be Green and Be Smart) that ensures a Fabric First approach is embedded into designs that is committed to in this Tier 1 Strategy. This includes how the principles of Passive Design will be integrated into the design to minimise energy demand whilst maximising passive solar gain. There is a commitment to meet and, where feasible, exceed Fabric Energy Efficiency Standards (FEES) for new homes against the current Building Regulations at the time of Tier 2 or Tier 3 planning applications. To support this commitment, domestic properties will need to achieve the following FEES target. This target will be reviewed to ensure the commitments are driving energy efficiency measures at Tier 2 and Tier 3 application stage.

Table 1 Fabric Energy Efficiency Standard (FEES) Target

Type of Development	Fabric Energy Efficiency Standard (FEES) ($kWh/m^2/yr$)
Block of Flats and mid terrace houses	<41
Semi-detached, end of terrace and detached houses	<48

- This Tier 1 application sets a commitment for Otterpool Park to a 45% carbon emissions reduction against current Building Regulation Standards (2013) for new homes**.** This exceeds the 31% carbon reduction target outlined in the Interim Future Home Standards for new homes (Ministry of Housing, Communities and Local Government, 2021). Future Tiers of the planning application will ensure carbon dioxide emissions will be minimised, working towards the Council's goal of carbon net zero by 2030. This will take account of all levels of the operational Energy Hierarchy and demonstrate how Building Regulations regarding carbon emissions, which are in place at the time of submission, have been met. It will show how opportunities to achieve energy and carbon reductions above and beyond the requirements of Building Regulations have been considered and applied where appropriate.
- Tier 2 and Tier 3 Energy Strategies will align with, and exceed where feasible, policy such as the Future Homes Standard and Future Buildings Standards (Ministry of Housing, Communities and Local Government, 2021) and set the Development on a path to carbon neutrality. The Future Homes Standard, due to be implemented from 2025, outlines the requirement to build new dwellings with a 75-80% carbon reduction (compared to the current Building Regulations (2013) at 31%) with a trajectory to net zero. This will include how community buildings shall seek to meet zero carbon standards as exemplars and in line with the Folkestone and Hythe Core Strategy Review (2022) an aspiration for the development to achieve carbon neutrality. An overview of the policy direction is provided in Figure 1 below:

Figure 1 Future Carbon Policy Direction



- This Tier 1 Energy Strategy commits to no gas for residential properties from the start of the development and for low carbon heating to be provided by electrically driven heat pumps from the outset of the development, whilst the viability for including emerging low carbon heating solutions such as hydrogen heating will be reviewed in future planning applications. Future Tiers of the planning application will also commit to no fossil fuels and will outline how low carbon heating will be included within building designs.
- Tiers 2 and 3 will provide further design guidance on specific measures to minimise energy consumption such as implementing a zoned heating and heat recovery strategy within the homes alongside smart meters and smart controls.
- All community buildings shall seek to meet zero carbon standards as exemplars, with an aspiration for the development to achieve carbon neutrality. Net Zero standard to be defined aligned with UK Green Building Council (2019) A Framework Definition excluding non-regulated energy and construction carbon initially however this could evolve in Tier 2 and Tier 3 planning submissions. It is also noted that community buildings such as schools may need to include construction carbon and non-regulated energy within net zero definition as part of requirements set by public bodies for new buildings. It is also noted that developing an offset fund for any remaining carbon required to achieve net zero is outside the scope of the management responsibilities of the development.
- At this Outline Energy Strategy stage there is a commitment to install renewable energy generation technology to meet a proportion of energy demand and help minimise exposure to energy costs. It is likely that solar PV will be the technology installed on buildings where feasible, or where it can be demonstrated that other renewable technologies will be installed such as solar thermal, which are more suitable. A renewable technology assessment demonstrating which suitable technologies, such as solar thermal and energy storage options will be undertaken for Tier 2 and Tier 3 planning applications, taking account of evolving technologies, viability, and policy.
- A commitment is made to meet and look to exceed where feasible Policy CC1 of the Places and Polices Local Plan (F&HDC, 2020) that outlines that the Planning applications for all major new build housing developments and new non-residential buildings of 1000 sqm or more gross floorspace will be required to reduce carbon emissions by a minimum of 10 per cent above the Target Emission Rate, as defined in Part L1A of the Building Regulations. Future planning applications will also include how opportunities for renewable generation and battery storage will be integrated into building

designs to provide flexibility on how and when energy is used, whilst providing some protection to occupants from volatile energy prices.

- This Tier 1 Energy Strategy and future applications will commit to incorporate high quality innovative design, new technologies, and construction techniques, including zero or low carbon energy and water, efficient design and sustainable construction methods. Future planning applications will respond to changes in national and local policy and guidance, for example, Folkestone and Hythe Council is proposing to develop a Net Zero Toolkit which would be taken into consideration as part of this process.
- Climate adaptation measures will be defined and incorporated into the design of the individual buildings, including reducing the impact of overheating in the home, preventing storm water ingress, mitigating the impact of flooding in the home and adopting climate adaptation measures in the immediate vicinity of homes and in public spaces. Specific measures will be defined and incorporated for Tiers 2 and 3 planning applications.
- A commitment is made to ensure overheating is considered and mitigated for new buildings taking account of climate change. Tiers 2 and Tier 3 planning applications will set out the methodology to ensure that this is achieved taking account of best practice guidance.
- This Tier 1 Application commits to homes, businesses and community buildings being equipped with smart technology to support data collection, analysis and monitoring of energy, waste and water, allowing for aggregated and comparative data. Future applications will set out how these commitments can be met and also show how occupants will be provided with safe tools to access digital infrastructure and data across the development as smart technology evolves.
- In principle a commitment is made to disclose and minimise the anticipated Energy Use Intensity at construction stage in accordance with the UK Green Building Council's Net Zero Carbon Buildings: A Framework Definition, 2019, as well as disclosing the anticipated Energy Use Intensity at design at pre-occupation stage and monitor and report on energy use 5 years post-occupancy, however the practicality of these activities will be further assessed at Tier's 2 and 3 of the planning submission to ensure the process and systems are available to undertake these activities. This will also support understanding and review the customer experience to ensure lessons are learned and the best solutions that deliver tangible results on the path to net zero are being delivered.
- BREEAM 'Excellent' will be set as a standard for all non-domestic buildings over 1,000m^2 and evolve with any changes to BREEAM over time. Future planning applications will show how principles of BREEAM could be embedded into Design Standards if BREEAM standard does not last the lifetime of the proposed Development.
- A commitment is made at this Tier 1 stage to use reasonable endeavours to design-in and connect to off-site decentralised energy systems where feasible to reduce the reliance on grid infrastructure; and offsite renewable generation should demonstrate additionality.
- As part of long-term stewardship arrangements a commitment to undertake a feasibility study to assess the establishment of an ESCO is made with the purpose of managing the renewable and low carbon energy infrastructure and energy supplies to individual households and non-domestic users alongside maintaining the carbon offsets required to achieve the net zero aspiration in the application.
- A commitment is made to undertake a feasibility assessment to understand the potential to recover energy from the installation of a new WwTW through a combination of biogas CHP and/or extracting heat, digestate, heavy good transportation biofuel, and associated renewable products from incoming sewerage and processing of the waste and recycling for use within the development.
- A commitment is made that at the Tier 3 planning stage all new development is to calculate whole life-cycle carbon emissions in accordance with current RICS Whole Life

Carbon Assessment guidelines and demonstrate actions taken or planned that will reduce life-cycle carbon emissions.

1.1.11 This Outline Energy Strategy has been developed to meet and exceed current national policy of the Buildings Regulations alongside regional local policy requirements. The Energy Strategy is aligned with the Regional Strategies in the Kent and Medway Energy and Low Emissions Strategy (Kent and Medway Councils, 2019) and the Tri-Local Enterprise Partnership (LEP) Regional Energy Strategy (Energy South 2 East, 2018).

1.1.12 With a focus on long term commitments, the Energy Strategy also addresses policies related to new garden settlements in the Folkestone and Hythe Core Strategy (F&HDC, 2022)

1.1.13 In order to best exploit new technology and commercial arrangements, further research including technology trials could be undertaken on properties in the initial phases. This will include developing an evidence base to determine the evolution of the Fabric First approach and Passive Design as well as Modern Methods of Construction. It could also focus on developing the mix of renewable energy generation and energy storage technologies (electric and/or thermal), storage locations (individual buildings or community level), and smart controls to enable demand site measures. The research could also cover electric vehicle infrastructure demand and charging locations, along with further commercial arrangements to deliver benefits to the community as the energy market changes. Research projects could be defined in more detail at subsequent stages of the planning hierarchy.

1.1.14 The Energy Strategy is linked with the Sustainability Strategy which sets out the foundations of integrated vision that links energy generation with energy storage, with the water strategy, transport, infrastructure, and place-making approaches. Energy is one element of the Sustainability Strategy for the Settlement which sets the vision for Otterpool Park to integrate sustainable solutions within the community.

1.1.15 The Energy Strategy supports the Transport Strategy taking a progressive approach to the future of mobility which acknowledges the Government's commitment to ban all new petrol and diesel cars and vans by 2030. Future Tiers of the Energy Strategy will provide details of the measures for properties to have ready access to slow, fast and rapid electric charging points; with integration of technologies into workplaces, community buildings, car parks, and infrastructure to facilitate the transition to electric vehicles. Alongside site-wide EV charging, Future Energy Strategies will further define the use of active travel, the use of Hydrogen Vehicles and the potential at the Settlement to Mobility as a Service (MaaS).

1.1.16 The development of this integrated sustainability strategy will exploit relevant technological advances to further increase the progressive and sustainable nature of Otterpool Park, and to enable the community to play an active role in sustainability and tackling climate change.

2 Introduction

2.1 Purpose of the Document

2.1.1 This Energy Strategy has been prepared by Arcadis to accompany an outline planning application submitted on behalf of Otterpool Park LLP.

2.1.2 Otterpool Park will be adjacent to the existing settlements of Lympne and Sellindge, and takes in Westenhanger, Barrow Hill and Newingreen hamlets as well as some ribbon development along local roads and the A20. The northern border is formed by the M20 and railway line and the eastern by the A20 and the edge of the Kent Downs Area of Outstanding Natural Beauty. The southern border is formed by the B2067 Aldington Road. The western border is formed by Harringe Lane and Harringe Brook Woods.

2.1.3 This document has been prepared in support of an Outline Planning Application that seeks permission for a new garden settlement accommodating up to 8,500 homes (Use Classes C2 and C3) and Use Class E, F, B2, C1, Sui Generis development with related infrastructure, highway works, green and blue infrastructure, with access, appearance, landscaping, layout and scale matters to be reserved.

2.1.4 The proposed Otterpool Park development would be constructed in phases, completing in approximately 2041/2042. This Energy Strategy also assesses whether the identified approach and infrastructure would be suitable for the development of 10,000 dwellings.

2.1.5 This Energy Strategy will be updated as part of the tiered planning application approach comprising of this Tier 1 Energy Strategy (at Outline Planning), Tier 2 (at detailed masterplans and design codes), and Tier 3 (Reserved Matters Applications).

2.1.6 This Tier 1 Energy Strategy has been prepared for the Outline Planning Application and sets the long term framework, ambition, and boundaries for future operation within the context that there will be significant changes in future policy, technology and best practice guidelines over the proposed Development build out timeline. This document therefore sets out the overall site wide approach for energy and key commitments that the development will deliver. This document will be updated periodically to reflect changes in national policy/regulations.

2.1.7 There is a commitment to develop an Energy Strategy with each relevant Tier 2 submission which demonstrates how the commitments in the Tier 1 Energy Strategy are being taken forward into the Energy Strategy for that Tier 2 area of land.

2.1.8 There is also a commitment to develop an Energy Statement with each relevant Tier 3 reserved matters application which will need to confirm how the proposed development is consistent with the Tier 1 and Tier 2 Energy Strategy commitments.

2.1.9 This Outline Energy Strategy sets commitments based on existing policy and regulations. Whilst effort has been made to determine how the future landscape may look, any targets and commitments outlined in this Energy Strategy would need to be reviewed in Tier 2 and Tier 3 applications in the light of changes to the Building Regulations and policy and guidance.

2.1.10 Otterpool Park is planned for construction over a long period and there will be changes in planning and regulatory requirements that will affect the approach. This document therefore provides a strategic direction for future planning applications taking into account potential changes in regulation and technological advancement.

2.1.11 Relevant guidance and case studies related to the direction of future energy policy and technological changes from Government, Government Bodies and relevant Stakeholders in the energy market have been reviewed to support the strategy and commitments set out in this Tier 1 Strategy.

2.2 Scope and content of the Report

2.2.1 The Energy Strategy comprises 12 sections that analyse the energy vision for Otterpool Park. These are outlined below, with a brief description of each section's content:

Section	Content
2 Utilities	Explores current energy infrastructure (natural gas and electricity) and estimated peak demand for Otterpool Park (further information in Utilities Strategy)
3 The Energy Market	Review of the future energy landscape, with current examples of best practice to highlight opportunities for Otterpool Park to embrace future innovations and commercial models. Includes electricity grid decarbonisation, tightening of Building Regulations, decentralised energy and microgrids, smart cities and community energy.
4 Energy Assessment Methodology	Outlines the approach taken to develop the Otterpool Park Energy Strategy.
5 Energy and Carbon Assessment – Baseline	Calculation of the baseline energy consumption of Otterpool Park against the current Building Regulations.
6 Be Lean: Reduce Demand	Outlines indicative designs of dwellings, and key design principles of non-domestic buildings, and their impact on energy and carbon emissions.
7 Be Clean: District Heating Study	Analyses the potential for site wide or smaller scale district heating networks based on energy supply and demand.
8 Be Green	Considers low and zero carbon technologies that could provide further energy and carbon savings from building integrated renewable energy technologies and stand-alone generating technologies.
9 Be Smart	The role of smart technology to support homes, communities and businesses
10 An Integrated Energy Strategy for the Future	Explores potential research and analysis to further develop the Energy Strategy for the future.
11 Impact of Future Building Regulations	Analysis of changes to carbon factors in the future Building Regulations.
12 Conclusion	Summary of how the Energy Strategy meets and exceeds national, regional and local policy requirements, and outlines the core commitments made for Otterpool Park.

2.3 Summary of the Proposed Development

2.3.1 The outline planning application proposes up to 8,500 homes and non-residential uses. A summary of the non-residential development proposed is set out in Table 1.

Table 2: Area Schedule for Otterpool Park Garden Settlement

Building Activity	Comments	Area (m^2) (Gross External Area) (GEA)
Education and Community Facilities	Schools, nurseries, creches, health centres, place of worship, community centres	Up to 67,000
Hotel	Hotel	Up to 8,000
Leisure	Sports pavilion and indoor sports hall	Up to 8,500
Mixed retail and related uses	Shops, professional services, restaurants, cafes, drinking establishments, hot food takeaways, offices, businesses	Up to 29,000
Employment	Commercial business space in hubs, commercial business park, light industrial business park.	Up to 87,500
Total	-	Up to 200,000

2.4 Utilities

2.4.1 Otterpool Park development is being designed to complement existing settlements. Through upgrading existing utility networks, it will increase the resilience of the networks and connectivity for a wider catchment and neighbouring settlements.

2.4.2 Consultation has been undertaken and preliminary negotiations with the five main utility providers (broadband and communication, gas, electricity, water supply and waste water) to discuss Garden Settlement energy requirements and discuss options and solutions have been undertaken.

2.4.3 Capacity of the current energy infrastructure alongside timelines and phasing of wider network upgrades are key areas of discussion and influence the direction of the Energy Strategy.

2.4.4 Please refer to the Utilities Delivery Strategy submitted with this application. This has been developed to support the Energy Strategy and help deliver the wider benefits that this would bring to new and existing communities.

Natural Gas Infrastructure

2.4.5 The proposed Development is planned to provide all-electric homes and also look to supply non-domestic buildings only with electricity.

2.4.6 Consultation has been undertaken with Southern Gas Networks (SGN) the incumbent local gas supplier as part of the infrastructure due diligence process. SGN has advised that if a significant gas demand is required the existing gas infrastructure in the area is not sufficient and significant network reinforcement will be required to serve the proposed development. It is noted that the lead-in for these works is estimated by SGN at 6 years.

2.4.7 SGN has advised that some capacity does exist within the existing low-pressure mains which could support properties on the initial phases of development potentially up to the first 1,000 properties if needed. However the intention is to provide all electric homes.

2.4.8 If natural gas was not required for the remaining site, the upgrade to the gas infrastructure would also not be required.

Electricity Infrastructure

2.4.9 The existing electric network is owned and managed by UK Power Networks (UKPN). A new electricity supply will be required from the statutory supplier to serve the new development.

2.4.10 There are approximately 3 Megavolt Amperes (MVA) of available capacity in the current electricity network which would serve around 650 properties if served by natural gas heating. As Otterpool Park is committed to not using gas in residential homes and as such, this allowance will provide power for approximately 350 homes.

2.4.11 For the remaining site an upgrade at Sellindge Grid Substation will be required for Otterpool Park to be supplied with electricity via a new primary substation, to be built on the site.

2.4.12 There is a need for a new primary sub-station to supply Otterpool Park. The maximum size available for this site is 63MVA which based on the modelling of electric heating and electric vehicles, should be sufficient for the development of this size. An analysis of the peak demand is presented in Table 2 below.

Peak Demand for the development

2.4.13 The peak electrical demand for the development has been estimated for the entire development, for the following scenarios:

- Low Demand Scenario: This is considered to be a typical representation of existing peak electrical demand that would include gas heating, gas cooking, and no allowance for electric charging of electric vehicles.
- Medium Demand Scenario: This is based on ASHP heating coupled with thermal storage for hot water usage, cooking is all electric, and an all-electric vehicles site.
- High Demand Scenario: This is based on electric resistance heating coupled without thermal storage, cooking is all electric, and an all-electric vehicles site.

2.4.14 Table 2 shows the assumptions used to estimate the peak electrical demand per dwelling.

Table 3 Residential Peak Electrical Demand per Dwelling.

(kVA/Dwelling)	Low: Gas + Elec + No EV	Med: ASHP + Thermal Storage	High: Electric Resistance Heating
Space Heating	-	1.66	3.33
Hot Water	-	0.95	1.89
Regulated Electricity	0.32	0.32	0.32
Unregulated Electricity	1.00	1.11	1.11
Streetlighting	0.04	0.04	0.04
EV charging (7kW charger)	-	1.84	1.84
Total kVA per dwelling	**1.36**	**5.92**	**8.53**

2.4.15 Using these assumptions, the estimated peak electrical demand for the proposed development is shown in Table 3.

2.4.16 The medium demand is considered the best representative scenario for the development which shows a peak electrical demand of 55.9 MVA.

Table 4 Residential and Commercial Peak Electrical Demand

	Low: MVA	Med: MVA	High: MVA
8,500 Dwellings	11.52	50.33	72.53
Hotel	0.15	0.23	0.30
Retail Space	0.55	0.82	1.10
Commercial Space	1.66	2.49	3.32
Schools	0.29	0.58	0.87
Sport	0.08	0.12	0.16
Health	1.06	1.33	1.59
Community	0.00	0.00	0.00
Total Site MVA	**15.3**	**55.9**	**79.9**

2.4.17 If the assessment is undertaken for 10,000 homes the medium scenario increases to 63MVA. This would therefore still be within the capacity of the new primary sub-station.

However, both this peak demand for 10,000 properties and for 8,500 are close to the electrical capacity of the new primary sub-station.

Utilities Summary

2.4.18 A Utilities Strategy (document ref OP5 Appendix 4.8) has been developed to enable all electric homes for the whole development. Due to the specification of electric heating and the increasing use of electric vehicles, this will lead to the requirement of larger electrical capacity than a development that used natural gas as the primary heating technology. An assessment has been undertaken of the diversified peak electrical demand to assess future capacity. Although this demonstrates it is likely to be within future capacity available, some load shifting may still be required.

3 The Energy Market

3.1 Introduction

3.1.1 The way energy is generated, delivered, purchased, traded and used is set to fundamentally change. With changes in policy and regulation, generation technology, information technology, smart controls, grid services, electrification of heat and vehicles, commercial strategies, consumer and community participation we are likely to see a revolution in the way energy is generated and used.

3.1.2 With access to information and smart controls, consumers will have increasing ownership of warmth, light, power and transport decisions. The Energy Strategy and choice of energy partners in the future should provide a route to enable these services to be provided cleanly, cheaply and efficiently by taking advantage of new energy technologies and digital enablers.

3.1.3 Otterpool Park will be built over a long timescale and therefore these changes will affect the overall Energy Strategy. It is important that the foundations are laid down for Otterpool Park to take advantage of these future changes whilst ensuring flexibility to adapt to circumstances and exploit opportunities that cannot be foreseen at this time.

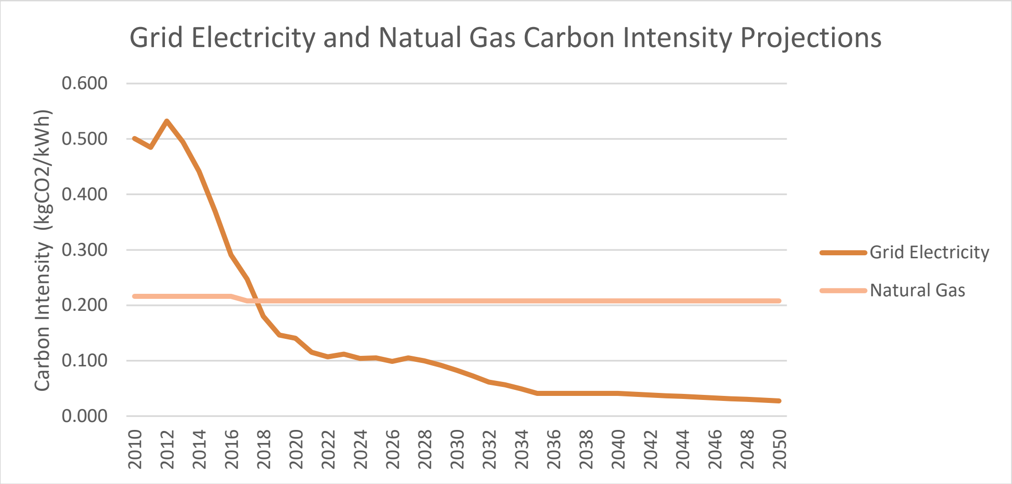
3.1.4 In this Section, the future energy landscape will be reviewed with current examples of best practice to highlight opportunities for Otterpool Park. The energy market will clearly look very different in the future, however by considering current trends a Strategy can be developed to ensure that Otterpool Park is well placed to embrace future innovations and commercial models.

3.1.5 Outlined below are some key guidance documents and current innovations in the energy market that will guide the Energy Strategy.

3.2 Electricity Grid Decarbonisation

3.2.1 The UK electricity grid is decarbonising as a result of an increasing proportion of lower carbon and renewable technologies within the electricity generation mix and policies to limit the use of carbon intensive fuels such as coal. Carbon emission factors for annual reporting cycles produced by the government each year have shown significant reductions in the grid emission factor. Government forecasts (HM Treasury, 2020) show a continuing trend of grid decarbonisation.

Figure 2 UK Government Forecast (HM Treasure 2020)) of Carbon Intensity of Grid Electricity and Natural Gas



3.2.2 Part L of the Building Regulations sets out the compliance process for new buildings. Carbon Emission factors used for Part L are currently taken from the Government's Standard Assessment Procedure for Energy Rating of Dwellings Version 9 (SAP) (BRE, 2012).

3.2.3 The BRE has published an updated version of SAP (Version 10) (BRE, 2018) which includes updated carbon emission factors for electricity and gas. Although this new version is not currently used for any official purpose (and outlines that SAP 2012 should continue to be used for Building Regulations compliance until further notice), it is likely that the proposed carbon emissions factors will be used from this document when the Building Regulations are next updated.

3.2.4 The SAP Version 10 carbon emission figures are compared with the current emission factors from SAP version 9 (2012) in Table 4 below. This shows a 74% reduction in the carbon emission intensity of electricity in the new version of SAP which is due to the increase of renewable energy generation within the energy mix.

Table 5 Current and Future Carbon Emission Factors in Building Regulations

Year	Natural Gas	Grid Electricity
SAP Version 9 (2012)- Used in current Building Regulations	0.216	0.519
SAP Version 10.1 – proposed to be used in future Building Regs (2020)	0.210	0.136

Electrification of Heating and Vehicles

3.2.5 Coupled with grid decarbonisation technology, innovation is taking place in the heat and vehicle markets which is driving a move towards the electrification of heating systems and vehicles.

3.2.6 According to the report Next Steps for UK Heat Policy (Climate Change Committee, 2016), electrically driven heat pump technology should be the leading low carbon option for buildings not connected to the gas grid. The report highlights that new-build properties and buildings off the gas grid can help to create the scale needed for supply chains to develop, including developing skills and experience, potentially in advance of accelerated roll-out after 2030. Where heat pumps have been installed correctly, satisfaction levels are high, even though installations are often disruptive and heat pumps operate in different ways to gas and oil boilers.

3.2.7 Additionally, the UK Government has published a Road to Zero Strategy (Department for Transport, 2018), which outlines the actions to develop a cleaner road transport. The aim is to put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040. The Government now aims to bring this forward on new petrol and diesel vehicles to 2035 (from 2040), or earlier if a faster transition appears feasible.

3.2.8 The Road to Zero Strategy includes proposals to support the development of one of the best electric vehicle infrastructure networks in the world including launching a £400 million Charging Infrastructure Investment Fund to help accelerate charging infrastructure deployment.

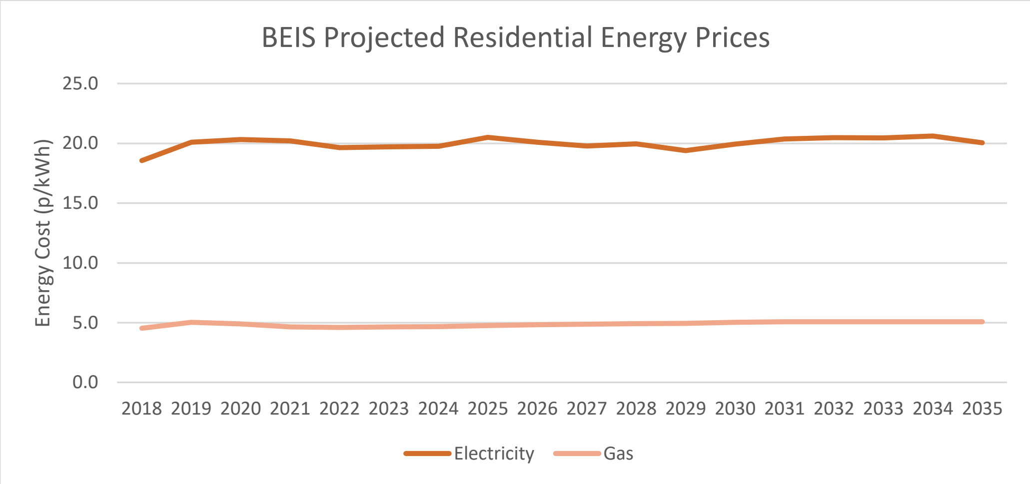
3.2.9 In the Future Energy Scenarios (National Grid, 2018), there could be as many as 11 million EVs by 2030 and 36 million by 2040. Due to increased electrification of transport and heating electricity demand could grow significantly by 2050.

Energy Prices

3.2.10 With the electrification of heat and transport, there will be further demand from the electricity network. Distributed energy, smart grids and digital controls within an evolving grid are being developed however there still may be an impact on electricity prices. It is important that the unit cost of energy is considered for the tenant when determining energy solutions in the future.

3.2.11 Figure 3 shows the Government projection (Department for Business, Energy & Industrial Strategy, 2018) on domestic gas and electricity unit costs. As can be seen electricity is projected to remain significantly higher than natural gas.

Figure 3 Projected Gas and Electricity Unit Costs (Source BEIS)



3.3 Tightening of the Building Regulations

3.3.1 The tightening of Part L of the Building Regulations is the main instrument that Government uses to drive energy and carbon reduction in new buildings.

3.3.2 The last revision of Part L, the relevant section for energy efficiency and carbon standards in the Building Regulations, occurred in 2013.

3.3.3 The Government has consulted on changes to Part L Building Regulations for 2021 under the Future Homes Standard (FHS) Consultation (Ministry of Housing Communities and Local Government, 2019) for dwellings and for non-domestic buildings.

3.3.4 This consultation sets out the Government's plans for achieving the Future Homes Standard, including proposed interim options to increase the energy efficiency requirements for new homes in 2022 as a meaningful and achievable steppingstone to the Future Homes Standard – which is yet to be defined.

3.3.5 The consultation sets out two options to uplift energy efficiency standards and requirements for the interim Building Regulations.

- Option 1 - 'Future Homes Fabric' (20% CO_2 reduction) which includes very high fabric standards (typically with triple glazing).
- Option 2 - 'Fabric plus technology' (31% CO_2 reduction): This is the Government's preferred option aimed to encourage the use of low-carbon heating or renewables. This option has lower fabric standards but incorporates either renewable technology or low carbon heating.

3.3.6 The Government response to the Future Homes Standard Consultation (Department for Levelling Up, Housing and Communities, 2021) confirmed that Option 2 will be the preferred target and the Interim standards will be implemented from 2022. This move is designed to help the industry get ready to meet the new standards by 2025.

3.3.7 When introduced in 2025 the FHS will ensure homes emit 75-80% less carbon emissions than homes delivered under current regulations and are designed to be net zero as the grid decarbonises.

3.3.8 Table 5 shows how the Building Regulations has been tightened since 2002 and the proposed changes under the Future Homes Standard.

Table 6 Previous changes to the Building Regulations.

Building Regulations Year	Improvement on Previous Part L (Dwellings)	Improvement on Previous Part L (Non-Dwellings)
2006	15%	15%
2010	25%	25% (Aggregate across build types)
2013	6%	9% (Aggregate across build types)
2016	0%	0%
Future Homes Standard and Future Buildings Standard (2021)	31%	27%
Future Home >2025	Not known at present	Not known at present

3.4 Decentralised Energy and Microgrids

3.4.1 Decentralised energy is a term to describe energy produced close to where it will be used, rather than at a large plant elsewhere. This can be local heat, power and combined heat and power generation, generated locally as opposed to using the national electricity grid or conventional gas mains individual boiler route.

3.4.2 Microgrids have a similar definition which is a small network of electricity users with a local source of supply and control that is usually attached to a centralised national grid but is able to function with a form of independence.

3.4.3 The benefit of decentralised supply is that local electricity generation reduces losses of transmission over long distances from power plants and can reduce carbon emissions if generated from low and zero carbon sources. Other benefits include security of supply as the energy supply is diversified from the single source of the electricity grid.

3.4.4 The potential also exists for lower energy costs by generating electricity locally and reducing the charges associated with traditional transmission and distribution of energy.

3.4.5 Viability of decentralised energy and aspects of microgrids are becoming increasingly viable due to increased digitisation of the grid, smart controls, local energy generation, energy storage, consumer participation and evolving energy tariffs and commercial arrangements.

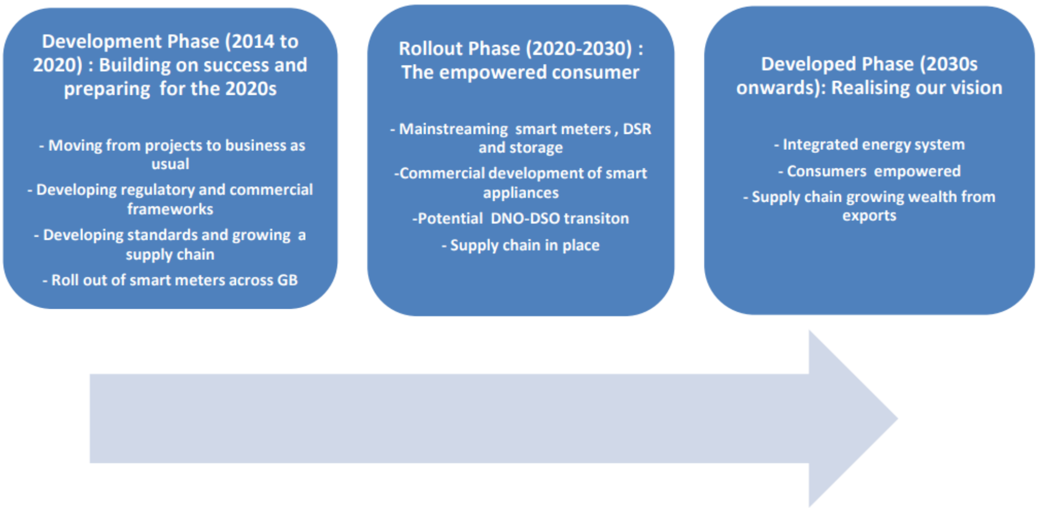
3.4.6 The opportunity for smart grids is being explored in communities in the UK and around the world in places such as Germany and Japan. These grids are still relatively new, and the viability of implementing such a system on a large scale is currently unclear, though optimism over the opportunities offered by such a move remains strong in the industry.

3.4.7 The concepts of decentralised energy and smart/micro grids will be explored for Otterpool Park as part of the integrated strategy proposed in this document. Smart grids use sensors that collect data about consumers' energy usage and requirements. Simply, a smart grid is more economical, reliable, sustainable and secure. It allows real-time communication with technology and consumers to create a more personalised service. Prior to investment in smart technology for the grid, the needs of the occupants and the potential benefits need to be understood and studied, to enforce an optimised smart system.

3.4.8 For the implementation of smart grids, it will take some time for all the technologies to be perfected, equipment installed, and systems tested before it comes fully online. And it won't happen all at once — the Smart Grid is evolving, piece by piece, over the next decade or so.

Currently, the UK are in the Rollout Phase (2020-30), preparing for the developed phase where there will be an integrated energy system in place in time for the completion of Otterpool Park.

Figure 4 Smart Grid - Key development stages



3.5 Smart Cities

3.5.1 There are many definitions of a Smart City. The Government's Smart Cities background paper (Department for Business Innovation and Skills, 2013) outlines that a Smart City is 'essentially enabling and encouraging the citizen to become a more active and participative member of the community'. For example, providing feedback on the quality of services or the state of roads and the built environment, adopting a healthier lifestyle, volunteering for social activities or supporting minority groups. Furthermore, citizens need employment, and "Smart Cities" are often attractive locations to live, work and visit. It brings together hard infrastructure, social capital including local skills and community institutions, and (digital) technologies to fuel sustainable economic development and provide an attractive environment for all.

3.5.2 The paper outlines that there are five key aspects of a Smart City:

- A modern digital infrastructure, combined with a secure but open access approach to public re-useable data, which enables citizens to access the information they need, when they need it
- A recognition that service delivery is improved by being citizen centric
- An intelligent physical infrastructure ("smart" systems or the Internet of Things), to enable service providers to use the full range of data both to manage service delivery on a daily basis and to inform strategic investment in the city
- An openness to learn from others and experiment with new approaches and new business models; and
- Transparency of outcomes/performance, for example, city service dashboards to enable citizens to compare and challenge performance.

3.5.3 For Otterpool Park to be successful in the 21st Century it is considered that it must embrace the principles of a Smart City and the evolving definition and principles that this concept embodies.

3.5.4 At the detailed design stage further consideration will be given to the infrastructure and commercial requirements that would be needed to exploit the benefits of a smart city and how it relates to energy infrastructure and services. This would likely be best achieved at Tier 2/3 of the planning process, where detailed development proposals will allow an informed assessment of the requirements for Otterpool Park to exploit the benefits of a smart city.

3.6 Community Energy - Commercial Options

3.6.1 A key idea within the Garden Settlement philosophy and intertwined with the direction of the energy market is to enable community participation. For energy this could mean to participate in, and benefit from, local energy generation, storage, controlling the time energy is used and providing associated grid services.

3.6.2 Commercial models and energy tariffs are available for communities that are served by a district heating system or decentralised energy structures, such as micro-grids, to benefit from the advantages of locally managed energy.

3.6.3 Traditionally, electricity generated by community energy has been developed to ensure that the benefits of an energy generating technology, such as a wind turbine, stay within the local area. However, these models could also apply to individual renewable generators and smart controls allowing consumers to provide grid services.

3.6.4 The report Local Supply: Options for Selling Your Energy Locally (Stevens Scown, 2016), outlines some of the key approaches that a community could participate in an energy market at Otterpool Park. These models are mainly focused on electricity supply, but some are also relevant to the heat market. Some relevant options include:

1. Energy Services Company (ESCo)
    - ESCo's provide energy services, such as hot water, lighting or energy efficiency savings, as opposed to the direct supply of electricity or gas. Therefore, the ESCo revenue is often not directly linked to energy consumption, which incentivises the ESCo to create energy savings.
    - If an ESCo delivers services outside of the current regulatory arrangements, such as heat networks, they will not require a licence. But if they are directly supplying electricity, they will need to partner with a licensed supplier or set up a private wire.
2. A White Label
    - A white label supplier works in partnership with a licensed supplier to offer tariffs under a different brand. The white label supplier negotiates their own tariff and can therefore shape it to meet their own objectives, whether that is profit generation, lower tariffs, investing in local energy efficiency measures or developing its own generation.
3. Local Tariff
    - Suppliers are able to offer local tariffs that are linked to a local generating site. This option relies on there being local generation to benefit from.
4. Fully licensed supplier
    - Some Local Authorities such as Bristol City Council have become a licensed supplier to have full control over the purchasing and retail of electricity. This enables the Local Authority to help it achieve objectives of investing in locally generated, low carbon energy and providing a competitive energy tariff its households.

3.6.5 These commercial options will be considered further as the design develops.

3.6.6 Future Energy Case Studies can be found in Appendix E.

4 Energy Strategy Methodology

4.1 Introduction

4.1.1 A traditional Energy Strategy covers operational energy and demonstrates how a building or development meets compliance with national, regional & local planning policies including the relevant sections of the current Part L of the Building Regulations for the new buildings. Energy data to support this approach is usually based on the calculations using SAP and SBEM the Government approved methods for demonstrating compliance with Part L1A and Part L1B (2013) of the Building Regulations.

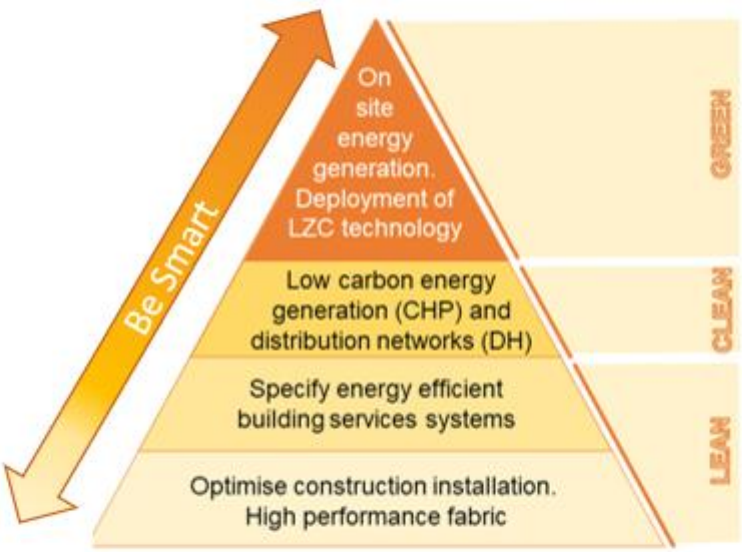
4.1.2 The following sections outline an indicative approach to how the energy and carbon commitments outlined in the Executive Summary can be achieved. The specifications and design measures are not prescriptive at this stage, allowing for flexibility, innovation and evolution at the Tier 2 and Tier 3 planning application stages. Future specifications and Standards will consider any future regulations or guidance, including the proposed Zero Carbon Toolkit that Folkstone and Hythe Council is considering to provide guidance for new buildings.

4.1.3 Furthermore, as construction of Otterpool Park is not planned to start until 2023, Building Regulations will not be the same as the current version of the Building Regulations (2013) and will also change further during development timescale which may lead to different requirements and changes to the design.

4.1.4 An approach has been developed following the principles of a traditional Energy Strategy, whilst also assessing the potential changes that the energy market and regulations would have on design choices for future Energy Strategies.

4.1.5 A recognised approach to develop an Energy Strategy is through consideration of design measures using an energy hierarchy. This energy hierarchy is based on the application of the principles of resource efficiency use to - ‘reduce, reuse, recycle and recover’. The key elements of the hierarchy are as outlined in Figure 5 below.

Figure 5 Energy Hierarchy



4.1.6 The first consideration is to reduce the amount of energy used by minimising demand, then improve the efficiency of all mechanical and electrical services to reduce energy consumption. With all achievable methods of reduction in place and all plants/boilers functioning efficiently, it is then appropriate to consider how to generate energy from renewable sources. This hierarchical approach can be illustrated to comprise of three steps once the energy consumption and carbon emissions of the baseline development to meet the Building Regulations has been determined:

- Energy efficient measures to reduce carbon dioxide emissions (Be Lean),
- Further reductions in carbon dioxide emissions through the development of a district heating/cooling network (Be Clean),
- Proposals to further reduce carbon dioxide emissions through the use of on-site renewable energy technologies (Be Green).

4.2 Energy Demand Model

4.2.1 An energy and carbon prediction model has been developed using SAP and SBEM, the Government approved methods for demonstrating compliance with Part L1A2013 and Part L1B2013 of the Building Regulations. This model has been developed to assess the benefits of energy efficiency measures, efficient and clean technologies, and low and zero carbon technologies.

4.2.2 This model has also been developed to take account of the phasing timetable of Otterpool Park providing an option to calculate the potential impact of future changes to the Building Regulations during the future development timescales. Based on Government Forecast (HM Treasury, 2020) the key changes that have been included in the prediction model are carbon emissions factors and potential further tightening of the Building Regulations from the existing standards.

The Challenge Modelling Part L1A Future Changes

4.2.3 Currently under Part L1A Building Regulations for new dwellings a building is assessed against a notional building. The Building Regulations set out requirements for specific aspects of building design and construction. It requires that 'where a building is erected, it shall not exceed the target CO_2 emission rate for the building'. The target emission rate (TER) for CO_2 sets a minimum allowable standard for the energy performance of a building and is defined by the annual CO_2 emissions of a notional building of same type, size and shape to the proposed building. TER is expressed in annual kg of CO_2 per m^2.

4.2.4 The CO_2 emission rate of the proposed building is calculated based on its actual specification and is expressed as the dwelling emission rate (DER) for dwellings and building emission rate (BER) for buildings other than dwellings. The DER or BER for the proposed building must not exceed the TER.

4.2.5 The TER for dwellings is based on a notional building with set design parameters including the heating and hot water provided by mains gas boiler.

4.2.6 To account for this Part L1A has introduced fuel factors that relax TER for homes heated by a more carbon intensive fuel than gas (e.g. off-gas grid homes, electrically heated apartments etc.). Without a fuel factor these homes would need to meet the same TER as if using gas. With a fuel factor the TER is eased.

4.2.7 The fuel factors used in Part L1A have previously been rebased to align with the new TER methodology and with the revised government carbon dioxide emission factors.

4.2.8 Changes to these fuel factors have been included in the future modelling of compliance with the Building Regulations and rebased with the grid decarbonisation so that the benefits of electric heating are not overstated.

4.3 Regulated and Unregulated Energy

4.3.1 The Building Regulations covers ‘Regulated’ energy which is the energy consumption and carbon emissions which relates to carbon emissions associated with the building’s fabric, air tightness, heating and cooling, and fixed lighting.

4.3.2 Unregulated energy relates to energy and associated carbon emissions that are not covered by the Building Regulations. This includes energy for appliances in dwellings and equipment for non-domestic buildings.

4.3.3 In this assessment the energy and carbon emissions associated with regulated and unregulated activities have been calculated. However, unregulated energy and carbon have not been included in target setting and the calculations showing the improvements on Be Lean, Be Clean and Be Green opportunities. These have been shown only against the Building Regulations baseline.

4.4 Summary of Methodology

4.4.1 The Energy Strategy methodology therefore looks to combine the traditional approach of assessing compliance on planning policies and Building Regulations using the current standards (Part L 2013) and calculations inputs whilst developed to consider the future Building Regulations and how the evolving energy market and grid decarbonisation may influence the standards.

4.4.2 A qualitative element is also included in developing the Energy Strategy as future changes to the energy market cannot be quantitively modelled with complete certainty.

5 Energy and Carbon Assessment – Baseline

5.1 Introduction

5.1.1 The baseline energy consumption of the proposed Development against the current Building Regulations (ADL1A, ADL2A 2013) is calculated in this section. This baseline will serve as a starting point for setting energy efficiency improvement goals as well as a comparison point for evaluating efforts aimed at reducing the development's CO_2 emissions.

5.1.2 The baseline energy use and resulting CO_2 emission rate of the development has been assessed using an energy model with SAP, and SBEM Part L Approved Software inputs. Without specific building designs, the baseline energy use and resulting CO_2 emissions are calculated based on meeting the TER specified in the Building Regulations ADL1A 2013 for a generic building of that type.

5.2 Domestic Baseline

5.2.1 The baseline annual energy use and CO_2 emissions are presented in Table 6 below. To reduce complexity, although built across several phases and a 19-year timeframe, the baseline accounts for all 8,500 properties.

5.2.2 For the proposed electric heating, due to the current approach to calculation Part L1A 2013 which increases the heating demand by a fuel factor which also elevates the TER baseline. For the notional building used to calculate the TER the heating demand is specified with a gas boiler and the fuel factor of 1.55 is employed to account for electric heating.

Table 7 Baseline Domestic Energy Consumption and Carbon Emissions – Electric Heating

End Use	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)
Space Heating	37,622,114	12,595,854
Hot Water	19,954,897	6,680,899
Electricity (Lighting, Pumps and Fans)	4,016,015	2,084,312
Total Part L	**61,593,026**	**21,361,065**
Equipment (Unregulated Energy)	25,707,958	13,342,430
Total (including equipment)	**87,300,984**	**34,703,496**

5.3 Non-Domestic Baseline

5.3.1 The non-domestic baseline emissions have been calculated to achieve Part L2A 2013 compliance with the Building Regulations. Based on the SBEM modelling the following building types were developed to account for the future demand and activities at Otterpool Park.

Table 8 Parameters Used in SBEM Modelling

Building Activity	Comments	Area (m^2) (Gross External Area) (GEA)
Education and Community Facilities	Schools, nurseries, creches, health centres, place of worship, community centres	Up to 67,000
Hotel	Hotel	Up to 8,000
Leisure	Sports pavilion and indoor sports hall	Up to 8,500
Mixed retail and related uses	Shops, professional services, restaurants, cafes, drinking establishments, hot food takeaways, offices, businesses	Up to 29,000
Employment	Commercial business space in hubs, commercial business park, light industrial business park.	Up to 87,500
Total	-	Up to 200,000

5.3.2 Part L2A 2013 for non-domestic buildings does not have the same fuel factor as domestic buildings covered by Part L1A of the Building Regulations (which improves the carbon benefit of electric heating) so the TER is the same as the BER. The baseline energy and carbon emissions across all building types is presented in Table 8 below.

5.3.3 For the proposed electric heating, the TER remains the same, however energy consumption does vary between end uses.

Table 9 Baseline Non-domestic Energy Consumption and Carbon Emissions – Electric Heating

End Use	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)
Space Heating	2,043,679	441,435
Cooling	904,952	469,670
Hot Water	3,334,973	720,354
Electricity (Lighting, Pumps and Fans)	6,693,424	3,473,887
Total Part L	**12,977,028**	**5,105,346**
Equipment (Unregulated Energy)	6,071,577	3,151,148
Total (including equipment)	**19,048,605**	**8,256,494**

5.4 Summary of Energy Demand Baseline

5.4.1 The electric baseline has been used as the site will be developed with all electric heating, and energy efficiency and decarbonisation measures have been assessed against this baseline.

Table 10 Baseline Energy Consumption and Carbon Emissions

End Use	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)
Space Heating	39,665,541	13,037,234
Cooling	904,952	469,670
Hot Water	23,289,870	7,401,254
Electricity (Lighting, Pumps and Fans)	10,709,439	5,558,199
Total Part L	**74,569,802**	**26,466,357**
Equipment (Unregulated Energy)	31,779,535	16,493,579
Total (including equipment)	**106,349,338**	**42,959,936**

6 Be Lean: Reduce Demand

6.1 Domestic Properties

6.1.1 At this stage, the design of the dwellings for Otterpool Park are not yet finalised, however, in this Section some indicative designs are outlined and the impact on energy and carbon emissions provided. However, it is likely that developers will have variations as there will be flexibility on how they meet energy efficiency targets and carbon targets.

6.1.2 The current standards required to meet Building Regulations (2013) require a high level of thermal performance and efficient design. The proposed Development would reduce energy consumption and emissions beyond Building Regulations requirements by incorporating a range of energy efficiency measures to achieve the high standards of sustainable design and construction.

6.1.3 All properties will be designed following fabric first approach ethos. For domestic properties this will include a requirement for an improvement on Fabric Energy Efficiency Standards against the current Building Regulations at the time of the planning application.

6.1.4 The domestic properties will be designed using the Option 2 of the Interim Future Homes Standards as a minimum benchmark. However, this only achieves a 31% carbon reduction on current Building Regulations and further fabric, renewable energy or low carbon heating measures are required to improve on this level.

6.1.5 The fabric standards and further design measures in this section are illustrative of one approach to achieve a 45% carbon reduction on current Building Regulations. To provide flexibility for future developers, the exact approach to energy efficient design is not prescriptive at this stage, however, low non-fossil fuel carbon heating and renewable PV, where feasible, are required to be incorporated into the design.

Table 11. Indicative Be Lean Specification for Residential Developments

	Indicative Measurements	Indicative Design Optimisation
Be Lean Measurements	6.1.6 U-Values as proposed in • Table 11. • Air Permeability as proposed in Table 12. • Low carbon heating in the form of ASHPs in the initial stages, ensuring flexibility for the inclusion of new technologies if they become available. • Smart monitoring and controls • Highly efficient LED light fittings. • Wastewater Heat Recovery	• Maximising natural ventilation where possible. • Optimise passive design measures to prevent overheating and cooling requirements. • Optimise daylighting in compliance with BS EN 17037:2018 • Low-flow taps and showers

6.1.7 The following U-values are indicative and provide a possible solution for achieving the 45% carbon reduction target, and can be achieved by incorporating good levels of insulation. Indicative levels of improvement are outlined in Table 11 below. These are compared to the limiting values outlined in Part L1A 2013 Building Regulations with 2016 amendments.

Table 12 Indicative Fabric and Window Specification above current Building Regulations (2013)

Fabric	Part L U-Limiting Value	Interim Future Homes Consultation Proposed Minimum Standards	Indicative Lean U-Value
Roof U-value	0.20 W/m²/K	0.16 W/m²/K	0.11 W/m²/K
External Walls U-value	0.30 W/m²/K	0.26 W/m²/K	0.18 W/m²/K
Floor U-value	0.25 W/m²/K	0.18 W/m²/K	0.13 W/m²/K
Window units (whole window) U-value	2.0 W/m²/K	1.6 W/m²/K	1.2 W/m²/K double glazing

6.1.8 **Air Permeability**: High levels of air tightness will further reduce the energy requirements of the development and an indicative value is outlined in Table 12 below.

Table 13 Indicative Air Permeability Specification above current Building Regulations (2013)

Building Element	Building Regulations Limiting Factor	Indicative Specification
Air permeability	15 m³/(h.m²) at 50 Pa	5 m³/(h.m²) at 50 Pa

6.1.9 Current Part L Building Regulations set a maximum air permeability of 10 m³/(h.m²) at 50Pa. The proposed limiting value in the Future Homes Standard Consultation is 8 m³/(h.m²) at 50Pa. By adopting good practice construction techniques, the proposed Development may seek to improve upon this to achieve 5 m³/(h.m²) at 50Pa and further reduce energy consumption.

Domestic Savings after Be Lean

6.1.10 Calculations demonstrate that average regulated energy efficiency savings of 38.5% per dwelling against Building Regulations electricity baseline could be achieved if this indicative specification was used.

6.1.11 Table 13 summarises the reduction in building energy consumption and the corresponding reduction in CO_2 emissions resulting from the implementation of the measures mentioned above. All calculations have been carried out with the SAP calculation procedure – the government approved calculation methodology.

Table 14 Be Lean – Domestic Energy and Carbon Savings with electric heating

	Baseline (Part L)		Be Lean (Electric heating)		Carbon Reduction (%)
	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Carbon Reduction (%)
Space Heating	37,621,863	12,595,800	13,327,564	6,917,006	45.1%
Hot Water	19,954,897	6,680,899	8,337,643	4,327,237	35.2%
Equipment (Unregulated)	4,016,015	2,084,312	3,633,515	1,885,794	9.5%
Total Part L	61,592,775	21,361,011	25,298,722	13,130,037	38.5%
Equipment (Unregulated)	25,707,958	13,342,430	25,707,958	13,342,430	0.0%
Total (including equipment)	7,300,733	34,703,441	51,006,681	26,472,467	23.7%

6.2 Non-Domestic Properties

6.2.1 The design of the non-dwellings for Otterpool Park has not yet been finalised, however in this Section some key design principles are outlined and the impact on energy and carbon emissions for the non-domestic buildings is provided. The design measures outlined below are indicative of the philosophy and strategy aimed at energy reduction. However, these may vary depending on the building type and changes in technology in the future.

6.2.2 The current standards required to meet Building Regulations (2013) require high level of thermal performance and efficient design. The Future Homes Standard Consultation to update Part L of the Building Regulations and efficiency standards has currently only been updated for domestic buildings. For non-domestic buildings, energy efficiency improvement thresholds have been determined to reduce energy consumption and emissions beyond the current Building Regulations requirements. Non-domestic properties at Otterpool Park will achieve a BREEAM rating of 'Excellent'.

6.2.3 To quantify the energy and CO_2 reductions expected at the development, the following proposed measures were modelled:

Table 15. Indicative Be Lean Specification for Non-domestic properties

	Indicative Measurements	Indicative Design Optimisation
Be Lean Measurements	6.2.4 U-Values as proposed in • Table 11. • Air Permeability as proposed in Table 12. • Low carbon heating in the form of ASHPs in the initial stages, ensuring flexibility for the inclusion of new technologies if they become available. • Smart monitoring and controls • Highly efficient LED light fittings.	• Maximising natural ventilation where possible. • Optimise passive design measures to prevent overheating and cooling requirements. • Optimise daylighting in compliance with BS EN 17037:2018 • Low-flow taps and showers • Mechanical Ventilation Heat Recovery

6.2.5 The following U-values are indicative and provide a possible solution for achieving the carbon reduction target and can be achieved by incorporating good levels of insulation. Indicative levels of improvement are outlined in Table 15. This is compared to the limiting fabric parameters outlined in Part L2A 2013 Building Regulations with 2016 amendments.

Table 16 Indicative Fabric and Window Specification above Current Building Regulations (2013)

Fabric	Part L U-Value Limiting Fabric Parameters	Indicative Lean U-Value
Roof U-value	0.25 W/m²/K	0.15 W/m²/K
External Walls U-value	0.35 W/m²/K	0.2 W/m²/K
Floor U-value	0.25 W/m²/K	0.15 W/m²/K
Window units (whole window) U-value	2.2 W/m²/K	1.4 W/m²/K double glazing

6.2.6 **Air Permeability:** High levels of air tightness will further reduce the energy requirements of the development and an indicative value is outlined in Table 16 below.

Table 17 Indicative Air Permeability Specification above Current Building Regulations (2013)

Building Element	Building Regulations	Indicative Specification
Air permeability	10 m³/(h.m²) at 50 Pa	5 m³/(h.m²) at 50 Pa

6.2.7 Current Part L Building Regulations set a maximum air permeability of 10 $m^3/(h.m^2)$ at 50Pa, by adopting good practice construction techniques, the proposed Development could seek to improve upon this to achieve 5 $m^3/(h.m^2)$ at 50Pa.

6.2.8 Potential specification for light fittings could be to use low energy Light Emitting Diode (LED) lighting, potentially utilizing 1.2 W/m^2 LED, 100 Lux.

Non-domestic Savings after Be Lean

6.2.9 Calculations demonstrate that savings vary depending on the building type and detailed designs to meet Building Regulations. These designs may also be influenced by future changes to the Building Regulations.

6.2.10 Average regulated energy efficiency savings of 20% against Building Regulations electricity baseline could be achieved using this indicative specification. An electricity baseline has been chosen as that is the most likely fuel supply for the non-domestic buildings in the future.

6.2.11 Table 17 shows indicative carbon savings separated by building type. As recognised in the Building Regulations, due to variations in demand between building types (hot water, cooling, heating), variations exist between ease of compliance with Building Regulations.

Table 18 Be Lean Non-Domestic Improvements with Building Regulations

Building Type	Electric Heating		
	Carbon Emissions Baseline ($kgCO_2/yr$)	Carbon Emissions Be Lean ($kgCO_2/yr$)	Carbon Savings (%)
A1: Retail_2	655,393	521,937	20.4%
A3: Café restaurant_2	692,332	559,073	19.2%
B1: Offices_2	1,822,708	1,474,613	19.1%
C1: Hotel_2	351,110	285,344	18.7%
D1: Community_2	385,223	309,490	19.7%
D1: Education_2	915,038	712,046	22.2%
D2: Indoor sports_2	283,543	229,270	19.1%

6.2.12 Table 18 below shows the impact of energy saving measures on the electrical heated buildings.

Table 19 Summary of energy saving measures for domestic and non-domestic buildings

	Baseline (Part L)		Be Lean (Electric heating)		Carbon Reduction (%)
	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Carbon Reduction (%)
Space Heating	2,043,679	441,435	595,228	308,924	30.00%
Cooling	904,952	469,670	887,723	460,728	1.90%
Hot Water	3,334,973	720,354	1,147,231	595,413	17.30%
Equipment (Unregulated)	6,693,424	3,473,887	5,253,771	2,726,707	21.50%
Total Part L	12,977,028	5,105,346	7,883,953	4,091,772	19.90%
Equipment (Unregulated)	6,071,577	3,151,148	6,071,577	3,151,148	-
Total (including equipment)	19,048,605	8,256,494	13,955,530	7,242,920	12.30%

6.3 Summary after Be Lean Measures

6.3.1 Table 19 below outlines the benefit of the indicative passive and energy efficiency measure on the energy and carbon baseline based on electric heating combined for domestic and non-domestic buildings.

Table 20 Savings from Be Lean Measures based on Electric Heating

	Baseline (Part L)		Be Lean (Electric heating)		Carbon Reduction (%)
	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Energy (kWh/yr)	Carbon Emissions (kgCO2/yr)	Carbon Reduction (%)
Space Heating	39,665,541	13,037,234	13,922,792	7,225,929	44.6 %
Cooling	904,952	469,670	887,723	460,728	1.9%
Hot Water	23,289,870	7,401,254	9,484,874	4,922,650	33.5 %
Equipment (Unregulated)	10,709,439	5,558,199	4,780,746	4,612,501	17.0 %
Total Part L	74,569,802	26,466,357	29,076,136	17,221,809	34.9 %
Equipment (Unregulated)	31,779,535	16,493,579	31,779,535	16,493,579	-
Total (including equipment)	106,349,338	42,959,936	60,855,671	33,715,387	21.5 %

6.3.2 These indicative measures from domestic and non-domestic regulated energy could reduce carbon emissions by 34.9% from the current Building Regulations baseline.

7 Be Clean – District Heating Study

7.1 Introduction

7.1.1 In order to assess the 'Be Clean' Stage of the energy hierarchy, the potential for generating energy efficiently, a district heating study for Otterpool Park has been undertaken by AECOM assessing up to 1,000 dwellings. The full report can be found in Appendix F. The key findings from the study are outlined in this Section. The report has been funded by Homes England working with the Department for Business, Energy and Industrial Strategy (BEIS) who are funding a number of studies of new build housing schemes where a district heating scheme may be appropriate. We support and agree with the conclusions of this study, which aligns with our own analysis.

7.2 Background

7.2.1 The present system of energy generation and distribution in the UK is relatively inefficient. Electricity is generated centrally, resulting in electricity transmission losses and large amounts of waste heat from power stations currently not used. Heat is usually generated at a building scale which means that only small-scale technologies can be used (most commonly natural gas-fired boilers). Whilst alternative forms of heat generation are available, they are often more difficult and expensive to implement at a building scale. By localising electricity generation and capturing heat from localised generation systems for distribution, it is possible to improve efficiencies through the capture of waste heat and reduced electricity losses.

7.2.2 A key component of a Decentralised Energy (DE) scheme is a district heat network (DHN). This provides opportunities for capturing heat and distributing it to a number of customers. The generation of heat at a larger scale, and subsequent distribution to a larger number of connected buildings, allows alternative and more efficient forms of heat generation to be used which would not be viable at a building scale, the capture and delivery of waste heat, and the transition to new lower carbon technologies in the future (due to a single point technology change rather than the retrofitting of multiple individual buildings).

7.2.3 A heat network comprises a system of insulated pipes which distributes hot water from a centralised heat generation plant to a number of different buildings to provide space heating and hot water. Schemes can range in size from simply linking two buildings together, to spanning entire cities. In some continental European countries, the use of heat networks is widespread – in Denmark around 60% of the country's heat load is connected to heat networks, including a scheme covering most of Copenhagen.

7.2.4 The use of DE in Otterpool, comprising heat networks and energy generation plants at a district scale, may offer a number of potential benefits:

- Carbon Dioxide savings: The combination of more efficient generation and the ability to use alternative technologies and fuels means that heat networks may provide CO_2 reductions to communities.
- Carbon cost savings: Policy and Regulation such as the Climate Change Levy place a value on carbon emissions (effectively a carbon tax) and it is expected that such policies may increase in future as the pressure to reduce emissions increases. Therefore, a reduction in CO_2 will also provide economic benefits.
- Energy security: The higher efficiencies combined with the ability to provide alternative forms of heat generation (for example from large heat pumps or energy from waste).

7.3 Heat Demand

7.3.1 The energy demands were estimated based on the assumption that all homes are built to high energy efficiency standards. Energy use for proposed non-domestic buildings for this element of the study came from benchmarks derived from AECOM's work on new construction for the Greater London Authority (GLA) (AECOM, 2017).

7.3.2 District heating is generally most viable in existing city centres with high concentration of heat demand, new developments with diverse loads or high-density flats.

7.3.3 The proposed Otterpool Park masterplan covers a large area, and a phasing schedule lasting many years. The housing density and non-domestic build will vary across the masterplan. Therefore, an indicative masterplan with a high-density housing area close to non-domestic loads was used for analysis to demonstrate the potential viability for district heating.

7.3.4 This area is modelled to have higher heat demand density compared to the majority of the rest of the site. Furthermore, it should indicate whether or not the heat network could be expanded to further site locations in the future, where there is a lower housing density and a heat network would be less likely to be economically viable.

7.3.5 The indicative district heat network was developed with large areas of high density housing and non-domestic properties, including a hotel and schools, and assumed to be built in the early phases of the build schedule.

7.3.6 The resulting energy demand data have been plotted to generate energy maps of the area of the site which was assumed to have the highest heat density in the early phases of the site development. This is the study area.

7.3.7 Based on this demand analysis heat network options were created with increasing network length and heat demand. The three indicative options analysed were:

- Option 1: including a hotel, community centre, nursery, indoor sports hall, primary school, secondary school, and main retail high street
- Option 2: Option 1 plus additional high-density housing
- Option 3: Options 1 and 2, plus the rest of the development within this map.

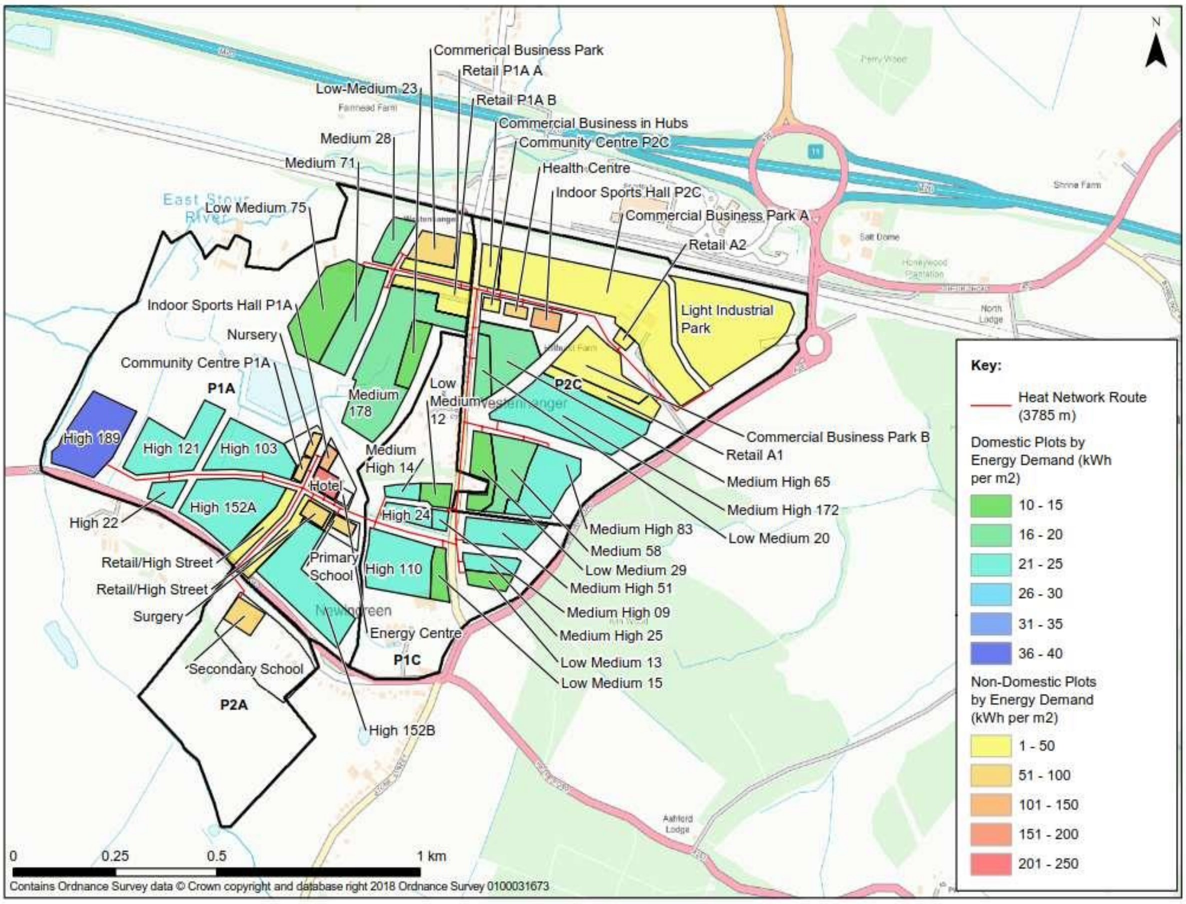
7.3.8 The chosen analysis area has the following buildings:

- 1,816 homes
- 1 x primary school
- 1 x secondary school
- 1 x hotel
- 2 x community centres
- 2 x indoor sports halls
- 1 x health centre
- 1 x nursery
- 1 x surgery
- Multiple retail areas
- Commercial business parks
- A light industrial park.

7.3.9 There is assumed to be very few constraints in terms of barriers for a heat network on this proposed site, other than some existing properties located in the centre of site (but not within any of the phase boundaries) and a body of water towards the centre of phase P1A (as shown on Figure 9).

7.3.10 Using the assumed annual energy demands for each property, the heat load per m^2 was calculated for each zone of the study area. An energy demand heat map was finally created within the GIS tool (ARCGIS). The outcome of this can be seen in Figure 9.

Figure 6 Calculated Heat Density Map in Assessment Area (Taken from AECOM Report in Appendix D)



7.3.11 On the heat map the areas of highest heat density are shown in colours towards the blue end of the green-blue colour scale for domestic plots, and towards the red end of the yellow-red colour scale for non-domestic plots/buildings. The areas with no assumed heat load or excluded from the study are coloured white.

7.4 Heat Supply Options

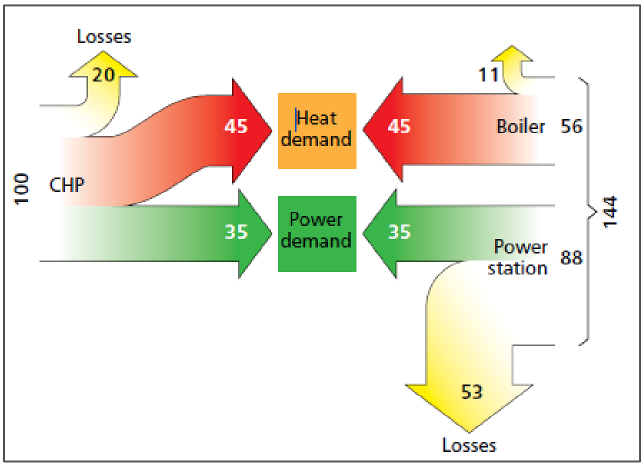
7.4.1 Energy supply options for generating heat and in some cases electricity have been reviewed to identify their suitability to provide a cost-effective and reliable energy supply that will also deliver environmental benefits.

7.4.2 An overview of key options is outlined in the paragraphs below.

Gas Combined Heat and Power

7.4.3 Combined heat and power (CHP) is an efficient process that captures and utilises the heat that is a by-product of the electricity generation process. By generating heat and power simultaneously, CHP can reduce carbon emissions by up to 30% compared to the separate means of conventional generation via a boiler and power station. However, carbon reduction is based on the difference in gas and electricity carbon emission factor, which is projected to change significantly over the next 5-10 years.

7.4.4 The heat generated during this process is supplied to a heat demand that would otherwise be met by a conventional boiler (or ASHP). CHP systems are highly efficient, making use of the heat that would otherwise be wasted when generating electrical or mechanical power. This allows heat requirements to be met that would otherwise require additional fuel to be burnt.



7.4.5 For Otterpool Park, a gas CHP would require a significant gas supply which could be a limiting factor as a new sufficient gas supply may require 6 years to enforce.

7.4.6 Otterpool Park LLP is committed to no gas within the residential element of Otterpool even in advance of the government requirement for no gas boilers in new homes from 2025, so a gas CHP would only potentially serve the commercial developments.

7.4.7 The attached figure from Carbon Trust Good Practice Guide 388, 2004, shows the energy efficiency of the CHP using less primary energy for the generation of the same amount of heat and power.

Biomass / Biomass CHP

7.4.8 Wood-fuelled heating systems, also called biomass systems, burn wood pellets, chips or logs to provide warmth in a single room or to power central heating and hot water boilers for buildings or a district heating system.

7.4.9 Boiler systems that burn biomass, such as wood chips and pellets, tend to be physically larger and more expensive than the equivalent gas or oil boiler. This is partly a result of the physical requirements for a high temperature combustion environment and transporting the fuel.

7.4.10 Biomass utilised for heat and/or power also has the huge advantage that its production and use is very nearly carbon neutral, unlike fossil fuel sources such as coal, oil and gas. Almost all of the carbon dioxide released on combustion is reabsorbed by crops or trees that have replaced the fuel being burnt.

7.4.11 Pellet boilers require less maintenance than chip ones and produce considerably less ash residue.

7.4.12 Other considerations with biomass boilers are that they require access for fuel delivery, space for fuel storage and sufficient flue height for dispersion of the products of combustion.

7.4.13 There are air quality issues related to the combustion of biomass fuel. Pollutants associated with biomass combustion include particulate matter (PM10 / PM2.5) and nitrogen oxides (NOx) emissions can be significantly higher than gas fired boilers. These pollution emissions can have an impact on local air quality and affect human health. Although in theory, this can be overcome with the use of flue dilution, however, this technology can be large and expensive and is really only appropriate for much larger systems.

7.4.14 Biomass CHP technologies below around 2MWe including Organic Rankine Cycle Biomass and Biomass Gasification below around 2MWe are still a relatively immature technology. Many of these technologies are under active development and the reliability is uncertain. Medium to large scale biomass CHP above around 2MWe can use conventional superheated steam turbine technology, can be used with reasonable efficiency and is a relatively mature technology. However, this technology requires a large area and a significant baseload which makes it unsuitable for the district heating market and more suited to the industry.

Heat Pump Options

7.4.15 All heat pumps operate in the same way, in that they use electricity to drive an evaporation/condenser cycle to move heat from one side of the system to another. They are, in basic operation, identical to a chiller that provides cooling in a building or a fridge. They differ in terms of how they are used. When a heat pump is used only for heating, they require a heat source. This can be from the air, the ground, water, sewers, or other waste heat. Heat pumps are often referred to by the source of energy that they use.

7.4.16 For this study heat pumps have been considered to heat a smaller heat network than for the main part of the study. There are no obvious water sources (i.e., river or lake) and no advantage can be seen for connecting air source heat pumps into a network over their use in individual buildings, as for the counterfactual. Therefore, the solutions considered were:

- Ground source through close loop boreholes, and
- Sewer heat recovery.

7.4.17 Although in principle the whole site could be served by heat pumps it would be likely in practice, if this option was pursued, to deliver it through a series of separate smaller networks. This is because unlike with CHP, heat pumps do not benefit significantly from economies of scale in either efficiency or cost. For this reason, the assessment at Otterpool Park has focussed on the lower density housing area to the west of the site as an example of where it could be implemented, and also near to where the sewer flows are more concentrated.

7.4.18 **Ground Source Heating:** A GSHP system uses the same basic type of heat pumps as an ASHP, but it is connected to one of two main types of system to collect heat from the ground. There are two types of system:

7.4.19 *Open Loop*: In an open loop system a borehole is drilled down to reach a large body of water (aquifer), and water is then pumped up to the surface and heat extracted by the heat pump. The cooled water is then reinjected into the ground through a second borehole a sufficient distance from the first to avoid a 'short-circuit' with the same water being made colder and colder. The main benefit of an open loop system is that when there is good availability of water, it can be more cost effective than a closed loop system, particularly at larger scales. There are risks, however, in the availability of water and in gaining permissions for its extraction due to the small risk of contamination of groundwater.

7.4.20 An open loop system requires the availability of ground water. A high-level hydrogeological assessment of the feasibility of a proposed infiltration basin at the Otterpool Park development has been undertaken, which shows that there is not a large accessible source of ground water in the area.

7.4.21 *Closed Loop*: In a closed loop system a number of boreholes are drilled and pipes are inserted into them. A fluid is passed through these to extract warmth from the ground, and this fluid is used to warm the cold side of the heat pump. There is no direct contact with ground water. A typical borehole can recover around 5 to 7 kW depending on the ground conditions and depth of borehole. The pipes to these boreholes need to be linked together to allow all of the useful heat to be brought to the energy centre where the heat pump(s) are located.

Boreholes are typically spaced at least 6m apart from centre to centre of boreholes to avoid thermal linkage and loss of efficiency.

Sewer Water Heat Recovery

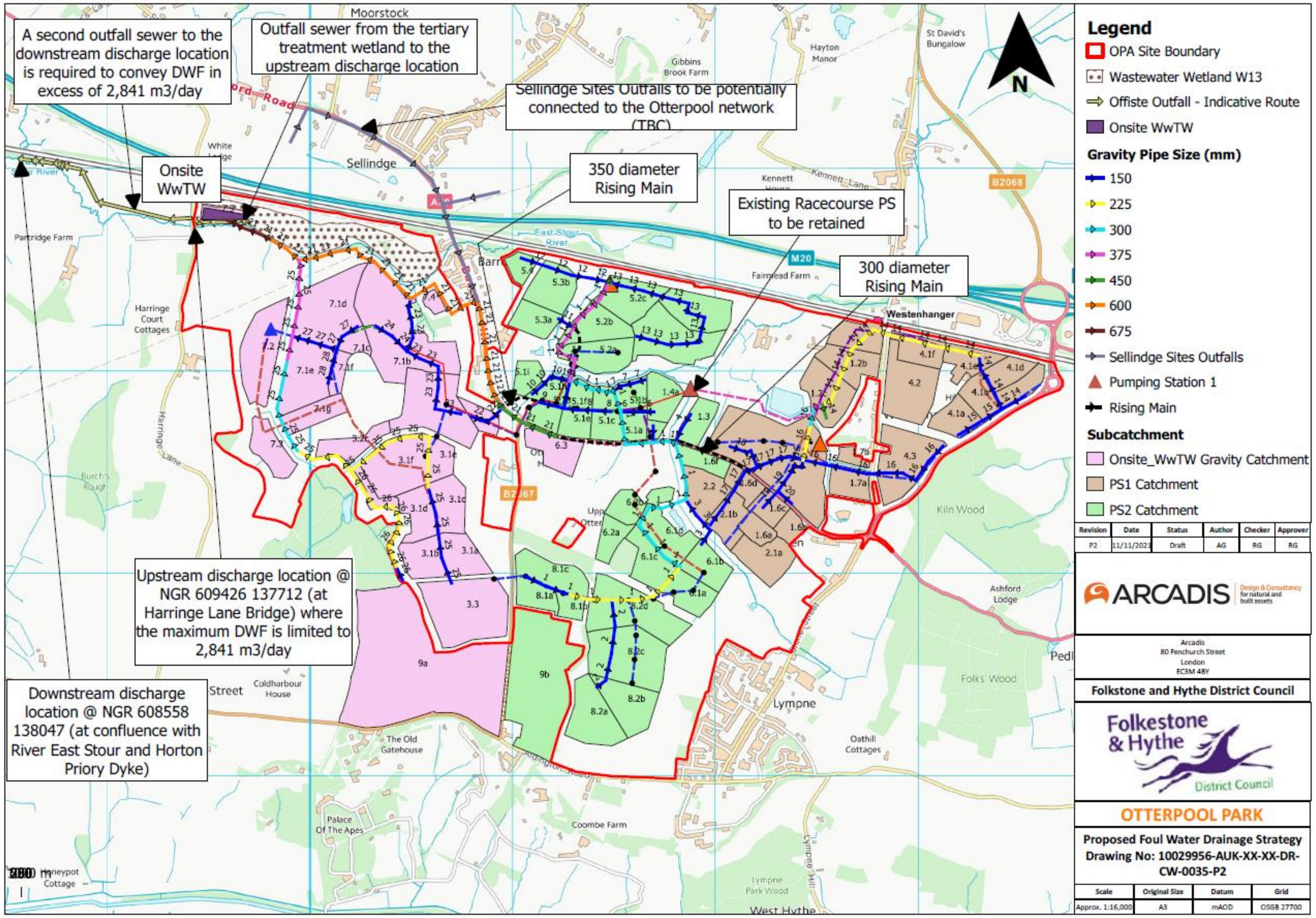
7.4.22 The water that leaves a home is at a higher temperature than the ground because of the effect of heating in the home and because part of the flow is from domestic hot water (bath or shower water). From previous case studies, wastewater is typically available at temperatures between 14-22°C. Sewer water is therefore a potentially useful resource for a heat pump system as the temperature is higher than the air or ground, resulting in better heat pump system performance. There is also the added benefit that a new development will have newly laid sewage and storm water drains separated, which will minimise temperature reduction in the wastewater from rainwater. A maximum temperature drop of approximately 5°C is allowed to the waste water so as to not impact the microbial processes at treatment works further along the sewage system.

7.4.23 There is thought to be the most potential for sewage heat recovery where the sewage system joins together in the centre of the site or the west of the Otterpool site (see Figure 7), near to where the Waste Water Treatment Plant (WWTP) is expected to be located. This will allow the sewage foul water from the site to accumulate to a large enough volume to allow heat to be effectively extracted. An analysis will be undertaken as the waste water infrastructure strategy is developed.

7.4.24 **In Line Sewage Heat Recovery Technology:** There are products available that recover heat from the sewer without affecting flow (i.e., in-line technology), and these are best installed at the same time as the sewers. These either line the sewer or form part of it and contain pipes through which a liquid is pumped capturing heat from the sewer. A company called Suez has such an ‘in-line’ system called ‘Degrees Blues’, in which heat exchangers are laid within the bottom of the sewage pipe over a maximum of 200m lengths, and typically achieve heat outputs of around 1-2kW/m of installation. There are only a few such installations in use at present, so the real performance is not yet known and the costs of these systems are not well established.

7.4.25 **Off-line sewage heat recovery technology:** In the UK a company called ‘HUBER’ who have installed sewage heat recovery systems on several sites across the UK. This system is an off-line technology, in that the sewage water is taken from the sewage pipe to a separate heat exchanger and then returned to the sewage pipe and is usually used for individual buildings.

Figure 7 Foul Water Strategy (Drawing Ref. 10029956-AUK-XX-XX-DRCW-0035-P1)



Waste Water Treatment Works – Energy Recovery

7.4.26 One of the options for Waste Water Treatment at the site is for the installation of a new Waste Water Treatment Works in the north-west of the Site.

7.4.27 As a result, an opportunity exists to include anaerobic digestion of biological material converting waste materials into a methane rich gas mix that can then be used for the generation of green energy. As the gas can be burnt in a CHP engine it can generate both heat and electricity.

7.4.28 At Otterpool the CHP size and heat and power would be limited by the resource available. Further assessment would be required but theoretically this could serve up to 200 homes which would most economically be placed close to the Waste Water Treatment works.

7.4.29 Alternatively, heat can be extracted from the incoming sewer or outgoing water from the treatment works. This heat can be utilised using a heat pump for a proportion of new homes. It is deemed possible for a Waste Water Treatment site to be utilised for Otterpool Park, however, further understanding of the economic impact and infrastructure requirements is required. Therefore, Waste Water Energy Recovery is not currently being proposed for Otterpool Park.

Energy from Municipal Waste

7.4.30 Energy can be generated from food waste from the site, also within an anaerobic digestion plant. The typical scale of a commercial AD plant is around 2MW electric, which requires around 40-45,000 tonnes of food waste per year.

7.4.31 The average UK home generates around 0.27 tonnes of food waste per year, and so a single plant would be able to process the food waste from up to 170,000 homes, far above the planned development at Otterpool. Therefore, a scheme would only work if it also received food waste from the wider area. Up to 20,000 MWh of heat might be generated by the plant over a year, which might support around 4,000 homes.

7.4.32 It may be possible to site an AD plant at Otterpool, but there would be several implications, including the large additional area of land required and increased vehicle movements delivering the county waste stream to the site and resulting combustion emissions. Therefore, Energy from Waste is not currently being proposed for Otterpool Park.

Hydrogen Fuel

7.4.33 Hydrogen is an abundant element that produces no carbon emissions when burned and has a high energy density.

7.4.34 Currently around 50 million tonnes (50 Mt, or around 2,000 TWh of energy equivalent) of hydrogen is produced globally each year, of which the UK produces around 0.7 Mt (27 TWh).

7.4.35 Hydrogen is useful as a compact energy source in fuel cells and batteries. Many companies are developing technologies that can efficiently exploit the potential of hydrogen energy for heating or to power vehicles or electric devices. It has started to be used in commercial fuel cell vehicles such as passenger cars and has been used in fuel cell buses for many years.

7.4.36 Hydrogen is usually considered an energy carrier, like electricity, as it must be produced from a primary energy source such as solar energy, biomass, electricity (e.g., in the form of solar PV or via wind turbines), or hydrocarbons such as natural gas or coal. The most common methods today are natural gas reforming (a thermal process), and electrolysis.

7.4.37 In the UK natural gas suppliers are looking to trial the use of hydrogen in the dilution of natural gas grid or sole energy carrier to homes. This trial will use the existing gas infrastructure with modifications to domestic boilers to make them compatible to the new fuel source.

7.4.38 Hydrogen is a smaller molecule than methane, so may leak more easily than natural gas. Different combustion characteristics could also make it more of a safety risk. Like natural gas, a hydrogen flame is colourless and odourless, so may require the addition of colourants and odorants in order to make it visible and detectable.

7.4.39 For district heating currently the cost of fuel cells and hydrogen fuel does not currently make the technology competitive with other technologies. However this may change in the future.

7.5 District Heating Results

7.5.1 Table 20 sets out a summary of the option analysis carried out for district heating technologies.

Table 21 District Heating Technology Summary of Option Analysis (Based on AECOM report)

Technology	Assessment	Taken Forward for Assessment
Community Gas	Requires gas infrastructure Higher losses compared to individual boilers	Part of peak supply only
Community Biomass boilers	Biomass supplier within 10 miles Technology is designed to work at high temperatures	Yes
Large Power Station Heat Offtake	No power plants within 1km of the boundary of the development site, deemed not suitable due to pipe run distances and costs.	No
Industrial/ commercial waste heat	No know sources of significant waste heat in vicinity or planned within development	No
Gas-fired CHP	Requires provision of gas infrastructure. Provides benefits of heat and power generation. Not suitable for this site due to commitment to be gas-free.	No
Biomass-fuelled CHP	Not suitable at this scale	No
Fuel cell CHP	Considered too immature at present for large scale DHN deployment.	No
Energy from Municipal Waste (AD)	No current site within vicinity. Waste generated from the site would be insufficient. The waste from the site would have to be integrated with waste from other local communities, which has been considered.	No
Air Source Heat Pump (ASHP)	Considered a building scale technology. It is not expected that the marginal improvement in efficiency resulting from the scale of application would offset the infrastructure costs of a district energy solution.	No
Ground Source Heat Pump (GSHP)	Large array to obtain a suitable amount of heat, but this might be suitable on a smaller scale within the site as the development	Yes
Water Source Heat Pump (WSHP)	There are no suitable rivers, canals etc. near the Otterpool site that could be used as a source	No
Waste Water Treatment Heat Recovery	This is considered a viable option for wastewater treatment. Further investigation of option progresses.	Yes
Waste Water Treatment – Anaerobic Digestion	Waste water treatment looks viable for this site, there is potential for producing heat from the resulting waste	Yes

Technology	Assessment	Taken Forward for Assessment
	through anaerobic digestion, further investigation required.	
Sewage Heat Recovery	Sewer heat recovery may be possible as for much of the site the sewerage system will need to be installed as part of the development	Yes
Hydrogen Fuel	Potential for existing natural gas network.	No

7.5.2 The main options considered were gas CHP and biomass boilers. Alternative options were heat pumps using the ground or sewer water as their heat source. These were modelled for a smaller, low-density, domestic development, as is expected to be developed to the west of the Otterpool development, where these technologies would be more likely to be feasible.

7.5.3 To assess the viability of the network options, estimates have been made of the total capital costs associated with the network and plant, the costs associated with operation and maintenance, and the revenue from the sales of heat and electricity. These estimates are based on recent quotes from suppliers and AECOM's previous experience of delivering district heating projects. The costs have been run over 25- and 40-year periods with a range of discount rates to determine the cash flows and calculate net present value (NPV), and internal rate of return (IRR). The associated carbon savings have also been estimated.

7.5.4 As a general rule, an IRR of around 6% may be expected to attract public funding, and an IRR of more than 10% to attract private funding.

7.5.5 The headline finding of the study is that none of the options return a positive IRR, with all of the options giving a large negative NPV at a discount rate of 3.5%. These reflect the fact that the schemes all have a relatively low heat demand for the length of the network needed to reach all of the loads. Expressed in MWh per metre of network length, this was found to be less than one tenth of the magnitude of other schemes that AECOM has worked on.

7.5.6 In other locations it is normal to use individual gas boilers as the counterfactual case for a heat network, as this is the most common solution adopted in the UK. However for Otterpool Park an alternative counterfactual of electrically driven individual ASHP's has been considered.

7.5.7 The comparison against the counterfactual has included the avoided costs of gas or electricity infrastructure, as outlined in the utilities overview in Section 9. This includes the avoided cost of the new gas infrastructure of approximately £8million.

7.5.8 The analysis has been completed with both options: i.e., a gas boiler in each home with a typical gas network; an individual electric air source heat pump providing space heating and a proportion of the hot water, with direct electrical top up of the hot water to 60ºC. A summary of the key outcomes is given in Table 21 and Table 22 for a 40-year lifecycle assessment against the two different counterfactuals used for this study.

7.5.9 The three options analysed in AECOM's study were:

- Option 1: including the hotel, community centre, nursery, indoor sports hall, primary school, secondary school, and main retail high street.
- Option 2: including the high-density housing in phase P1A near to Option 1.
- Option 3: including the rest of the development within this analysis area.

Table 22 Summary of District Heating Options assessed against gas boiler counterfactual - 40-year lifecycle (NPV £m)

Gas Boiler Counterfactual	Gas CHP	Biomass boiler	Ground source heat recovery	Sewer source heat recovery
Option 1: NPV (£m)	-1.55	-1.18	n/a	n/a
Option 2: NPV (£m)	-9.96	-8.45	n/a	n/a
Option 3: NPV (£m)	-22.72	-22.12	n/a	n/a
Low density 100 home example	n/a	n/a	-1.21	-1.16

Table 23 Summary of District Heating Options assessed against ASHP counterfactual - 40 year lifecycle (NPV £m)

ASHP Counterfactual	Gas CHP	Biomass boiler	Ground source heat recovery	Sewer source heat recovery
Option 1: NPV (£m)	-8.09	-9.28	n/a	n/a
Option 1: NPV (£m)	-13.21	-16.24	n/a	n/a
Option 1: NPV (£m)	-18.69	-15.30	n/a	n/a
Low density 100 home example	n/a	n/a	-0.73	-0.64

7.5.10 The results all show significant negative values for Net Present Value (NPV) as they are not able to overcome the cost of the network. An improved outcome is found when a higher electrical sale price (in the case of the gas CHP network) and a lower pipe installation cost are assumed within the techno-economic assessment of this study. However, even with these financial improvements, the economic results of the schemes are still reasonably poor. The best results come from the sewage heat recovery technology; however, this is only feasible where the sewage network would accumulate, probably to the west of the Otterpool development where lower density domestic developments are more likely.

7.5.11 For any of the schemes to achieve a positive Internal Rate of Return (IRR), essentially the whole initial capital cost of the scheme would need to be grant funded. This would not be acceptable to the funding potentially offered by Heat Network Investment Programme (HNIP). With the rest of the Otterpool site appearing to have an even smaller heat demand density due to even lower density housing, a domestic heat network appears to not be viable for the whole site.

7.5.12 These results are linked to the low heat density of the scheme. The load per metre of heat network is a key metric that affects the cost effectiveness of any scheme. Clearly the longer the network the more it will cost, and the load that it carries is the key input to the income that a network can earn. In the Otterpool case the cost per metre of delivering the network is relatively low, as the expectation is that it would be built in soft ground before the roads are built, and the pipe diameters are small. However, this is not enough to overcome the very low load per metre that is found in this study. Table 23 lists some examples from AECOM previous work of schemes that returned a positive IRR against the three Otterpool networks.

Table 24 Comparison of heat load per meter at Otterpool Park compared to other City Schemes

Scheme	Total Length (m)	Total Load (MWh)	Load per MWh/m
Otterpool (HN Option 1)	922	1,559	1.70
Otterpool (HN Option 2)	13,587	4,572	0.34
Otterpool (HN Option 3)	34,361	11,383	0.33
Southend High Street Cluster	2,800	23,500	8.39
Southend Victoria Avenue Cluster	1,600	10,800	6.75
Tottenham Scheme	2,100	23,900	11.38

7.5.13 This supports the findings of the study that it would take a very large increase in heat demand density (i.e., a higher heat demand in a smaller area) to make this scheme viable, particularly when connecting developments that are very spread out such as in Options 2 and 3.

7.5.14 In terms of using heat pumps to serve a heat network of low-density housing, it appears as though the high capital cost of vertical borehole GSHPs means they are not economically favourable without significant funding. It is expected that the space for the boreholes would be available, due to the nature of Otterpool Park having lots of green space. However, the system efficiencies are not high enough to overcome the large capital cost of the heat collecting system.

7.5.15 A sewage heat recovery-based heat pump has a more favourable economic output, because of a higher possible efficiency due to the higher heat source temperature, and the smaller capital costs associated with this solution. Whilst their main negative point is the large sewage flow rate required, it is thought this may be possible in later phases when the Otterpool development has been built out to the west, and a collective sewage system is fed this way.

7.5.16 Large scale use of sewage heat recovery technology seems highly unlikely unless the sewage network is integrated with the surrounding area.

7.5.17 The large-scale use of anaerobic digestion from food waste could only be made feasible for the site if food waste was also collected from the surrounding area and would therefore require a regional integrated strategy.

7.5.18 In summary, the housing density at Otterpool Park makes a district heating scheme unattractive for the whole site.

7.5.19 More innovative small-scale district energy options for sewage heat recovery or recovery of energy from a Waste Water Treatment Plant could provide heat to selected customers to the West of the site. As the maturity of the technology are still uncertain including the likely costs and performance, any scheme would require more detailed assessment before progressing further.

7.5.20 The potential for district heating will be explored further on Tier 2 and Tier 3 planning applications where the technologies, policies and resulting economics of district heating on a site wide or community scale network may have changed.

8 Be Green

8.1 Introduction

8.1.1 The next stage of the energy hierarchy is the 'Be Green' stage after decentralised energy and district heating has been considered. In reality, a number of 'Be Green' technologies and strategies have already been considered as part of the District Heating analysis (outlined in Section 7).

8.1.2 This Section therefore, considers low and zero carbon technologies that could provide further energy and carbon savings from building integrated renewable energy technologies and stand-alone electricity generating technologies.

- Biomass Heating
- Wind Power
- Heat Pumps
- Air Source Heat Pumps
- Ground Source Heat Pumps
- Solar PV
- Solar Thermal
- Hydrogen
- Phase Change Thermal Storage
- Electricity Storage
- Electric Vehicles

8.1.3 The Government currently provides financial incentives for the inclusion of technologies for the generation of renewable heat in the form of the Renewable Heat Incentive (RHI). This scheme was set up to encourage uptake of renewable heat technologies amongst householders, communities, and businesses through financial incentives. However, the Non-Domestic RHI closed on 31st March 2021 and the Domestic RHI is due to end in March 2022.

8.1.4 An overview of the technologies is provided in Appendix E.

8.2 Summary of Be Green Assessment

8.2.1 The feasibility of a number of renewable and low and zero carbon technologies has been reviewed. Table 24 summarises the renewable systems analysed compared against an electric boiler baseline. The different aspects taken into consideration including estimated payback, technology lifetime, and technical feasibility. The column relating to site feasibility indicates how feasible the technology is for the proposed Development (1 being the least feasible and 10 being the most feasible).

8.2.2 This assessment has been undertaken with respect to the current understanding of technology feasibility parameters – future Tier 2 and Tier 3 applications may find different results to the technology assessment, including the review of further technologies not included at this time.

Table 25 Summary of Low and Zero Carbon Energy Technologies

Technology	Energy Reduction Achievable (MWh)	CO2 Reduction Achievable (tCO_2)	% CO2 Reduction over Part L (2013)	Simple Payback (Years)	Lifetime (Years)	Technical Feasibility	Feasibility Score
Photovoltaics	16,177	8,396	32%	10	25	Yes	9
Solar Thermal	23,408	4,859	18%	15	15	No	5
ASHP	24,752	5,346	20%	15	15	Yes	9
GSHP	33,002	7,128	27%	25	15	No	6
CHP	(27,700)	7,724	29%	15	15	No	4
Biomass Heating	6,296	18,682	71%	20	15	No	3

Table Notes: Feasibility score, 1 = least feasible, 10 = most feasible

8.2.3 Key assumptions used in this analysis are provided below:

- Solar PV: It is currently assumed that until the Future Homes Standards become enforceable, where feasible, houses and flats are equipped with PV, in preparation for the FHS coming online in 2025. Outputs taken from SAP calculations. Outputs based on general PV module efficiency.
- Solar Thermal: Sized to provide half of domestic hot water demand
- ASHP: Using an efficiency of 2.5 COP and account for all of space heating and 100% of hot water demand
- GSHP: Same assumptions as ASHP but with a higher efficiency of 4.0 COP.

8.2.4 Based on this assessment using an electric boiler baseline, Solar PV is the preferred renewable energy option. The additional cost of carbon savings with ASHP assessed under the 2013 Building Regulations is not supported at this stage.

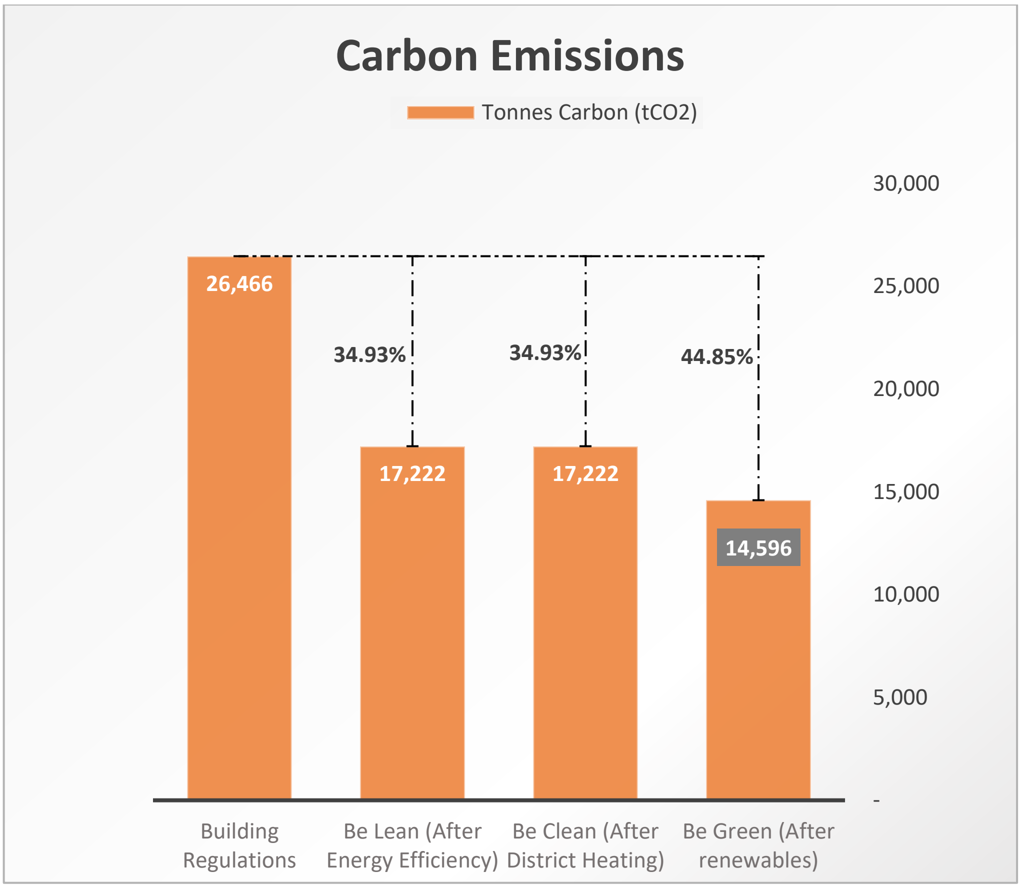
8.2.5 Table 25 below shows the indicative carbon savings from baseline of electric boilers, energy efficiency measures and the introduction of Solar PV.

Table 26 Carbon Savings following Energy Hierarchy at Otterpool Park

	Energy and Carbon Savings against Building Regulations Baseline			Energy and Carbon Savings Including Unregulated Energy		
	Tonnes Carbon (tCO2)	Carbon Savings (tCO2)	Savings (%)	Tonnes Carbon (tCO_2)	Carbon Savings (tCO_2)	Savings (%)
Building Regulations	26,466			42,960		
Be Lean (After Energy Efficiency)	17,222	9,245	34.93%	33,715	9,245	21.52%
Be Clean (After District Heating)	17,222	9,245	34.93%	33,715	9,245	21.52%
Be Green (After renewables)	14,596	11,871	44.85%	31,089	11,871	27.63%

8.2.6 Figure 8 below shows the indicative carbon savings of regulated and unregulated energy following the energy hierarchy approach and specifications used in this assessment. At this stage no savings are shown from the Be Smart element as the technologies, the way residents use the technologies, and the savings are not clear.

Figure 8 Indicative Carbon Savings following Energy Hierarchy at Otterpool Park



8.2.7 However, this is not the end of the analysis as the first phase of the development is not due to be started until 2023 and the final phase potentially as far as 2042. The impact of these changes on the heating strategy is considered in the next Section as well as in Tier 2 and Tier 3 planning applications.

9 Be Smart

9.1 Energy Efficient, Smart Residents and Communities

9.1.1 In order to achieve significant carbon reduction, the electricity sector is becoming decentralised whilst maintaining resilience by engaging with users and communities to develop more innovative and empowered energy systems. Through the provision of technology and tools, the aim is that residents and communities will be able to generate and utilise energy as close to its use as possible. This not only reduces inefficiencies but maximises the local benefit of the energy infrastructure and assets (e.g., solar power generation and energy storage) within the home or community, as opposed to it being taken away by third parties.

9.1.2 A first element will be to ensure energy efficiency is at the heart of the development and that the Fabric First and passive design approach continues to evolve and be integrated into the building designs.

9.1.3 Information gathering including possible onsite research and trials could provide the evidence on how Otterpool Park could embed these concepts. These concepts include the ‘active home’ or ‘buildings as power stations’, where occupants have the technology to integrate solar and storage technologies for heat, power or both. There is also the potential to trade surplus energy with the grid, surrounding buildings and electric vehicles (Institute for Public Policy Research, 2018).

9.1.4 Further research and analysis can be undertaken to define the concept of a smart settlement for Otterpool Park. As smart settlements are a relatively new concept, research will be undertaken to understand the requirements and benefits for a smart settlement and determine how this could be optimised to serve the community at Otterpool Park. The wider integration with buildings, transport, data, and wellbeing will be developed and placed within the place-making infrastructure.

9.1.5 The Cornwall Local Energy Market is another project that is enabling homes and businesses to benefit from producing or using energy and trading surplus to provide an income and support the DNO with grid services.

9.1.6 The trials in the Cornwall Local Energy Market project will be reviewed and discussed with relevant stakeholders in Kent. There could be direct participation with peer-to-peer trading. Alongside suppliers there could be direct trading with generators, consumers, and prosumers (those who produce and consume energy).

9.1.7 Energy Storage maybe important to enable homeowners and businesses to exploit the benefit of the energy market. This could be through heat storage, home batteries, centralised battery storage or making use of the battery within electric vehicles. Determining the most suitable approach is linked to the cost of technology and the services specified for the home and commercial structures developed to exploit the benefits.

9.1.8 Ensuring homes are initially equipped with the information technology to exploit the future energy market changes will be set out in subsequent Tiers of the Energy Strategy .

10 An Integrated Energy Strategy

10.1 Introduction

10.1.1 The Energy Strategy is not being developed in isolation of the rest of the development and is being integrated to drive efficiencies, and minimise resource use. This integrated approach is developed further in the Sustainability Strategy and aligned with the Economic Strategy which have also been developed for the Settlement.

10.2 Integrating Mobility

10.2.1 Mobility is linked with the Energy Strategy. The Government drive to develop low carbon vehicles will lead to an increasing proportion of electric vehicles.

10.2.2 Electric vehicles will lead to increased electricity demand, however, combined with a home energy system or centralised community battery, electric vehicles will support an integrated Energy Strategy across the development to provide community benefits.

10.2.3 Integrated with the Transport Strategy, this Energy Strategy will help to develop the concept of Mobility as a Service (MaaS) where the Transport Strategy is developed to reduce energy consumption and provide the most efficient transport services for residents.

10.2.4 Kent County Council has orchestrated the creation of a sustainable multi-modal MaaS Framework and is to introduce MaaS in Ebbsfleet. The Customer MaaS app & website will seek to deliver integrated journey planning, ticketing and payments and support door to door travel for a wide range of transport offering monthly multimodal travel subscription products as well as Pay As You Go (PAYG) to an integrated transport system. The introduction of MaaS into Otterpool Park would bring a key shift away from private car ownership, and would enable the community to utilise more sustainable and accessible modes of transport.

10.2.5 This strategy details the proposed Electric Vehicle (EV) charging infrastructures for the Otterpool Park development, which could aide in the provision of electric pool cars (either self-drive or Connected and Autonomous Vehicles) as part of the development or even included within home purchase or rental agreements.

10.2.6 Furthermore, Otterpool Park should remain active in the implementation of all potential, future forms of low carbon vehicles such as hydrogen buses to minimise emissions and improve air and social quality.

10.3 Integrating On-Site Resources

10.3.1 The site's resources could be used to improve the efficiency of heat pumps from the sewers, ground or waste water. Water sourced heat pumps have been shown not to be viable, as there is not sufficient flow from the water courses on the site.

10.3.2 The site wide district heating assessment considered a range of supply options including gas CHP, biomass heating, ground and water source heating. A site wide scheme was found not to be viable, however the potential for localised schemes for blocks of flats or smaller clusters of dwellings using local resources may still be viable and will be investigated.

10.3.3 Initial analysis shows that sewage heat recovery technology could be a viable technology. This technology enables a more efficient heat pump than air source heating due to the higher heat source temperature. However, this is only feasible where the sewage network accumulates, and sufficient resource is available from the homes connected to the sewage system over the phasing of the development. This option will be investigated further and integrated with water and infrastructure strategy as the technology will need to be incorporated within the sewer infrastructure.

10.3.4 Energy could also be recovered from a proposed on-site waste water treatment plant, which could provide heat to selected customers to the west of the site. This is still uncertain due to the maturity, costs and performance of the technology. Any scheme would need more detailed assessment before progressing further.

10.3.5 Otterpool Park has the benefit of green areas and surrounding homes and businesses. This opens the opportunity for ground source heating, which will be investigated for blocks of flats or homes with sufficient open space.

10.3.6 In terms of using waste from the site, the large-scale use of anaerobic digestion from food waste could only be made feasible for the site if food waste was also collected from the surrounding area. It would therefore require a regional integrated strategy – which is not proposed for this site.

10.4 Integrating Future Technology

10.4.1 The evolving Energy Strategy will also ensure that new technologies such as hydrogen heating continue to be assessed and whether new technologies have a role in the future development.

10.4.2 The Committee on Climate Change (CCC) report (Committee on Climate Change, 2018) outlines that hydrogen could play a valuable role as part of a heating solution for UK buildings, primarily in combination with heat pumps as part of 'hybrid heat pump' systems. The CCC outlines that that heat pumps, powered by increasingly low-carbon electricity, offer the potential to provide heat efficiently for most of the time.

10.4.3 The use of hydrogen in residential properties and the gas networks is currently being investigated in research projects such as Leeds City Gate hydrogen project or a project being led by Scottish Gas Networks in Fife. These are research projects testing the viability in locations where an existing gas infrastructure already exists.

10.4.4 The role of new technology such as hydrogen in Otterpool Park for buildings and for transport will be kept under review and opportunities to test the application on site will be actively pursued.

10.5 Integrating Management and Commercial Opportunities

10.5.1 An integrated Energy Strategy will not be delivered without support. This includes applications for research and trials, developing and enabling standards, advising businesses and residents, funding energy infrastructure and technical solutions, monitoring and metering energy and carbon emissions through to managing a complex energy system, and more broadly management of the integrated energy infrastructure that is developed.

10.5.2 There is likely to be third party involvement from academics, suppliers and investors and there could also be a role for the local authority to be involved in the local energy system.

10.5.3 Folkestone and Hythe District Council could create a local energy service company (ESCo). In this case the investment is made on behalf of the community into electricity generation, energy storage and mobility. This may require investment in the creation of ESCo for centralised investment and participation from the local authority or third party in the local energy system.

10.6 An Integrated Energy Strategy for the Future

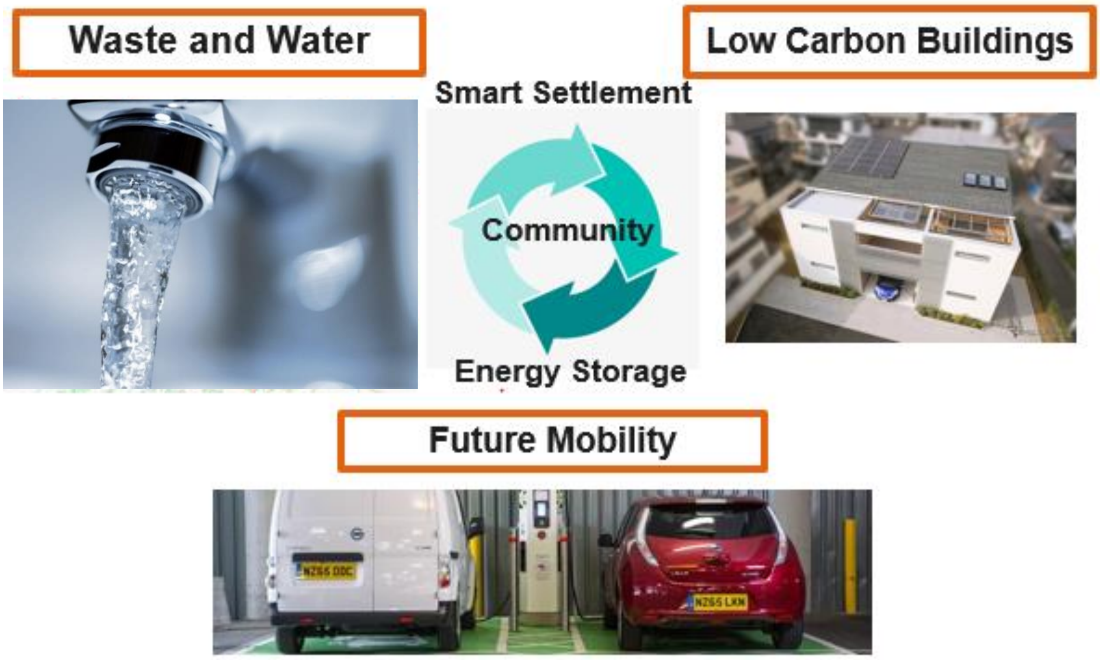
10.6.1 This Energy Strategy sets out the foundations of integrated vision that links energy generation with energy storage, with the water, transport, infrastructure, and place-making approaches. This integrated vision will allow the communication between energy production, storage and usage, providing optimised production and distribution. This integrated vision will explore pipeline technologies that could enhance the Otterpool Park development throughout the development years, as these technologies progress.

10.6.2 To support this approach, pilot studies with monitoring and evaluation could be undertaken in the initial phase of the development in order to identify solutions that benefit most from these technologies and exploit the evolution of grid services and community involvement.

10.6.3 These studies could bring together key stakeholders from the electricity sector, the construction industry, technology providers, mobility providers academia, government, and funders to test and develop solutions that are right for Otterpool Park.

10.6.4 Figure 9 shows an integrated vision that needs to be tested and developed as the design of Otterpool Park develops. These elements are overlapping, and a holistic approach is being adopted in order to bring these together through the pilot studies and this carbon-place making approach.

Figure 9: Energy Strategy Integrated Approach

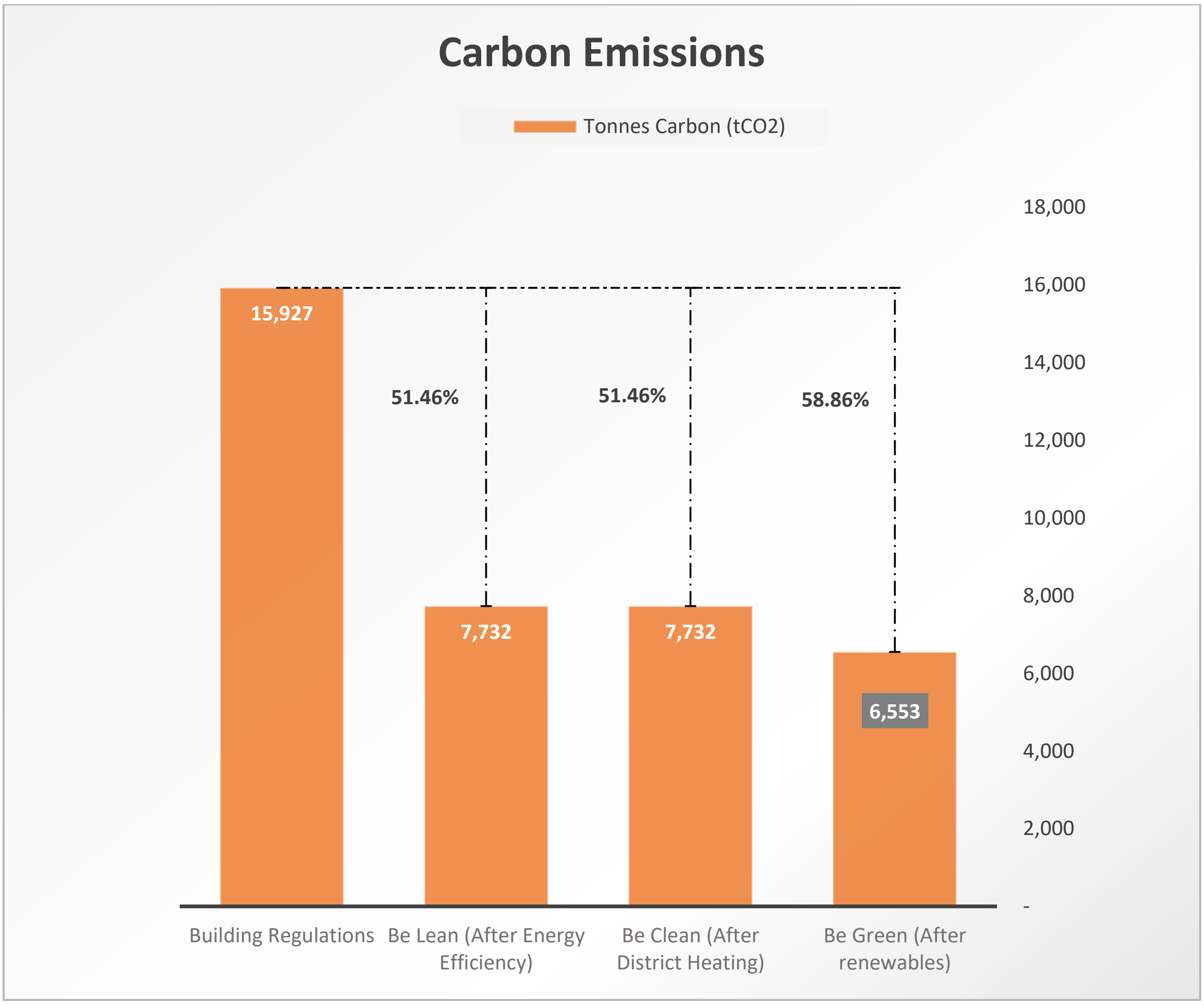


11 Impact of Future Carbon Factors and Costs

11.1 Future Carbon Factors

11.1.1 A variation of the energy hierarchy that considers the consultation version of the Part L 2020 is presented in this Section. The main change is the carbon factors (from Table 4). The results, in Figure 10, show that there is an improvement in the CO_2 reduction impact of Be Lean measures, but a slight reduction in the impact of Be Green measures. Both are a consequence of the reduction in the Electricity Carbon Factor.

Figure 10 Carbon Savings with updated carbon factors (consultation version of the Part L 2020)



11.1.2 An energy prediction model of SAP and SBEM has been used to assess the impact of potential changes to the Building Regulations over the lifetime of the proposed Development. As discussed in Section 3, the key potential changes to the Building Regulations are:

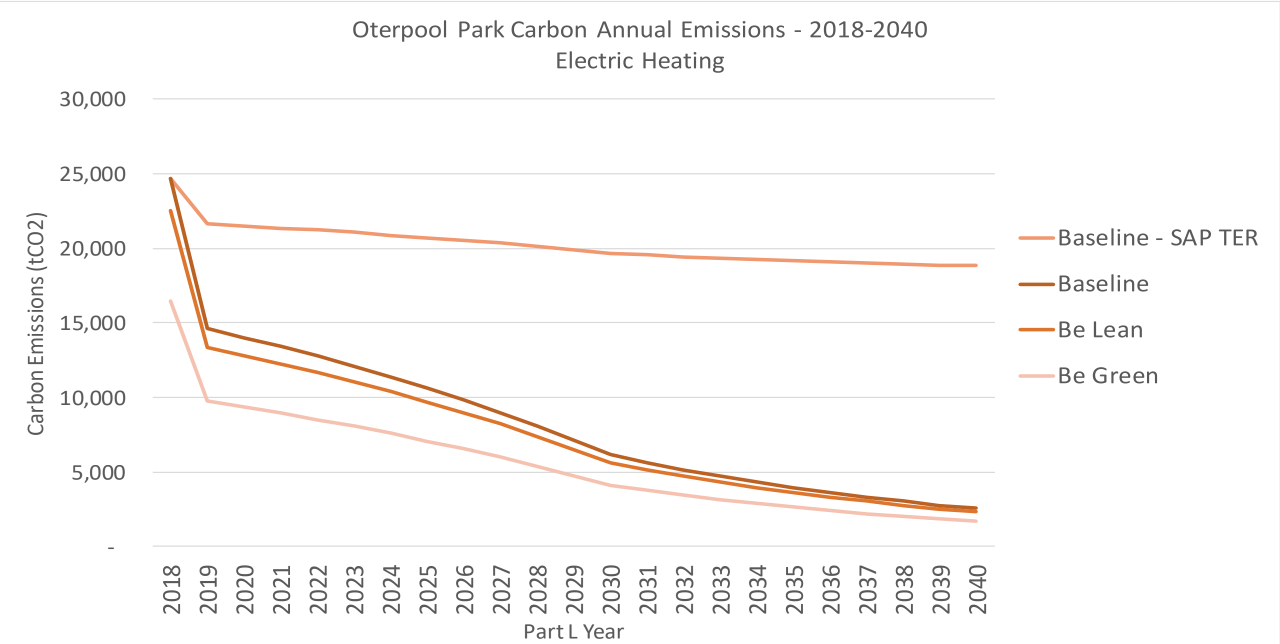
- Reduction in the electricity carbon emission factor
- Tightening of current standards
  - Carbon Target – Improved TER
  - Fabric Efficiency
  - Lighting and plant efficiency
  - Low and Zero Carbon Technologies
  - Include unregulated energy.

11.1.3 As a result, the model developed has included elements of these changes, with the main variations being the impact of the reduction in grid electricity and the impact on the Part L1A fuel factor.

11.1.4 Figure 11 shows the impact on carbon emissions from an all-electric scenario based on the Governments projections on changes to Carbon Emission Factors Appendix B. Aside from the emission factor and the Part L1A fuel factor, all other variables (including the Solar PV array size) in the Be Clean scenario have remained the same.

11.1.5 Figure 11 shows the impact of decreasing grid factor if electric heating is used in domestic and non-domestic buildings. As can be seen with electric heating specified, Otterpool Park can benefit from the decreasing grid factor. The carbon benefit of solar PV decreases as the grid carbon factor decreases, which is why the Be Green line increases over time.

Figure 11 Carbon Savings 2018-2040 with Electric Heating



11.1.6 The results of this analysis show that there will be a drive to move towards electric heating in the future and it may become challenging to meet Building Regulation standards without electric heating.

11.1.7 It also shows that the SAP calculation approach, which artificially increases heating energy using a fuel factor and uses the gas emissions factor for the electricity TER baseline, will need to change. In this scenario, the fuel factor is linked to grid decarbonisation, but the carbon factor still has a significant impact on the TER.

11.1.8 Based on this analysis, gas boilers with solar PV would be a suitable strategy for initial phases, but based on grid decarbonisation, the majority of Otterpool Park should be heated using grid electricity. The preferred technology on a domestic level at present is ASHP. Solar PV technology could be used in combination with ASHP technology for further carbon savings.

11.2 Future Energy Costs

11.2.1 The unit cost of electricity is currently around three times the price of gas. This difference in price between gas and electricity 'also known as the spark gap' is projected to remain in the future (see Appendix B). Specifying buildings with electric heating therefore needs to be addressed as part of the Energy Strategy.

11.2.2 High efficiency ASHP, which can generate 3 units of heat from 1 unit of electricity, can minimise the exposure to the higher cost of electricity. The additional benefit of solar PV array will reduce energy costs. The impact on consumer energy prices on combining these technologies has been modelled and shows a reduction in annual energy costs than a conventionally gas heated home.

12 Conclusion

12.1 Strategic Vision

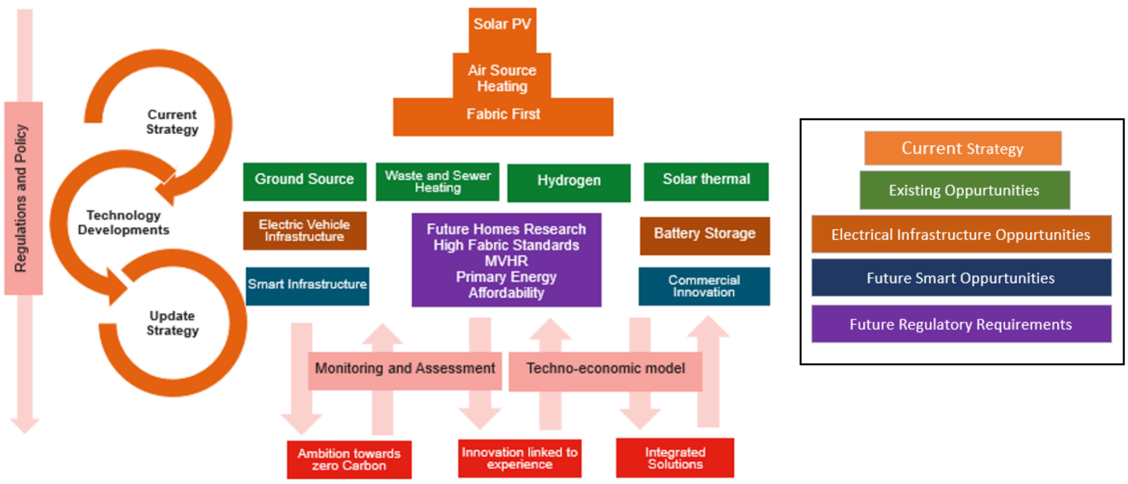
12.1.1 This Tier 1 Outline Energy Strategy sets out a strategic framework for achieving net zero carbon by 2030. It sets out initial commitments based on current and future policy direction and existing technologies with the requirement that these are updated Energy Strategies at regularly including with each Phase Level Tier 2 (detailed masterplans and design codes) and Tier 3 (Reserved Matters Applications). Tier 2 Applications will set out the overall approach towards energy and carbon for that phase having regard to national and local planning policy adopted at that time, with the consideration also given to any supplementary guidance and relevant legislation.

12.1.2 This Tier 1 Outline Energy Strategy has been developed to set long term framework, ambition and boundaries for future operation within the context that there will be significant changes, in future policy, technology and best practice guidelines over the proposed

12.1.3 The vision for Otterpool Park is to be a flexible and innovative development, embracing the opportunities from the changing energy market. The Energy Strategy has been developed to ensure that Otterpool Park is well placed to exploit new technology and commercial arrangements and providing a sustainable, cost-effective home across the development lifecycle.

12.1.4 Otterpool Park's Energy Vision is shown in Figure 12 below and provides an overview of the Tier 1 strategic approach to the Energy Strategy. This shows the core elements of a Fabric First approach, Air Source heat pumps and Solar PV for the strategy for the initial phases of the development. This figure also shows the potential revenues for undertaking research and trials in the early phases of the development and how this can feed back into the energy strategy. This could support the development in making the most of technical, infrastructure and commercial opportunities and linking in with the Local Energy Hubs, Kent County Council Strategy and wider research and innovations. A techno-economic model is required to ensure the upcoming technologies can provide value for money, whilst also reducing the environmental impact of Otterpool Park.

Figure 12 Otterpool Park Energy Strategy Strategic Approach



12.1.5 Following the tiered approach to planning, this Energy Strategy will be updated through Tier 2 and Tier 3 Energy Strategies.

12.1.6 Using this iterative approach, this Energy Strategy is able to set ambitious long-term targets with certainty of approach in the near-term, whilst providing the flexibility and information to move towards a carbon neutral development in the long-term.

12.2 Policy Compliance

12.2.1 The Energy Strategy has been developed to meet and exceed current national policy of the Buildings Regulations alongside regional local policy requirements. The Energy Strategy is aligned with the Regional Strategies in the Kent and Medway Energy and Low Emissions Strategy (Kent and Medway Councils, 2019) and the Tri-Local Enterprise Partnership (LEP) Regional Energy Strategy (Energy South 2 East, 2018).

12.2.2 The Energy Strategy will exceed Policy CC1 of the Folkestone and Hythe Adopted Places and Policies Local Plan (F&HDC, 2020) which requires new build housing developments and non-residential buildings over 1,000m^2 to reduce carbon emissions by a minimum of 10% above the Building Regulations (2013). The Energy Strategy and future Tier 2 and 3 Energy Strategies will also addresses Policy CC2 of the Local Plan (Sustainable Design and Construction) which outlines that "The development minimises energy demand through passive design and layout and landscape mitigation measures with an aspiration for new major residential developments to achieve zero carbon homes

12.2.3 This Energy Strategy and future Tier 2 and Tier 3 Energy Strategies respond to the Folkestone and Hythe Core Strategy Review (F&HDC, 2022) Policy SS8 which requires the new garden settlement to:

- Demonstrate how best practice in energy conservation and generation will be achieved at both the micro and macro level in homes and commercial buildings; This will undertaken through the review and update to the Energy Hierarchy to ensure the proposed Development maximises the opportunities at each Tier of planning application
- *Include the potential for a site-wide heat and power network and decentralised energy networks*; The potential for site wide heat and power has been reviewed (Section 7) at this Tier 1 Energy Strategy and will be continually reviewed as policy and technology evolve in subsequent Tier 2 and Tier 3 Energy Strategies.
- Demonstrate how the development takes a fabric-first approach, makes the maximum use of passive solar gain, as well as energy generation from the latest technologies in and on buildings and structures. All community buildings shall seek to meet zero carbon standards as exemplars, with an aspiration for the development to achieve carbon neutrality; The Fabric First Approach and Passive Design and required to be the heart of heat of the Energy Strategy (Section 6) and will be key elements of Tier 2 and Tier 3 Energy Strategies.
- Demonstrate how the settlement will meet the government's commitment to ban all new petrol and diesel cars and vans by 2040 and include measures from the outset for all properties to have ready access to slow, fast and rapid electric charging points. Section 3 outlines the grid requirements to provide every home with EV charging points, setting out the potential for this to be achieved at Otterpool Park. The Government has now brought this forward to 2030. Integrating the energy strategy with the transport and sustainability strategies at each Tier of the planning applications will ensure these policy requirements are met.

12.2.4 Policy SS6 states that “Environmentally the settlement will be a beacon of best practice, making best use of new technologies, and will be designed to achieve a low carbon, low waste and highly water efficient development.”. The glossary of the Core Strategy defines low carbon as “a development which achieves an annual reduction in net carbon emissions of 50% or more from energy use on site e.g. by reducing energy demand through passive design and energy efficient technology and supplying energy from renewable sources.” This strategy outlines how Otterpool Park can achieve immediate carbon saving that exceed the current regulatory standards, through a fabric first approach whilst utilising low-carbon heating and renewable sources in the form of photovoltaic cells, and also setting out an integrated strategy to put it on a path to becoming a net-zero carbon development.

12.2.5 Paragraph 4.185 of the Core Strategy Review (F&HDC, 2022) outlines that “the Energy strategy should set out how the lowest possible carbon targets will be achieved, in both the short- and long-term, making best use of renewable energy on- and off-site. As technology is rapidly evolving, the strategy will need to demonstrate how buildings can be designed to be adaptable with the potential to incorporate new technologies, such as battery energy storage, creating individual or decentralised energy networks. The strategy will show how the use of energy efficient technologies will result in significantly lower energy use than the national average" is also addressed by the commitments in this Tier 1 Energy Strategy whilst providing the flexibility for new technologies and decentralised energy options to be considered as part of Tier 2 and Tier 3 Energy Strategies.

12.2.6 Policy SS9 (2c) states that smart monitoring of energy use shall be available to allow users to compare energy usage. This has been proposed for the development in the Be Lean (Section 6) and through Be Smart measurements (Section 9) and commitments to monitoring and reporting will be included as part of Tier 2 and Tier 3 Energy Strategies.

12.2.7 Policy SS3 outlines that "proposals should be designed to contribute to local place shaping and sustainable development by including sustainable construction measures, measure to optimise water efficiency and (in the case of new build development), measures to optimise energy usage from renewable and low carbon sources" this is addressed in Section 6 and also more broadly in the Sustainability Strategy.

12.2.8 This Energy Strategy has been developed respond to the Core Strategy Review and demonstrate a sustainable vision for energy generation and demand over the lifetime of the Garden Settlement.

12.3 Energy Strategy – Core Commitments

12.3.1 The vision for Otterpool Park is to be a progressive and innovative development, embracing the opportunities from changes policy, low carbon technologies and the energy market.

12.3.2 This Energy Strategy will be updated as part of the tiered planning application approach comprising of this Tier 1 Energy Strategy (at Outline Planning), Tier 2 (at detailed masterplans and design codes), and Tier 3 (Reserved Matters Applications). It is anticipated that these updates will be secured through planning condition.

12.3.3 This Tier 1 Energy Strategy has been prepared for the Outline Planning Application and sets the long-term framework, ambition, and boundaries for future operation within the context that there will be significant changes in future policy, technology and best practice guidelines over the proposed Development build out timeline. This document therefore sets out the overall site wide approach for energy and key commitments that the development will deliver. This document will be updated periodically to reflect changes in national policy/regulations.

12.3.4 There is a commitment to provide an Energy Strategy with each relevant Tier 2 submission which demonstrates how the commitments in the Tier 1 Energy Strategy are being taken forward into the Energy Strategy for that Tier 2 area of land. The Strategy for each Phase Level Masterplan will set out the overall approach towards energy and sustainability matter for that phase having regard to national and local planning policy adopted at that time, with the consideration also given to any supplementary guidance and relevant legislation.

12.3.5 There is also a commitment to develop an Energy Statement with each relevant Tier 3 reserved matters application which will need to confirm how the proposed development is consistent with the Tier 1 and Tier 2 Energy Strategy commitments.

12.3.6 This Tier 1 Energy Strategy provides a framework for the path to net-zero carbon by 2030. The Tier 2 and Tier 3 level Energy Strategies will set out how the commitments in this Tier 1 Energy Strategy will be delivered or exceeded, and any further relevant measures that are identified in the development of these applications.

12.3.7 Outlined below are commitments in the Tier 1 Energy Strategy framework and how these will be incorporated into future Tier 2 and Tier 3 Energy Strategies/ Statements:

- Future Energy Strategies to be submitted at Tier 2 and Tier 3 will adhere to the operational Energy Hierarchy (Be Lean, Be Clean, Be Green and Be Smart) that ensures a Fabric First approach is embedded into designs that is committed to in this Tier 1 Strategy. This includes how the principles of Passive Design will be integrated into the design to minimise energy demand whilst maximising passive solar gain. There is a commitment to meet and, where feasible, exceed Fabric Energy Efficiency Standards (FEES) for new homes against the To support this commitment, domestic properties will need to achieve the following FEES target of <41kWh/m^2/yr for Block of Flats and mid terrace houses and <48 kWh/m^2/yr for Semi-detached, end of terrace and detached houses. This target will be reviewed to ensure the commitments are driving energy efficiency measures at Tier 2 and Tier 3 application.
- This Tier 1 application sets a commitment for Otterpool Park to a 45% carbon emissions reduction against current Building Regulation Standards (2013) for new homes**.** This exceeds the 31% carbon reduction target outlined in the Interim Future Home Standards for new homes (Ministry of Housing, Communities and Local Government, 2021). Future Tiers of the planning application will ensure carbon dioxide emissions will be minimised, working towards the Council's goal of carbon net zero by 2030. This will take account of all levels of the operational Energy Hierarchy and demonstrate how Building Regulations regarding carbon emissions, which are in place at the time of submission, have been met. It will show how opportunities to achieve energy and carbon reductions above and beyond the requirements of Building Regulations have been considered and applied where appropriate.
- This Tier 1 Energy Strategy commits to no gas for residential properties from the start of the development and for low carbon heating to be provided by electrically driven heat pumps from

the outset of the development, whilst the viability for including emerging low carbon heating solutions such as hydrogen heating will be reviewed in future planning applications. Future Tiers of the planning application will also commit to no fossil fuels and will outline how low carbon heating will be included within building designs.

- Tiers 2 and 3 will provide further design guidance on specific measures to minimise energy consumption such as implementing a zoned heating and heat recovery strategy within the homes alongside smart meters and smart controls.
- All community buildings shall seek to meet zero carbon standards as exemplars, with an aspiration for the development to achieve carbon neutrality. Net Zero standard to be defined aligned with UK Green Building Council (2019) A Framework Definition excluding non-regulated energy and construction carbon initially however this could evolve in Tier 2 and Tier 3 planning submissions. It is also noted that community buildings such as schools may need to include construction carbon and non-regulated energy within net zero definition as part of requirements set by public bodies for new buildings. It is also noted that that developing an offset fund any remaining carbon required to achieve net zero is outside the scope of the management responsibilities of the development.
- At this Outline Energy Strategy stage there is a commitment to install renewable energy generation technology to meet a proportion of energy demand and help minimise exposure to energy costs. It is likely that solar PV will be the technology installed on buildings where feasible, or where it can be demonstrated that other renewable technologies will be installed such as solar thermal, which are more suitable. A renewable technology assessment demonstrating which suitable technologies, such as solar thermal and energy storage options will be undertaken for Tier 2 and Tier 3 planning applications, taking account of evolving technologies, viability, and policy.
- A commitment is made to meet and look to exceed where feasible Policy CC1 of the Places and Polices Local Plan (F&HDC, 2020) that outlines that the Planning applications for all major new build housing developments and new non-residential buildings of 1000 sqm or more gross floorspace will be required to reduce carbon emissions by a minimum of 10 per cent above the Target Emission Rate, as defined in Part L1A of the Building Regulations. Future planning applications will also include how opportunities for renewable generation and battery storage will be integrated into building designs to provide flexibility on how and when energy is used, whilst providing some protection to occupants from volatile energy prices.
- This Tier 1 Energy Strategy and future applications will commit to incorporate high quality innovative design, new technologies, and construction techniques, including zero or low carbon energy and water, efficient design and sustainable construction methods. Future planning applications will respond to changes in national and local policy and guidance, for example, Folkestone and Hythe Council is proposing to develop a Net Zero Toolkit which would be taken into consideration as part of this process.
- Climate adaptation measures will be defined and incorporated into the design of the individual buildings, including reducing the impact of overheating in the home, preventing storm water ingress, mitigating the impact of flooding in the home and adopting climate adaptation measures in the immediate vicinity of homes and in public spaces. Specific measures will be defined and incorporated for Tiers 2 and 3 planning applications.
- A commitment is made to ensure overheating is considered and mitigated for new buildings taking account of climate change. Tiers 2 and Tier 3 planning applications will set out the methodology to ensure that this is achieved taking account of best practice guidance.
- This Tier 1 Application commits to homes, businesses and community buildings being equipped with smart technology to support data collection, analysis and monitoring of energy, waste and water, allowing for aggregated and comparative data. Future applications will set out how these commitments can be met and also show how occupants will be provided with safe tools to access digital infrastructure and data across the development as smart technology evolves.

- In principle a commitment is made to disclose and minimise the anticipated Energy Use Intensity at construction stage in accordance with the UK Green Building Council's Net Zero Carbon Buildings: A Framework Definition, 2019, as well as disclosing the anticipated Energy Use Intensity at design at pre-occupation stage and monitor and report on energy use 5 years post-occupancy, however the practicality of these activities will be further assessed at Tier's 2 and 3 of the planning submission to ensure the process and systems are available to undertake these activities. This will also support understanding and review the customer experience to ensure lessons are learned and the best solutions that deliver tangible results on the path to net zero are being delivered.
- BREEAM 'Excellent' will be set as a standard for all non-domestic buildings over 1,000m^2 and evolve with any changes to BREEAM over time. Future planning applications will show how principles of BREEAM could be embedded into Design Standards if BREEAM standard does not last the lifetime of the proposed Development.
- A commitment is made at this Tier 1 stage to use reasonable endeavours to design-in and connect to off-site decentralised energy systems where feasible to reduce the reliance on grid infrastructure; and offsite renewable generation should demonstrate additionality.
- As part of long-term stewardship arrangements a commitment to undertake a feasibility study to assess the establishment of an ESCO is made with the purpose of managing the renewable and low carbon energy infrastructure and energy supplies to individual households and non-domestic users alongside maintaining the carbon offsets required to achieve the net zero aspiration in the application.
- A commitment is made to undertake a feasibility assessment to understand the potential to recover energy from the installation of a new WwTW through a combination of biogas CHP and/or extracting heat, digestate, heavy good transportation biofuel, and associated renewable products from incoming sewerage and processing of the waste and recycling for use within the development.
- A commitment is made that at the Tier 3 planning stage all new development is to calculate whole life-cycle carbon emissions in accordance with current RICS Whole Life Carbon Assessment guidelines and demonstrate actions taken or planned that will reduce life-cycle carbon emissions.

12.3.8 This Outline Energy Strategy has been developed to meet and exceed current national policy of the Buildings Regulations alongside regional local policy requirements. The Energy Strategy is aligned with the Regional Strategies in the Kent and Medway Energy and Low Emissions Strategy (Kent and Medway Councils, 2019) and the Tri-Local Enterprise Partnership (LEP) Regional Energy Strategy (Energy South 2 East, 2018).

12.3.9 The Energy Strategy is linked with Settlement's Transport and Sustainability Strategies which supports the government's commitment to ban all new petrol and diesel cars and vans by 2030 by including measures for properties to have ready access to slow, fast and rapid electric charging points; with integration of technologies into work places, community buildings, car parks, and infrastructure to facilitate the transition to electric vehicles through this Tier 1 and subsequent planning applications.

APPENDIX A

Legislation Policy and Guidance

Introduction

This section provides a review of the relevant national, regional and local policy relative to energy and carbon emission reduction. A summary of current and future Building Regulations, and Government Commitments is provided.

The policy landscape around Energy and Climate Change Mitigation has been rapidly moving with many new policies and changes to existing policy over the last number of years which will influence the way in which the Energy Strategy for the scheme may come forward. It is also safe to suggest that policy will continue to evolve over the period in which the development progresses; and therefore, maintaining flexibility in any strategy is crucial to facilitating continued sustainable development.

Legislation and Policy

Legislation

United National Convention on Climate Change (UNFCCC) and Paris Agreement

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty adopted on 9 May 1992. The UNFCCC objective is to "stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

The Paris Agreement is an agreement within the UNFCCC. It was adopted in 2015 and entered into force in November 2016, aiming to limit global temperature increase this century to less than 2° degrees Celsius above pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C.

The EU's Energy Performance of Buildings Directive, European Commission, (2002)

The Energy Performance of Buildings Directive (EPBD) (European Commission, 2002) is the European Union's main legislative instrument aiming to promote the improvement of the energy performance of buildings within the Community. The first version of the EPBD, Directive 2002/91/EC, was approved on 16 December 2002 and entered into force on 4 January 2003.

The recast of the EPBD (2012), Article 9.1. regulates that "Member States shall ensure that by 31 December 2020, all new buildings are nearly zero-energy buildings (1a) and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero energy buildings."

Climate Change Act, UK Government, 2008 (Order 2019)

The Climate Change Act (UK Government, 2008) introduced a legally binding target to reduce the UK's greenhouse gas (GHG) emissions to at least 80 per cent below 1990 levels by 2050. It also provides for a Committee on Climate Change (CCC) which sets out carbon budgets binding on the Government for 5-year periods. The 3rd carbon budget (2018-2022) requires a 37% reduction on 1990 levels, the 4th carbon budget (2023-2027) a 51% reduction and the 5th carbon budget requires a 57% reduction on 1990 levels.

The CCC also produces annual reports to monitor progress in meeting these carbon budgets.

The 2019 draft amendment commits the UK to reduce its carbon emissions to net zero by 2050. This order does not include measures for achieving this target.

National Planning Policy Framework (NPPF), Department for Communities and Local Government, July 2021

The National Planning Policy Framework (NPPF) (Department for Communities and Local Government, 2021) sets out the Government's planning policies for England and how these are expected to be applied. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

New development should be planned for in ways that can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards.

- The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to shape places in ways that contribute to radical reductions in greenhouse gas emissions; minimise vulnerability and improve resilience; encourage the reuse of existing resources including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure.
- To help increase the use and supply of renewable and low carbon energy and heat, plans should:

  a) provide a positive strategy for energy from these sources, that maximises the potential for suitable development, while ensuring that adverse impacts are addressed satisfactorily (including cumulative landscape and visual impacts);

  b) consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure their development; and

  c) identify opportunities for development to draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.
- Local planning authorities should support community-led initiatives for renewable and low carbon energy, including developments outside areas identified in local plans or other strategic policies that are being taken forward through neighbourhood planning.
- In determining planning applications, local planning authorities should expect new development to:

  a) comply with any development plan policies on local requirements for decentralised energy; supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and

  b) take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.
- When determining planning applications for renewable and low carbon development, local planning authorities should recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions.

Part L1A of the Building Regulations, Department for Communities and Local Government, 2013 (with 2016 Amendments)

Part L of the Building Regulations (Department for Communities and Local Government, 2016) is the cornerstone regulatory tool that is used to regulate the use of fuel and power in buildings and ultimately drive improvements in building efficiency and reduction in carbon emissions.

The methodology for demonstrating compliance requires the building carbon emissions ($kgCO_2/m^2$/year), to be below a compliance target emission measure specifically calculated for that building. The 2013 Building Regulations for dwellings introduced a Target Fabric Energy Efficiency rates (TFEE) to sit alongside carbon emission calculations. The TFEE is the minimum energy performance requirement for a new dwelling. The Dwelling Fabric Energy Efficiency (DFEE) rate is the actual energy performance of the new dwelling must not exceed the TFEE.

For non-domestic buildings the carbon emission calculation is produced following the National Calculation Method (NCM). This can be done by using approved simulation software (Approved Dynamic Simulation Models (DSMs)) or by using the Simplified Building Energy Model (SBEM), a 'simplified' compliance tool. For dwellings, a Standard Assessment Procedure (SAP) is followed using approved software.

Ministry of Housing, Communities and Local Government, Future Homes Standard Consultation and Draft Part L Building Regulations (2019)

The Government has consulted on the changes to Part L (and Part F ventilation) of the Building Regulations for new dwellings through The Future Homes Standard (Ministry of Housing Communities and Local Government, 2019). This consultation introduces the Future Homes Standard for new build homes to be future-proofed with low carbon heating and world-leading levels of energy efficiency. Energy efficiency requirements for new homes are set by Part L (Conservation of Fuel and Power) and Part 6 of the Building Regulations. This consultation sets out our plans for achieving the Future Homes Standard, including proposed options to increase the energy efficiency requirements for new homes in 2020 as a meaningful and achievable steppingstone to the Future Homes Standard – which is yet to be defined.

The consultation sets out two options to uplift energy efficiency standards and requirements:

- Option 1 - 'Future Homes Fabric' (20% CO_2 reduction)
  - Very high fabric standards (typically with triple glazing).
- A gas boiler
- A wastewater heat recovery system
- Adds £2557 to the build-cost of a new home
- Saves households £59 a year on energy bills.
- Option 2 - 'Fabric plus technology' (31% CO_2 reduction)
  - This is the Government's preferred option aimed to encourage the use of low-carbon heating and/or renewables.
- An increase in fabric standards (but not as high an increase as in Option 1, e.g. double glazing)
- A gas boiler
- PV panels
- A wastewater heat recovery system
- Adds £4847 to the build-cost of a new home
- Saves households £257 a year on energy bills
- The Standard outlines that developers can/would choose less costly ways of meeting the option 2 standard, such as putting in low-carbon heating. This would cost less than the full specification, at £3134 for a semi-detached house.

Building Regulations: Approved Documents L 2020, Volume 1: dwellings (consultation version) following the consultation is due to be implemented in 2020. As outlined, it considers two options to uplift the current Part L energy efficiency standards in 2020 for new homes. It also considers the wider impacts of Part L for new homes, including changes to Part F (Ventilation), airtightness, improving as built performance and changes to transitional arrangements in 2020.

A key change in this approved document is in redefining the performance metrics to assess the energy performance of new homes to the following metrics:

- Primary energy target
- CO_2 emission target
- Householder affordability rating
- Minimum standards for fabric and fixed building services.

The calculation methodology for assessing these metrics has not been published therefore any calculations that look to demonstrate the impact of future changes to the Building Regulations can only be estimated at this stage.

Future Projections of the Building Regulations, Department for Communities and Local Government

Part L of the Building Regulations is the key mechanism for implementing the Building Act (1984) with regard to the conservation of fuel and power in buildings and for implementing the EPBD in the UK. It is the regulatory tool that is used to regulate the use of fuel and power in buildings and ultimately drive improvements in building efficiency and reduction in carbon emissions.

The current methodology for demonstrating compliance requires the building carbon emissions (kgCO2/ m2/year), to be below a compliance target emission measure specifically calculated for that building. The 2013 Building Regulations for dwellings introduced a Target Fabric Energy Efficiency rates (TFEE) to sit alongside carbon emission calculations. The TFEE is the minimum energy performance requirement for a new dwelling. The Dwelling Fabric Energy Efficiency (DFEE) rate is the actual energy performance of the new dwelling must not exceed the TFEE.

For non-domestic buildings the carbon emission calculation is produced following the National Calculation Method (NCM). This can be done by using approved simulation software (Approved Dynamic Simulation Models (DSMs)) or by using the Simplified Building Energy Model (SBEM), a 'simplified' compliance tool. For dwellings, a Standard Assessment Procedure (SAP) is followed using approved software.

The last substantive revision of the energy efficiency and carbon standards for the Building Regulations occurred in 2013 (although there were revisions not affecting the calculation approach in 2016) and there is no published information on future editions.

The Government has recently published a consultation on new Building Regulations (Approved Document L for new dwellings (Ministry of Housing, 2019). A complimentary consultation on the introduction of Part L within the scope of the Future Homes Standard was published at the same time (Department for Housing, 2019).

The Future Homes Standard was first announced in the government’s spring statement in 2019, but as yet the full details of the standard are yet to be mapped out.

The Future Homes Standard will complement the Building Regulations to ensure new homes built from 2025 will produce 75-80% less carbon emissions than homes delivered under current regulations. Once the legislation is passed 2025, all new homes will have to be built according to the standards.

An interim step announcing changes to Part L (conservation of fuel and power) of the Building Regulations is expected later this year, which will come into force in 2022. And a full technical specification for the Future Homes Standard will be consulted on in 2023, with the necessary legislation introduced in 2024, ahead of implementation in 2025.

In January 2021, the government issued its 114-page response to the consultation and confirmed that all new homes will be required to be equipped with low-carbon heating and be zero-carbon ready by 2025. This uplift is the first step in achieving the Future Homes Standard.

In its response, the government also confirmed the Building Regs will be updated next year, whereby all new homes must produce 31% lower carbon emissions, compared to current levels. This move is designed to help the industry get ready to meet the new standards by 2025.The government hopes the Future Homes Standard will act as a roadmap for the industry to reach its net zero target for 2050.

Regional Policy

The Kent State of the Environment Report, Kent County Council, 2016

The Kent State of the Environment report (Kent County Council, 2016) provides an evidence base and baseline in terms of Kent's environment and related economic, social and health performance indicators.

The Report has a vision to deliver a "competitive, innovative and resilient economy, with our natural and historic assets enhanced and protected for their unique value and positive impact on our society, economy, health and wellbeing".

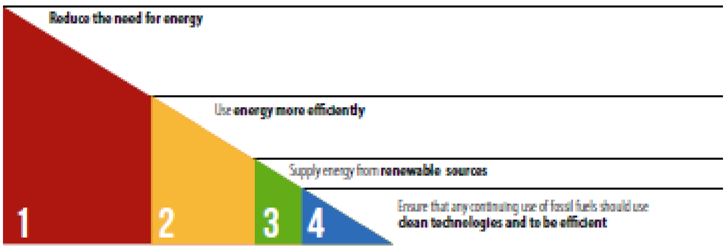
The report outlines that reducing carbon emissions can be tackled through reducing the demand for energy from non-renewable sources and using what is needed more efficiently e.g. through insulating buildings and using energy efficient equipment.

Reducing the usage of resources, such as energy and water, and wasting less provides the focus Priority of Theme 2 (Making Best Use of Existing Resources).

The Environment Report highlights the importance of following an Energy Hierarchy (Figure 13):

- First to reduce the need for energy
- Second to use energy more efficiently
- Third to supply energy from renewable sources
- And finally to ensure that any continuing use of fossil fuels should use clean technologies and to be efficient.

Figure 13 Kent Environment Report Energy Hierarchy



Core targets related to energy are:

- To reduce our emissions across Kent by 34% by 2020 from a 2012 baseline (2.6% per year)
- More than 15% the energy generated in Kent will be from renewable sources by 2020 from a 2012 baseline.

Energy South2East: Local Energy Strategy, 2018

This local Energy Strategy (Energy South2East, 2018) was developed by three LEPs - Coast to Capital (C2C), Enterprise M3 (EM3) and South East Local Energy Partnership (SELEP) – and covers a geographic area from Essex to Hampshire, representing a large swathe of the south-east of England.

This Energy Strategy sets out the region's aim to:

- Enable the tri-LEP region to decarbonise in line with the national trajectory as set down in the Climate Change Act.
- Position the tri-LEP region as a centre for innovation in the low carbon sector; where new concepts and technologies are demonstrated and commercialised to drive clean growth.

- Foster clean growth across the region, supporting fledgling low carbon businesses to evolve and prosper.
- Ensure that all energy produced, distributed and consumed across the region is clean and low-carbon.
- Ensure that local people and society are beneficiaries of the Energy Strategy and its delivery, both directly and indirectly.

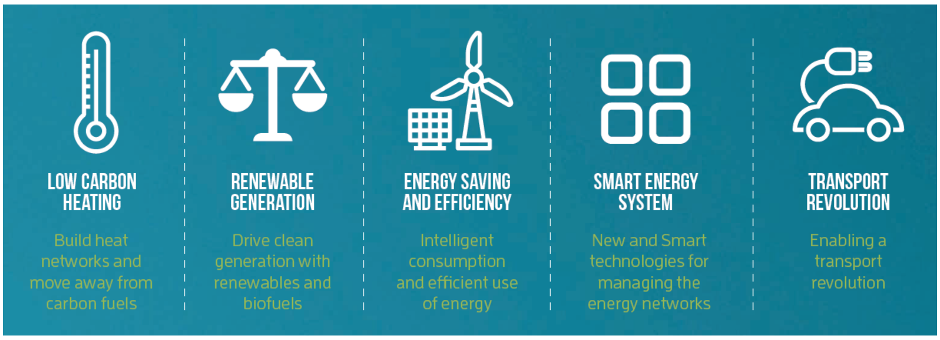
12.3.10 Their aims in terms of emissions and energy are shown in Table 26.

Table 27 Tri-LEP Region Carbon Budgets

Year	Carbon Budget ($KtCO_2e$)	Reduction below 1990 Levels
1990	64,312	-
2015	40,517	37%
2032	27,654	57%
2050	12,862	80%

12.3.11 Five key themes (see Figure 14) are highlighted throughout this strategy and have been aligned with model projects which act as exemplars for future developments in the tri-LEP region.

Figure 14 Key Themes in Tri-LEP Energy Strategy



1. **Low Carbon Heating:** Over a third of the energy used in the tri-LEP region is to produce heat and it accounted for over 10 million tonnes of CO2equivalent (CO2e) in 2015, around a quarter of total emissions. Not only does heat have a big impact on the environment it also affects the economy; as a country, consumers spend £32 billion a year on heating and about 70% of industrial energy use is for the production of heat.
2. **Renewable Generation**: The tri-LEP region is supported with ample renewable resources such as solar, on- shore and offshore wind and coastal and estuarine tides. Due to current planning restrictions on-shore wind and tidal power schemes are difficult to deliver but solar is commercially viable even without Feed In Tariff subsidies. By utilising space on buildings and land more effectively the region could produce a significant proportion of its own electricity needs.
3. **Energy Saving and Efficiency**: The tri-LEP region will consider how to deliver Project Models that address domestic energy efficiency such as insulation schemes, particularly those in fuel poverty, as part of the relevant Project Models. Affordability will be a key consideration, as the recommended changes will need funding that will hit low-income households the hardest; and combined with likely escalating energy prices, creates a double whammy for those typically living in poorer insulated homes.
4. **Smart Energy Systems**: The integration of large amounts of solar and wind generation has changed the way the electrical system operates and placed it under considerable strain,

primarily because the modernisation required has not kept pace with the rate of change and type of demand in society.

5. **Enabling a Transport Revolution**: Whilst the onset of low carbon forms of transport will alleviate many of the emissions and air quality problems in the tri-LEP region, it will also radically alter the structure of the local transport sector such as our fuelling infrastructure. The anticipated growth of the Electric Vehicles (EV) market represents a very significant shift in energy usage from petroleum fuels to electricity. This will have a profound impact in terms of the overall demand for electricity, and the peak demand for power that must be delivered to vehicle charging points throughout the country. The challenge for the local network is how to support multiple electric vehicles charging at a low voltage substation level which would typically serve 20 to 100 households.

Kent and Medway: Energy and Low Emissions Strategy, 2019

The aim for this strategy (Kent and Medway Councils, 2019) is that by 2050 the county of Kent has reduced emissions to Net-Zero and is benefiting from a competitive, innovative and resilient low carbon economy, where no deaths are associated with poor air quality.

Kent and Medway are growing. By 2031 it is anticipated that there will be almost 180,000 new homes and nearly 400,000 extra people, a 24% increase from 2011 levels. The local economy is expected to continue to expand, creating an additional 170,300 jobs by 2031 a 21% increase from 2011 levels, in line with forecast population growth.

In industry, approximately 75% of energy used is to produce heat, much of which is wasted. This is also true across Kent and Medway. The Government expects business and industry to improve energy efficiency by at least 20% by 2030, this includes a focus on industrial heat recovery.

Ensuring an affordable energy supply for all and continuing to promote energy efficiency, forms a significant element of the Strategy. Supporting new forms of renewable low carbon energy supply will be an important part of the mix. The county has already seen an increase in renewable energy generation of 726% since 2012 (230MW to 1900MW).

This Strategy covers three main themes:

- **Theme One: Building the Foundation for Delivery** - where decisions makers have an evidence-based understanding of the risks and opportunities relating to energy and emissions and are incorporating them into strategies, plans and actions.
- **Theme Two: Making the best use of existing resources, avoiding, or minimising negative impacts** - where existing infrastructure, assets and resources across the public, private and domestic sector are managed to reduce emissions and build a clean future energy supply.
- **Theme Three: Toward a Sustainable Future** - where Kent and Medway's communities, businesses and public sector have embraced clean growth and are working towards developing a clean, affordable and secure local energy future.

Local Policy

Folkestone & Hythe District Council Places and Policies Local Plan Adopted 2020

Folkestone and Hythe Council has published a (F&HDC, 2020) Places and Policies Local Plan sets out the vision for future development across the Folkestone and Hythe District. The Development Management Policies set out general policies relating to a number of topic areas including Climate Change. It sets out the new developments that can help reduce carbon emissions through maximising efficiencies according to the energy hierarchy:

- Reducing the energy load of the development
- Maximising the energy efficiency of the building fabric
- Delivering energy from renewable sources

- Delivering energy from low carbon technologies
- Any continuing use of fossil fuels to be clean and efficient for heating and co-generation.

Policy CC1 of this Plan sets out requirements on Carbon Emissions, the details are set out in the following bullets:

- "Planning applications for all major new build housing developments and new non-residential buildings of 1,000sqm or more gross floorspace will be required to reduce carbon emissions by a minimum of 10 per cent above the Target Emission Rate, as defined in the Building Regulations for England approved document L1A: Conservation of Fuel and Power in Dwellings.
- This should be through the use of on-site renewable and low-carbon energy technologies which could include an integrated system or site-wide solution involving the installation of a system that is not integrated within the new building".

Folkestone & Hythe District, Carbon Action Plan (2021)

Folkestone and Hythe District Council has committed to reducing its own carbon footprint to a net zero target by 2030. Folkestone & Hythe District Council declared a climate emergency along with many other councils in 2019 and a budget has been set aside for initiatives that will help the council hit its operational net-zero carbon emissions by 2030.

This Carbon Action Plan has been produced to reduce the Council's own operating carbon footprint to net zero by 2030 with costs measures and actions, energy saving, and carbon reduction outcomes based on currently available data and assessments. It takes as its baseline a study by Laser outlined later in this document that uses data from 2018/19 as an initial starting point.

Folkestone and Hythe District Council has identified several methods of reducing energy consumption and emissions, this includes:

- Carry out energy audits across the whole Council non-residential property and assets portfolio and implement low cost / no cost carbon reduction measures, e.g. energy efficiency measures such as insulation or LED lighting in buildings, as well as converting street lighting to LED. This would be as part of a programmed schedule of works when items are scheduled for renewal and were financially feasible.
- Review sub-metering installations as part of an improved energy monitoring strategy.
- Seek to source electricity purchased by the Council via a 'green tariff'.
- Expand the energy awareness campaign amongst council staff, members and contractors to reduce energy use.
- Consider the potential and implications for voltage optimization technology to reduce energy consumption.
- Explore options for a phased upgrade of the council fleet to hybrid (HEV) or full battery electric vehicles (BEV) where economically and operationally viable. To also actively consider new technology for example, solar powered commercial vehicles.
- Add to the Council's own estate EV charging infrastructure and evaluate the outputs from the first phase to consider future programmes of infrastructure.
- Examine the business case for Vehicle-to-Grid EV charging to reduce energy bills.
- Explore the use of EV staff pool car(s) to reduce grey business mileage costs.

Local Policy

Folkestone and Hythe District Council the Core Strategy Review– Regulation 19 Submission (F&HDC, 2022)

Folkestone and Hythe District Council has published a Draft Core Strategy (F&HDC, 2022). The draft strategy updates key parts of the existing Core Strategy which was adopted in 2013. It sets out the long-term vision for the district's communities, economy and environment.

As the Strategy has not been finalised, changes are possible to the draft targets outlined in the Sections below.

The Draft Core Strategy introduces the aspiration for a new garden settlement at Otterpool Park to help provide the new homes. This document explains the opportunity to create an attractive and vibrant place, to build well designed environmentally friendly homes, and provide new services and amenities, like schools, medical centres and parks.

Relevant sections of the Draft Core Strategy are:

- Section 3.2 Vision for Folkestone and Hythe
  - The Parties support the vision for Folkestone and Hythe to "flourish into a distinct area of high-quality towns, including a new garden settlement complemented by the contrasting strengths and distinctiveness of attractive countryside and coastal places"
  - Low carbon homes and increased resource conservation, including aim to be water-neutral
- Paragraph 4.88 Place-shaping and sustainable settlements strategy
  - states that "The garden town will achieve the highest possible standards for energy and water efficiency, with an aspiration that the development will achieve water and carbon neutrality
- Policy SS3
  - Proposals should be designed to contribute to local place-shaping and sustainable development through a proportion of energy coming from renewable and low carbon sources
- Policy SS6 New Garden Settlement – Development Requirements
  - "Environmentally the settlement will be a beacon of best practice, making best use of new technologies, and will aim be designed to achieve a low carbon, low waste and low water usage development with an overall aspiration towards for water and carbon neutrality."
- Policy SS8 New Garden Settlement – Sustainability and Healthy New Town Principles
  - A sustainable new town a). Development shall be guided by an Energy Strategy. The strategy shall demonstrate how best practice in energy conservation and generation will be achieved at both the micro- and macro-level in homes and commercial buildings. The strategy shall include the potential for a site-wide heat and power network and decentralised energy networks
  - A sustainable new town c). For non-residential development (particularly buildings for community use), the development shall achieve BREEAM 'Excellent' standard and aim to meet the 'Excellent' standard including addressing maximum water efficiencies under the mandatory water credits;
  - A sustainable new town d). The Energy Strategy shall demonstrate how the development takes a fabric-first approach, makes the maximum use of passive solar gain, as well as energy generation from the latest technologies in and on buildings and structures. All community buildings shall seek to meet zero carbon standards as exemplars, with an aspiration for the development to achieve carbon neutrality;
  - A sustainable new town e). The Energy Strategy shall demonstrate how the settlement will meet the government's commitment to ban all new petrol and diesel cars and vans by 2040 and include measures from the outset for all properties to have ready access to slow, fast and rapid electric charging points; with the integration of technologies into workplaces, community buildings, car parks and infrastructure to facilitate the transition to electric vehicles and provide appropriate charging facilities for electric bus provision at the transport hub.

- Policy SS9 New Garden Settlement – Infrastructure, Delivery and Management
  - Draft policy SS9 (2c) of the Core Strategy Review (2022) states that “Data analysis and smart monitoring of water and energy use and waste generation shall be available to all new homes, business and community buildings. Aggregated and comparative data shall be accessible to allow households to compare usage against the average for the development”.

Guidance

BREEAM, BRE, 2018

BREEAM (Building Research Establishment’s Environmental Assessment Method) (BRE, 2018) is a standard assessment method established by the Building Research Establishment (BRE), used to assess the environmental impact of non-domestic buildings. Credits are awarded where a building achieves a benchmark performance

Road to Zero. Department for Transport, 2018

This Strategy (Department for Transport, 2018) outlines the Next steps towards cleaner road transport and delivering the UK Industrial Strategy. The aim is to put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040. The Strategy includes proposals to support the development of one of the best electric vehicle infrastructure networks in the world, including launching a £400 million Charging Infrastructure Investment Fund to help accelerate charging infrastructure deployment.

Decarbonising Transport, DfT, 2020

The Transport Decarbonisation Plan (Department for Transport, 2020) sets out in detail what government, business and society will need to do to deliver the significant emissions reduction needed across all modes of transport, and aims to reduce carbon budgets and net zero emissions across every single mode of transport by 2050.

The TDP sets out plans to improve the decarbonised movement of people, goods and services. This looks at improving infrastructure for EV charging, cycling and walking.

The Strategy includes a proposal for new cars. Including CO_2 emission reductions regulations which came into effect on 1 January 2020 setting targets out to 2030, which applies in the UK. The regulation sets binding CO_2 emission reduction targets for new cars of 15% by 2025 and 37.5% by 2030. This is supporting the development and distribution of more EV, requiring more EV charging ports to be designed for future developments.

Hydrogen in a Low Carbon Economy, Committee on Climate Change, 2018

This Committee on Climate Change report (Committee on Climate Change, 2018) outlines the case for producing hydrogen in low-carbon ways and using it to meet challenging demands for heat in industrial processes, for heating buildings on colder winter days and for heavy transport. It concludes that hydrogen is likely to be an important part of the next stage of the UK’s energy transition.

The report concludes that hydrogen could play a valuable role as part of a heating solution for UK buildings, primarily in combination with heat pumps as part of ‘hybrid heat pump’ systems. The CCC outlines that that heat pumps, powered by increasingly low-carbon electricity, offer the potential to provide heat efficiently for most of the time, with hydrogen boilers contributing mainly as back-up to meet peak demands on the coldest winter days.

Practical Guides for Creating Successful New Communities - Planning for Energy and Climate Change (Town and Country Planning Association, 2016)

This Practical Guide (Town and Country Planning Association, 2016) outlines what that means in practice and sets out principles for developing a carbon strategy for a Garden City.

Masterplanning at the large scale offers a unique opportunity to consider and plan for a robust infrastructure that will support the aspirations of a sustainable community – not only in terms of demand reduction, energy efficiency and renewable energy supply, but also in relation to water and waste management, transport and biodiversity. All these issues must be considered from the earliest stage and will have a major influence on the masterplan concept.

An Energy Strategy should define the carbon-saving and energy generation opportunities for each stage in the development process. This allows for strategic decision-making on technologies that need to be installed at an early stage in the development of the site, such as district heating. Preparation – and subsequent refinement – of the Energy Strategy should be fully integrated into the development process from the earliest planning stage and throughout the master planning and design.

21st Century Garden Cities of To-Morrow, Philip Ross, 2013

This document provides an updated set of principles that have been developed for the 21st Century which also provides guidance to underpin the masterplan and have a strong bearing on community and overall sustainability:

- Residents are Citizens of the Garden City
- The Garden City owns itself
- Energy-efficient and carbon neutral
- Provides access to land for living and working to all
- Fair trade principles are practised
- No special privileges for anyone
- Fair representation and direct democracy
- Participatory design and public spaces
- A city of rights and the right to the city
- Wealth and harmony measured by happiness.

Smart Cities – Background Paper, Department for Business Innovation and Skills, 2013

There are many definitions of a Smart City. The Government's Smart Cities background paper (Department for Business Innovation and Skills, 2013) outlines that a Smart City is 'essentially enabling and encouraging the citizen to become a more active and participative member of the community. For example, providing feedback on the quality of services or the state of roads and the built environment, adopting more of a sustainable and healthy lifestyle, volunteering for social activities or supporting minority groups. Furthermore, citizens need employment and "Smart Cities" are often attractive locations to live, work and visit. It brings together hard infrastructure, social capital including local skills and community institutions, and (digital) technologies to fuel sustainable economic development and provide an attractive environment for all'.

UK GBC The Policy Playbook– Driving Sustainability in New Homes – a resource for local authorities 2019

This document (UKGBC, 2019) provides evidence and information to encourage a consistent approach by local government in setting planning policy for new homes with respect to energy and carbon, mitigating overheating risk and assuring performance.

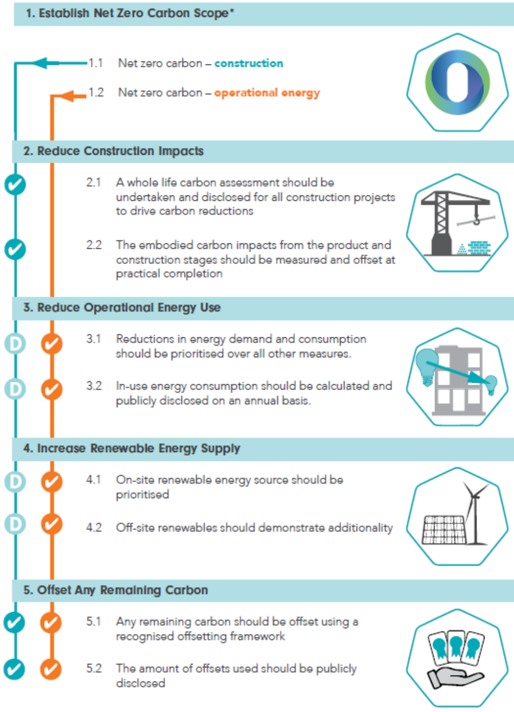
From a review of Government policy and legal context the guidance concludes that, currently local planning authorities can set a requirement for new homes in relation to energy and carbon demand reductions as:

- "A 19% reduction on the Dwelling Emission Rate (DER) against the Target Emission Rate (TER) based on the 2013 Edition of the 2010 Building Regulations (Part L) whilst meeting the TER solely from energy efficiency measures as defined within the SAP calculation model (the reference to 'solely energy efficiency measures' refers to DER against the TER (i.e. the current requirements of Part L 2013) not to the 19% improvement factor".

UK GBC – Net Zero Carbon Buildings: A Framework Definition

The World Green Building Council is catalysing the construction and property industry to lead the transition to a net zero carbon built environment, through its Advancing Net Zero campaign, which the UK Green Building Council (UKGBC) has embraced and adopted for a UK context.

In all instances, the building developer, owner or occupier seeking to achieve net zero carbon should do so over the greatest amount of building area they have influence or direct control over. In all examples, the boundary and related floor area should be clearly disclosed to allow the market to appreciate the extent to which the building developer, owner or occupier has achieved net zero carbon.



For net zero carbon – construction, the boundary is defined as all areas included in the whole life carbon assessment that have been reported and offset at practical completion. Where multiple buildings are being delivered, the aim should be to achieve net zero carbon for the whole development.

For net zero carbon – operational energy, the boundary (or energy scope) is defined as all areas under operational control or influence where a net zero carbon balance has been achieved on an annual basis. The energy scope should be disclosed to allow comparability between buildings.

This framework provides a set of overarching principles relevant to all building types and sizes. This enables the framework to be applied universally to achieve large-scale uptake of net zero carbon buildings. Ultimately, the framework is aiming for the maximum amount of floor area in the built environment to be verified as net zero carbon.

The framework places a strong emphasis on public disclosure to demonstrate how net zero carbon has been achieved and the extent to which the principles have been followed. For operational energy, it is recognised that the annual public disclosure of energy use, generation and offsets is currently more suited to commercial buildings than for individual homes. This is due to the limited extent of sophisticated energy monitoring systems in domestic properties and privacy issues with the use of energy data.

APPENDIX B

Project Assumptions

Carbon Emission Factors

Electricity carbon emission factors have been taken from Standard Assessment Procedure 09 (BRE, 2012) for current Building Regulations Carbon Factors, Draft Standard Assessment Procedure 10.1 (BRE, 2019) for 2020 to 2025 and from Treasury Green Book Supplementary Guidance (2021). Data Table 1: Electricity Emission Factor from 2025 onwards

Date	2018	2019	2020	2021	2022	2023
Carbon Emission Factor ($kgCO_2$/kWh	0.519[1]	0.519	0.519	0.519	0.136[2]	0.136

Date	2024	2025	2026	2027	2028	2029	2030
Carbon Emission Factor ($kgCO_2$/kWh	0.136	0.125[3]	0.092	0.076	0.071	0.066	0.053

Date	2031	2032	2033	2034	2035	2036	2037
Carbon Emission Factor ($kgCO_2$/kWh	0.042	0.036	0.031	0.028	0.025	0.021	0.019

Date	2038	2039	2040	2041	2042	2043	2044
Carbon Emission Factor ($kgCO_2$/kWh	0.018	0.017	0.016	0.013	0.012	0.012	0.011

Date	2045	2046	2047	2048	2049	2050
Carbon Emission Factor	0.010	0.009	0.008	0.008	0.007	0.007

[1] 2018-2022 This is based on Building Regulations (2013)
[2] 20220-2025 This is based on proposed Carbon Factor for Building Regulations (2022)
[3] 2025 onwards based on Treasury Green Book

Date	2045	2046	2047	2048	2049	2050
($kgCO_2$/kWh						

Energy Prices

Prices are taken from UK Government Updated energy and emissions projections: 2018. Annex M Growth Assumptions and Prices – Reference Scenario.

Date	2018	2019	2020	2021	2022	2023	2024
Electricity (Residential)	18.6	20.1	20.3	20.2	19.7	19.7	19.8
Natural Gas (Residential)	4.5	5.0	4.9	4.7	4.6	4.6	4.7

Date	2025	2026	2027	2028	2029	2030
Electricity (Residential)	20.5	20.1	19.8	20.0	19.4	19.9
Natural Gas (Residential)	4.8	4.8	4.9	4.9	5.0	5.0

Date	2031	2032	2033	2034	2035	2036	2037
Electricity (Residential)	20.4	20.5	20.4	20.6	20.1	20.1	20.1
Natural Gas (Residential)	5.1	5.1	5.1	5.1	5.1	5.1	5.1

APPENDIX C

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APPENDIX D

Future Energy Case Studies

This section has provided an overview of the direction of travel in the energy market based on available policy and guidance. Successful case studies of large-scale implementation of key changes in the sector, such as micro-grids and widespread electrification of heat and transport, are not currently available. However, a number of projects are being funded to explore these ideas and strategies and businesses are moving into this space to take advantage of the evolving market. A few relevant examples are highlighted below.

Trent Basin Nottingham

A community energy demonstration and research project[4], led by the University of Nottingham and funded by Innovate UK. The Trent Basin development, which is part of the 250-acre Waterside Regeneration area in Nottingham, currently comprises 45 homes and will eventually consist of 500 homes. The £6m investment in the energy project at the site is being delivered through two programmes – the Energy Research Accelerator (ERA) and Project SCENe (Sustainable Community Energy Networks).

Solar photovoltaics are being installed on the site, along with the communal battery, heat stores and ground source heat pumps. A community energy company has also been established which residents have the option of joining.

The Trent Basin energy system will be connected to the grid and, in addition to drawing renewable energy generated by the community, will also be able to buy and store electricity from the grid when it is cheapest, and redistribute to meet the demand of residents. In the short term, shared profits from the scheme will help residents to offset energy costs, while in the longer term the intention is to offer reduced price heating to Trent Basin households.

The development includes smart technology for homes to give residents more control over the energy they use and greater participation within the community scheme.

Domestic Battery Storage and Grid Services

Companies in the UK are beginning to offer individual residential battery systems with which provide grid support services as an energy aggregator, in turn delivering cost savings for the consumer.

For example, Moixa's Gridshare platform helps the System Operator to manage energy demands across the electricity network, and the consumer receives extra income in return. Currently the resident is offered a fixed fee but this is likely to change to a share in proportion of profits as the commercial model is proved.

The battery can also make better use of energy generated by solar panels on the consumer's rooftop and enable suppliers to reward consumers who charge their batteries during periods of low demand, when prices decrease.

In another example, Octopus Energy has an Agile Energy Tariff that tracks the daily average consumption pattern. If customers can switch to using energy at different times of day they save on their energy bills. This can be useful for customers with electric vehicles or those that can shift the consumption outside peak periods.

The battery company Powervault has partnered with Octopus Energy and the Agile Tariff alongside adding smart hot water heater controls using Internet of Things technology. This aim is to efficiently integrate the Powervault 3 with the Agile tariff and ensure the

[4] https://www.trentbasin.co.uk/

hot water is on and the batteries are charged at the most economic hours of the day. This will help customers avoid importing expensive electricity from the grid at peak times to heat their hot water, which will help reduce their energy bills.

Electric Vehicles and Grid Services

Vehicle to Grid (V2G) and Vehicle to Home innovation projects are looking at technology that enables energy stored in an electric vehicle's battery to be fed back into the electricity network or homes.

Vehicle to Grid provides benefits by recharging when demand is low and putting energy into the electricity network when it is high, EV helps manage the peaks and troughs, balance the network and make it more efficient.

Vehicle to Home projects aims to demonstrate that in the future a car battery could be used to power your house or earn money by selling its spare energy back into the network at peak times, whilst ensuring there is sufficient energy in the vehicle for the next day's commute.

The results of these trials may steer design choices or requirements for properties to ensure that they can capture the full benefits of the EV revolution.

Cornwall Local Energy Market

A trial is taking place in Cornwall for a virtual local energy market that will test the use of flexible demand, generation and storage across both the domestic and business sectors.

As part of the trial a virtual marketplace has been created to provide participants with a platform to buy and sell energy and flexibility both to the grid and the wholesale energy market.

Homes and businesses are provided with technology to enable them to interface with the market and will allow the householders to both generate and store electricity and, as well as being able to power their homes, any excess energy is aggregated and connected to the virtual marketplace.

They can also get paid to reduce or delay their consumption. The result is that it will enable Western Power Distribution, the local Distribution Network Operator to balance the network in an area of the country with severe capacity constraints.

Since market trials started in summer 2019, over 32MWh of flexible energy has been dispatched to date through the platform and 150MWh of capacity reserved for the period until March 2020.

H21 Leeds City Gate Hydrogen Project

The H21 Leeds City Gate project is a feasibility study assessing the potential to convert the existing natural gas network in Leeds, to 100% hydrogen.

The H21 Leeds City Gate project aims to provides evidence that converting the UK gas network to hydrogen is technically possible and economically viable.

The project has found that converting the UK gas grid to hydrogen has the ability to provide "deep decarbonisation" of heat, as well as transport and power generation, with minimal disruption to customers. This has the combined potential to reduce carbon emissions by over 258 million tonnes a year by 2050.

H21 North of England report proposes conversion will begin in 2028, with expansion across 3.7 million properties in Leeds, Bradford, Wakefield, York, Huddersfield, Hull, Liverpool, Manchester, Teesside and Newcastle over the following seven years. A six-phase further UK rollout could see 12 million more homes across the rest of the country converted to hydrogen by 2050.

APPENDIX E

Be Green Technologies

Biomass

Biomass heating has been discussed in relation to district heating in Section 7. For dwellings, pellet boilers are usually specified as they require less maintenance than chip boilers and produce considerably less ash residue. Biomass installations would also qualify to receive payments for heat produced through the UK government's Renewable Heat Incentive if still operational at the time of the proposed Development.

If biomass technology is serving individual residential units, to reduce storage space at each property, one option would be to have a local store for neighbourhoods. This would reduce transport movements around the site. Each property would still require some area for fuel storage and delivery, and additional internal plant.

Domestic boilers also still have issues relating to air quality and there could be restrictions to installing thousands of biomass boilers around the site.

Although, in theory, these problems can be overcome with neighbourhood fuel stores and the use of flue dilution, it is considered impractical to have an individual biomass boiler for each property as the primary Energy Strategy for the proposed Development.

Wind Power

Wind turbines utilise the power of the wind to generate electricity. Wind turbines use large blades to catch the wind. In windy conditions, the blades are forced round, thereby driving a turbine that generates electricity. The stronger the wind, the more electricity produced.

There are two types of domestic-sized wind turbine:

- Small pole/mast mounted units are free standing on firm ground, erected in a suitably exposed position. Systems are often capable of generating from 5kW to 4,000kW depending on the size.
- Building mounted units are smaller than pole mounted systems, and can, therefore, be installed on the roof where there is a suitable wind resource. Often these are around 1kW to 2kW peak.

Due to uncertain wind speeds within the urban environment, it is recognised that wind technology at the small scale is not viable – either the pole mounted or roof mounted type.

Greater certainty is found with larger wind turbines where wind speeds are more predictable. The energy generating can be significant and be cost effective route to carbon reduction. With necessary commercial arrangements, the energy generated could be supplied to Otterpool Park or provide some community benefit.

Locating a large wind turbine within the red line of the proposed Development is challenging as a buffer is required to limit noise and impacts on other infrastructure. Additionally, the current planning system for on-shore large scale wind is challenging especially where turbines are located within or close to Environmentally Designated areas – such as the Area of Outstanding National Beauty.

It is therefore concluded that wind technology would not be viable for the proposed Development due to the uncertainty of wind resources in the urban environment and the challenges of locating a larger turbine.

Heat Pumps

As outlined in the district heating section, all heat pumps operate in the same way, in that they use electricity to drive an evaporation / condenser cycle to move heat from one side of the system to another. There are two potential options for serving homes using air or ground source heat pumps.

Heat pumps are suitable to both domestic and non-domestic applications.

Air Source Heat Pumps

Air source heat pump (ASHP) system uses an external unit to extract heat from the air to efficiently provide heating. Heat pumps operate on electrical current to drive the compressor in the heat pump, and thus eliminates gas consumption on site. This technology can also be coupled with other zero-carbon electricity generation technologies, contributing to a very low carbon emission building.

ASHP operate most efficiently at lower temperatures 35-40°C. Which requires a suitable internal distribution network within the building such as underfloor heating or oversized radiators.

Heat pumps efficiency drops when generating heat at a higher temperature or in colder external conditions. This means that an element of hot water generation may need to be provided from an electric immersion heater. Currently, heat pumps usually require a hot water cylinder for the home so that the heat can be generated at a lower temperature for longer and more efficiency. This adds to the cost of the system compared to a combi gas boiler.

A limitation of ASHP technology is that they are more expensive than a gas boiler. Although more efficient than a gas boiler, due to differences in electricity and gas prices the ASHP can lead to higher fuel bills.

Additionally, an issue regarding ASHPs is that the part of the plant (the evaporator) has to be located outside. Because of this, there can be noise issues associated with the units, particularly at night. Heat pumps are noisy due to their components – which consists of a compressor, AC condenser, expansion valve and evaporator. The noise is not entirely produced by the components operating, but also the vibrations of air passing through the heat exchanger. However, manufactures are developing a low noise version of the technology. Solutions include ASHP enclosures, with absorptive panels that reduce internal reverberation. Airflow requirements can be addressed by developments and many solutions comply with BS 4142:2014.

In addition to modern equipment, simpler solutions, such as, position and orientation could have a significant effect on the noise produced by an ASHP. An ASHP should be positioned so there is adequate space for uniform airflow and positioned far away from any potential obstructions.

Houses can be individually served with the external unit located in a suitable location. For blocks of flats, the external unit of the ASHP can be located on the balcony or wall of each home or could be served from the central plant either on the roof or ground mounted plant.

Heat pumps can be supplied with tools for energy management and smart controls including energy monitoring software, SD card commissioning, cloud and Wi-Fi control with access to dashboards on mobile phones and tablets.

In conclusion, it is likely that ASHP would be a key technology used in an electrically heated home, although some mitigation will be required of the issues raised above.

Ground Source Heat Pumps

As discussed in District Heating Section 7, Ground source heat pump (GSHP) systems use buried pipes to extract heat from the ground. Two types were discussed: an open loop system extracting water from underground and a closed loop system.

In the closed loop system, the electrically powered heat pump circulates a water and antifreeze solution around a loop of pipe. This is to absorb heat from the ground into the fluid and then pass it through a heat exchanger into the heat pump.

As the ground temperature is more stable than air temperature, GSHPs tend to be more efficient than ASHP. This is because heat pumps are more efficient when the temperature difference between the temperature source and the space demand is lower.

There are two distinct types of closed loop system systems: a trench/'slinky' system, where pipes are spread across horizontally in a field, or a borehole system, where pipes route vertically deeper into the ground.

Whatever the adopted system is, the longer the pipe system, the more heat that can be drawn from the ground. This heat can then be used to heat radiators, underfloor or warm air heating systems and hot water in the home.

As the ground stays at a fairly constant temperature under the surface, the heat pump can be used throughout the year.

A closed loop system requires enough free land for the boreholes to be drilled and connected to a network. Based on the masterplan and typical layout for a lower density housing the potential space exists for a borehole per home or park land for a shared GSHP.

However, the improved efficiency of the heat pump needs to be weighed against the additional capital cost of the ground source closed loop system infrastructure alongside the risks associated with underground circulation of heat transfer liquid.

Ground source heat pumps are not recommended as the primary technology for Otterpool Park. However, trial properties for blocks of flats or houses with sufficient external space should be considered within the first phases to develop data to compare against other heat sources.

Solar Photovoltaics

PV (Photovoltaic) cells are made from layers of semi-conducting material, usually silicon, which creates an electric field across the layers when exposed to light. The stronger the sunshine, the more electricity is produced, and without needing direct sunlight to work – they can still generate some electricity on a cloudy day. Groups of cells are mounted together in panels or modules that can either be mounted on your roof or on the ground. The power of a PV cell is measured in kilowatts peak (kWp). That's the rate at which it generates energy at peak performance in full direct sunlight during the summer.

PV cells come in a variety of shapes and sizes. Most PV systems are made up of panels that fit on top of flat or pitched roofs, or alternatively as solar tiles.

Currently, there are four types of solar cells available: mono-crystalline, poly-crystalline, thin film, and hybrid. Mono-crystalline and hybrid cells are the most expensive to produce but are the most efficient (12-20%), poly-crystalline cells are cheaper but their efficiency is lower (9-15%) and thin film cells are only 5-8% efficient but can be produced as thin flexible sheets.

For new builds, manufacturers are designing roof integrated technologies that can act as the roof covering and solar generator. The slight disadvantage is that the panels are harder to ventilate, and the systems are generally 5-10% less efficient than on roof systems because they operate at higher temperatures.

Photovoltaic panels are best orientated to the south and inclined between 30 and 40 degrees. Solar PV is most efficient on a south facing roof, however only limited loss in efficiency is experienced across the E-S-W orientation and the technology should be available to most properties in the proposed Development.

As part of the Strategic Design Principles, information to optimise the design of solar PV onto different property types has been outlined. This will link with optimum generation to ensure that suitable amounts of unshaded roof area for PV will be available. These would either be in banks on flat roofs or on roofs with a likely orientation within 45 degrees of south and inclination close to 30 degrees.

Once installed, Solar PV requires limited maintenance although the inverters may need to be replaced after approximately 5-10 years.

Solar PV costs have reduced significantly over the last few years to around £850/kW this compares favourably against the other technologies.

There is a strong case for solar PV to be included as renewable technology for Otterpool Park due to the reducing capital costs, ease of installation and potential for significant energy and carbon savings and the connection with other technologies such as battery storage and electric vehicles.

Solar Thermal

Solar thermal panels act in a similar way to PV array in terms of orientation and inclination, and use free heat from the sun to warm domestic hot water. A conventional boiler or immersion heater can be used to make the water hotter or to provide hot water when solar energy is unavailable.

There are two types of solar thermal water heaters: Evacuated tube and flat plate collectors are both commercially available. Although evacuated tube collectors are more expensive than flat plate collectors, the higher efficiency and higher temperatures of evacuated tube collectors make them a better choice for the UK climate. The best performance would come from a south-facing array with an optimum inclination of about 35 degrees.

Solar thermal would be used for domestic hot water only, not space heating since this is not required during the season when solar thermal is the most effective. A suitable solar thermal system would supply approximately 50% of the annual hot water consumption (the maximum feasible due to seasonal variations) and would be topped up with an additional heat source.

Solar thermal could be compatible with ASHP solution which is likely to require a thermal hot water cylinder to store domestic hot water.

Solar thermal would compete for space on a roof with solar PV which is currently more cost effective and could be sized to offset a larger proportion of energy and carbon solar thermal.

However, trial properties will be considered with solar thermal and ASHP and compared with solar PV solutions in the first phases of the development.

Hydrogen

Technology providing hydrogen to individual domestic properties can be used in hydrogen boilers or fuel cells. Boilers would be of a comparable price to gas boilers. Fuel cells are more expensive but also generate electricity. Their energy costs will be significantly higher, because the full hydrogen chain, from production to end-use, has a number of inefficiencies. There are also unresolved questions over the implications for nitrogen oxide (NO_x) emissions from burning hydrogen in boilers.

Tests are also being undertaken to add a proportion of hydrogen to an (existing) gas network (up to 20%) without having to modify existing gas infrastructure or domestic appliances.

In the Role of Hydrogen in a low carbon economy report (Committee on Climate Change, 2018) the CCC outlines that hydrogen could play a valuable role as part of a heating solution for UK buildings, primarily in combination with heat pumps, as part of ‘hybrid heat pump’ systems. The CCC outlines that that heat pumps, powered by increasingly low-carbon electricity, offer the potential to provide heat efficiently for most of the time, with hydrogen boilers contributing mainly as back-up to meet peak demands on the coldest winter day.

The role of hydrogen will be kept under review for Otterpool Park. However, at this stage the use of technology for hydrogen heating is still in the trial and research phase and would not be considered at this stage as a suitable heat source for the development.

Phase Change Thermal Storage

Phase-change Materials (PCMs) are substances which absorb or release large amounts of so-called ‘latent’ heat when they go through a change in their physical state (melting or freezing), i.e. from solid to liquid and vice versa. Freezing = Release of Energy; Melting = Energy Absorbed

They are substances with high heat of fusion. This means they are capable of storing and releasing large amounts of energy.

PCMs are used mainly for thermal energy storage. However, they are also very useful in providing thermal barriers or insulation, for example in temperature-controlled transport.

This technology can be used in two different ways:

- Thermal store that substitutes large volumes of hot water storage
- Exposed thermal mass that substitute the thermal performance of exposed concrete soffits.

Thermal storage using PCM is a relatively new technology and will be kept under review as a potential alternative to hot water thermal stores.

Electricity Storage

The use of battery storage for both domestic and non-domestic applications is becoming increasingly viable. Storage does not provide low or zero carbon energy generation, but it can enable the user to maximise the energy generated on-site or within the community which would otherwise be exported to the grid.

In the domestic sector this means the on-site renewable energy such as Solar PV, which generates electricity during most of the day - but often when the home is unoccupied - can be stored and used when the occupants are home.

In the future, with time of use tariffs and the potential to trade energy from your home, the battery could play an important role in exploiting grid services and providing energy and cost savings to the occupants.

In the non-domestic sector, who are larger consumers of energy, the cost of electricity can already vary significantly over the day and night. Energy storage can help smooth these cost variations. Storage can also be used to exploit the financial benefits of providing services to the grid such as providing capacity or reducing demand at certain times of the day or year.

With the electrification of the grid and vehicles, there will be an increasing proportion of electricity used in the home and non-domestic buildings. Batteries could help smooth consumption both on an individual level and a community level. The location of batteries could be in every property or at a neighbourhood level. This aggregation of energy could provide greater grid benefits and therefore greater income to the community.

The costs of batteries have reduced significantly over the last few years and are projected to fall further.

Battery storage will be considered for the properties at Otterpool Park. However, at this stage battery storage would not be specified as standard. Further investigation is required in early phases to determine whether batteries should be located at each property or at a more aggregated level.

Other questions about optimum sizing for the dwellings, assessing suitable software and controls and how these could benefit from commercial arrangements could all be investigated.

A potential limitation on the use of battery storage is that all electric properties with ASHP are likely to have thermal hot water storage. Solar PV or Solar thermal could be used to heat this store during the day which would minimise energy available for battery storage.

Electric Vehicles

The UK Government has published a Road to Zero Strategy (Department for Transport, 2018) which outlines the actions to develop a cleaner road transport. The aim is to put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040.

Vehicles are not conventionally covered within an Energy Strategy, however electric vehicles (EV) could potentially play a role within the energy solution for Otterpool Park.

The main benefits of electric vehicles are:

- More efficient than petrol and diesel cars

- Benefit from a reduction in grid decarbonisation
- Benefit from solar electricity generation if installed on the home
- No local pollution and less noise which benefits the community
- Potential to provide grid services to home, community or grid – such as exporting energy during the day from charged vehicles.

The disadvantages of electric vehicles are that the additional electricity demand could put additional strain on the electricity grid and local electricity infrastructure.

There are currently three main types of charging infrastructure:

- Slow: Up to a 3kW supply used for overnight charging (6-12 hours)
- Fast Chargers: Around 7kW -22kW supply for faster charge (3-4 hours)
- Rapid Chargers: From 43 -50kW (although some chargers now 150kW) supply rapid charge (30 min charge).

EV's can be charged at individual properties or at communal charging points. The direction of the market is moving is towards the fast chargers for domestic properties and rapid chargers on public networks.

Office car parks can also be fitted with EV charging options for employees and visitors. Like home charging, it can be a crucial aspect of running an EV since an employee's vehicle is typically stationary for most of the day when it can be conveniently charged. EV charging infrastructure links well with Solar PV for both domestic and public charges as the electric charges can make use of the solar power.

In the future, electric vehicles can play a part within the wider flexible decentralised energy market. With intelligent controls and smart grids electricity from vehicles can be charged, stored and released to provide grid services.

At Otterpool Park, EVs are likely to become the increasingly dominant form of vehicle. The EV technology and charging infrastructure are evolving rapidly and solutions available today may look very different in a few years' time.

The EV strategy for Otterpool Park will likely include a combination of domestic and public charging points. Trials will be undertaken in the initial phases of the development to test options and commercial arrangements to ensure the chosen solutions are steered towards the optimum destination.

APPENDIX F

District Heating Study

Otterpool Garden Village, Kent

Energy Masterplanning and Heat Network Feasibility study

Arcadis and Homes England

Project Number: 60570162

September 2018

Quality information

Prepared by	Checked by	Approved by
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Revision History

Revision	Revision date	Details	Authorized	Position
1	27/9/18	First draft	Andrew Cripps	Regional Director

Prepared for:

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Figures

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Executive Summary

Study context and scope

Homes England working with the Department for Business, Energy and Industrial Strategy (BEIS) are funding a number of studies of new build housing schemes where a district heating scheme may be appropriate. The overall aim is to identify which of these sites would provide feasible and viable opportunities for district heating assuming large scale housing and mixed use development; and with the overarching aim to:

- Reduce development costs
- Deliver carbon savings
- Reduce end occupier energy costs

Arcadis are working with Farrell as masterplanning architects on the development of a scheme for a Garden Village known as Otterpool, near to Folkestone in Kent. It could contain up to 10,000 homes built over a period of around 20 years.

AECOM have been instructed by Homes England to evaluate the potential for heat networks to contribute to the low carbon aims of the scheme. The study funding has come from the Heat Network Development Unit (HNDU) and follows, where appropriate, their standard scope and methodology.

Approach

The study explores the feasibility of delivering a local heat network and evaluates the options in relation to Council and stakeholder priorities. The standard methodology used, and followed where appropriate (i.e. no site surveys were undertaken), in this study is summarised in the diagram below.

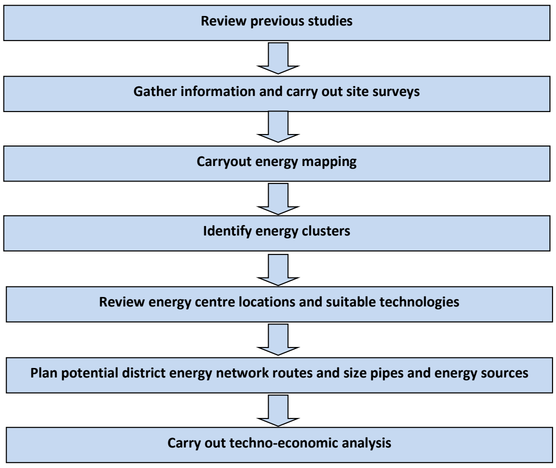


Figure 1: Standard Heat Network Analysis Methodology

The study was carried out in accordance with the objectives set out in the brief, as well as, where appropriate, objectives 2.1 to 2.12 of the CIBSE/ADE Heat Networks Code of Practice, which sets minimum and best practice standards for the development of heat networks in the UK, covering the feasibility stages.

Energy demand

The energy demands have been estimated based on assuming that all homes are built to the energy standard expected of the Code for Sustainable Homes Level 4. This results in an average energy use of around 5.3 MWh per house per year. Energy use for proposed non-domestic buildings came from benchmarks derived from work on new construction for the Greater London Authority (GLA).

Due to the large area of the masterplan, and a phasing schedule lasting many years, an appropriate region of the Otterpool Masterplan was selected for analysis. The north eastern region of the site was therefore chosen due to its large areas of high density housing, significant plans for non-domestic properties including a hotel and 2 schools, and that much of it is planned to be built towards the beginning of the phase schedule.

The resulting energy demand data have been plotted to generate energy maps of the study area – the area of the site which was assumed to have the highest heat density in the early phases of the site development. This is shown here and discussed further in section 4.

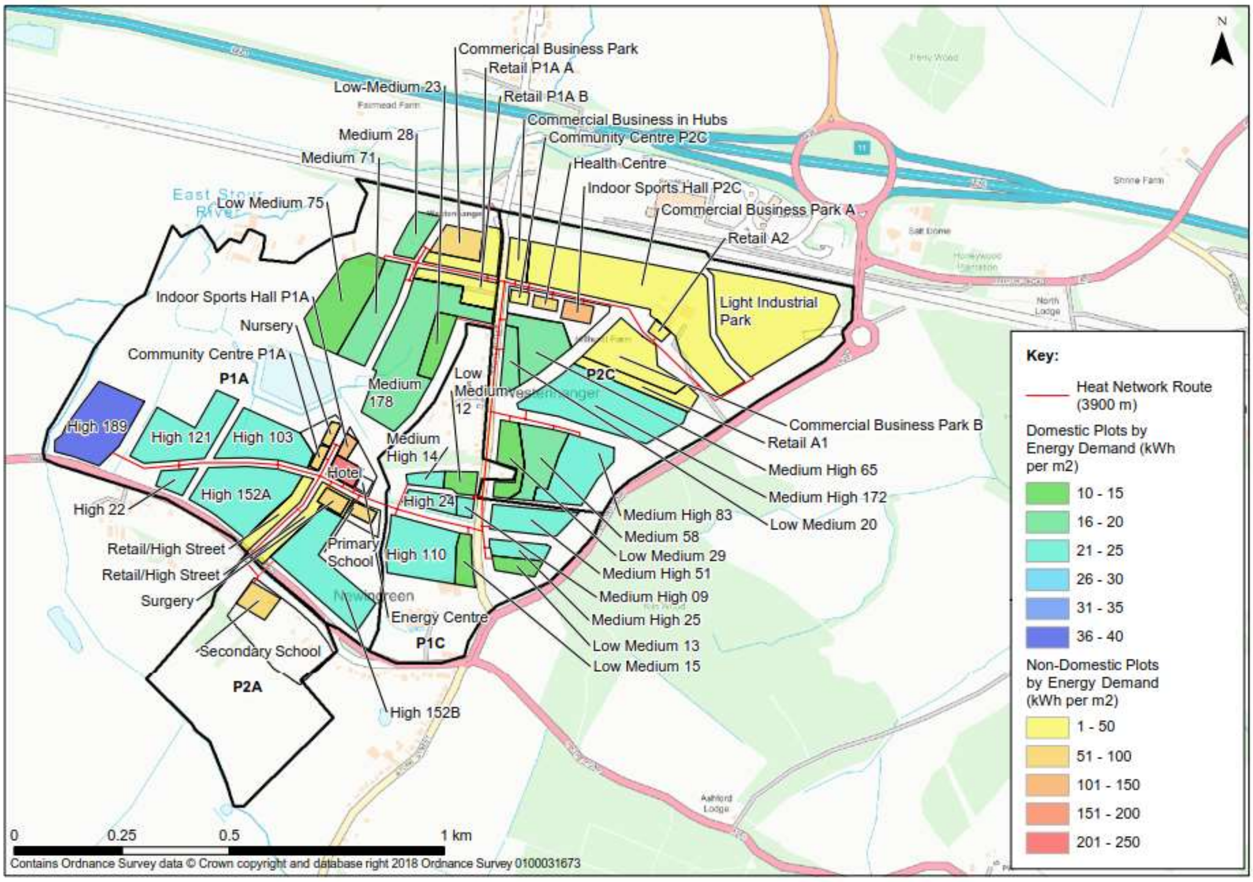


Figure 2: Map of estimated heat densities across the analysis area.

Potential heat networks, sources and energy centre

From Figure 2, three heat network options were created with increasing network length and heat demand. The three options analysed were:

- Option 1: including the hotel, community centre, nursery, indoor sports hall, primary school, secondary school, and main retail high street.
- Option 2: Option 1 plus the high density housing to the west of option.
- Option 3: Options 1 and 2, plus the rest of the development within this map.

In terms of sources of heat, the main options considered were gas CHP and biomass boilers. Alternative options were heat pumps using the ground or sewer water as their heat source which were modelled for a smaller low density domestic development, as is expected to be developed to the west of the Otterpool development, where these technologies would be more likely to be feasible.

Techno-economic analysis

To assess the commercial viability of the network options, estimates have been made of the total capital costs associated with the network and plant, the costs associated with operation and maintenance, and the revenue from the sales of heat and electricity. These estimates are based on recent quotes from suppliers and AECOM's previous experience of delivering district heating projects. The costs have been run over 25 and 40 year periods with a range of discount rates to determine the cash flows and calculate net present value (NPV), and internal rate of return (IRR). The associated carbon savings have also been estimated.

As a very general rule, an IRR of around 6% may be expected to attract public funding, and an IRR of more than 10% to attract private funding.

The headline finding of the study is that none of the options return a positive IRR, with all of the options giving a large negative NPV at a discount rate of 3.5%. These reflect the fact that the schemes all have a relatively low heat demand for the length of the network needed to reach all of the loads. Expressed in MWh per metre of network length, this was found to be less than one tenth of the magnitude of other schemes that AECOM have worked on.

In other locations it is normal to use individual gas boilers as the counterfactual case for a heat network, as this is the most common solution adopted in the UK. However at this site there may not be any gas provided, and therefore an alternative counterfactual of individual ASHP's has been considered. The analysis has been completed with both options: i.e. a gas boiler in each home with a typical gas network; and individual electric air source heat pump providing space heating and a proportion of the hot water, with direct electrical top up of the hot water to 60^{o}C. A summary of the key outcomes is given here for a 40 year lifecycle assessment against the two different counterfactuals used for this study:

40 year lifecycle - NPV (£m)				
Gas Boiler Counterfactual	Gas CHP	Biomass boiler	Ground source heat recovery	Sewer source heat recovery
Option 1	-1.55	-1.18	N/A	N/A
Option 2	-9.96	-8.45	N/A	N/A
Option 3	-22.72	-22.12	N/A	N/A
Low density 100 home example	N/A	N/A	-1.21	-1.16

Table 1: Summary Table of Results for gas boiler counterfactual

40 year lifecycle - NPV (£m)				
ASHP Counterfactual	Gas CHP	Biomass boiler	Ground source heat recovery	Sewer source heat recovery
Option 1	-8.09	-9.28	N/A	N/A
Option 2	-13.21	-16.24	N/A	N/A
Option 3	-18.69	-15.30	N/A	N/A
Low density 100 home example	N/A	N/A	-0.73	-0.64

Table 2: Summary Table of Results for ASHP Counterfactual

These all show significant negative values for NPV as they are not able to overcome the cost of the network. An improved outcome is found when a higher electrical sale price (in the case of the gas CHP network) and a lower pipe installation cost are assumed within the techno-economic assessment of this study. However, even with these financial improvements the economic results of the schemes are still reasonably poor. The best results come from the sewage heat recovery technology; however this is only feasible where the sewage network would accumulate, probably to the west of the Otterpool development where lower density domestic developments are more likely.

Risk register

A risk register has been developed as part of the consideration of the business structure and is set out in section 6. This focuses on the technical and economic parts of the process.

Next steps

It is expected that a heat network scheme will not be progressed, as the predicted economic performance is too weak. The project team must consider whether radical changes to the design of the site could take place to greatly increase the density of heat demands. Alternatively, a large amount of financial support may be forthcoming, though the amount required is unlikely to be available.

There does seem potential to utilise sewage recovery technology to provide heat to developments to the west of the Otterpool site, where the new sewage network is expected to accumulate to a high enough flow rate for the technology to be used. Whilst the cost of this is not accurately known, the better COP achievable due to the higher source temperature, suggest the system may give the most financially attractive results. This would require a more radical approach be taken, using pipes with much less insulation and shallower installation to improve the cost effectiveness. A large reduction in capital would be required to achieve an economically attractive IRR, and whilst it has not been tested, it could be possible with the more radical solution outlined.

1. Introduction

1.1 Background

This study has been prepared for Arcadis and Folkestone and Hythe Council, as part of a group of projects for Homes England funded by the Heat Networks Delivery Unit (HNDU) within the Department for Business Energy and Industrial Strategy (BEIS). The overall purpose is to establish whether a heat network is a viable and appropriate way to deliver heat to the new developments within the Otterpool Masterplan.

1.2 The benefits of Heat Networks and Decentralised Energy

The present system of energy generation and distribution in the UK is relatively inefficient. Electricity is generated centrally, resulting in electricity transmission losses and large amounts of waste heat from power stations currently not used. Heat is usually generated at a building scale which means that only small scale technologies can be used (most commonly natural gas-fired boilers). Whilst alternative forms of heat generation are available, they are often more difficult and expensive to implement at a building scale. By localising electricity generation and capturing heat from localised generation systems for distribution, it is possible to improve efficiencies through the capture of waste heat and reduced electricity losses.

A key component of a Decentralised Energy (DE) scheme is a heat network. This provides opportunities for capturing heat and distributing it to a number of customers. The generation of heat at a larger scale, and subsequent distribution to a larger number of connected buildings, allows alternative and more efficient forms of heat generation to be used which would not be viable at a building scale, the capture and delivery of waste heat, and the transition to new lower carbon technologies in the future (due to a single point technology change rather than the retrofitting of multiple individual buildings).

A heat network comprises a system of insulated pipes which distributes hot water from a centralised heat generation plant to a number of different buildings to provide space heating and hot water. Schemes can range in size from simply linking two buildings together, to spanning entire cities. In some continental European countries the use of heat networks is widespread – in Denmark around 60% of the country’s heat load is connected to heat networks, including a scheme covering most of Copenhagen.

The use of DE in Otterpool, comprising heat networks and energy generation plants at a district scale, may offer a number of potential benefits:

- CO_2 savings. The combination of more efficient generation and the ability to use alternative technologies and fuels means that heat networks may provide CO_2 reductions to communities.
- Carbon cost savings. Policies such as the CRC energy efficiency scheme place a value on CO_2 emissions (effectively a carbon tax) and it is expected that such policies may increase in future as the pressure to reduce emissions increases. Therefore a reduction in CO_2 will also provide economic benefits.
- Energy security. The higher efficiencies combined with the ability to provide alternative forms of heat generation (for example from large heat pumps or energy from waste) means that DE improves energy security, and reduces reliance and long term lock-in to gas.

Whilst a scheme can provide a range of benefits, it is important to establish priorities at the outset. This in turn guides the design and configuration of a scheme, and the commercial versus environmental drivers.

1.3 Overview

Arcadis are working with Farrell as masterplanning architects on the development of a scheme for a Garden Village known as Otterpool, near to Folkestone in Kent. It could contain up to 10,000 homes built over a period of around 20 years.

The Garden Village has sustainability as a key part of the brief, and so the efficient delivery of low carbon and secure energy is an essential part of this. Specific targets have not been set at this stage.

AECOM have been instructed by Homes England to evaluate the potential for heat networks to contribute to the low carbon aims of the scheme. The study funding has come from the Heat Network Development Unit (HNDU) and the study follows, where possible, their standard approach. However the masterplan is only developed to an early stage and none of the buildings are specified beyond their usage and approximate area. Therefore the analysis is necessarily based on assumptions and benchmarks.

Key drivers for the study are the rapid changes in the carbon emissions associated with the electricity grid and the limited availability of gas to the site in the short and medium term. These both suggest that a non-gas based solution may be more appropriate than has been the case in the past. However over the life of the development the Renewable Heat Incentive (RHI) is due to expire and it is not certain if it will be renewed. Therefore the viability of electrically sourced heating from heat pumps may be low.

1.4 Site Details

The proposed Otterpool Garden Town site is located in the South East of England near Folkestone, Kent and is bordered by the M20 motorway to the north. The site is currently surrounded by of a few small communities and rural land, and covers an area of approximately 5-6 km^2. The general location is shown below:

Figure 3: Location of proposed Otterpool Garden Town relative to surrounding area.

The build-up of the proposed development is spread over many phases, consisting of up to 10,000 homes, with the usual non-domestic developments accompanying these such as schools, retail, health / community centres and commercial properties.

1.4.1 Technology options review

AECOM have reviewed energy supply options for generating heat and in some cases electricity, to identify their suitability in terms of providing a cost effective and reliable energy supply that will also deliver environmental benefits.

The analysis of possible energy sources is summarised in the table below, with those considered most suitable highlighted.

Technology	Temperature of DHN	Fuel Costs	Comments	To Consider Further
Community gas boilers	High	High - gas	To install a gas fired community boilers system there would need to be a provision of gas infrastructure first to any potential energy centers. The high operating temperature of the heat network would require highly insulated pipe runs which would further increase the costs of the network. Based on this information and previous experience of high temperature district heating network this option is deemed not suitable as the main heat source.	Yes – for supply of peak load heat
Community biomass boilers	High	High – fuel pellets	There is a suitable biomass supplier within 10 miles of the site, just North of the nearby community of Hawkinge (South East Wood Fuels Ltd). As the technology is designed to work at high temperatures this option could be viable if economically sustainable.	Yes
Large power station heat take-off	High	Low – waste heat	There is believed to be no power plants within 1km of the boundary of the development site, so this solution is deemed to be not suitable due to pipe run distances and costs.	No
Industrial/ commercial waste heat	Low	Low – waste heat	There is not thought to be any sites planned within the development or already existing in surrounding areas that could be used as a source of waste heat.	No
Gas-fired CHP	High	High – gas	To install a gas fired CHP system there would need to be a provision of gas infrastructure first to any potential energy centers. The high operating temperature of the heat network would require highly insulated pipe runs which would further increase the costs of the network. However the benefits of CHP DHN, as explained in this report, mean that it should be considered.	Yes
Biomass-fueled CHP	High	High – fuel pellets	While there is a biomass pellet provider within a suitable distance of the development a biomass fuelled CHP system would have issues of scale for a development of this size, as the most common technologies (steam or organic Rankin cycle turbines) would be considered too big for the estimated demands of the site.	No
Fuel cell CHP	High	Low - electricity	This technology is considered too immature at present for large scale DHN deployment.	No
Energy from waste – Incineration	High	Low – waste heat	There is believed to be no waste incineration plants within 1km of the boundary of the development site, so this solution is deemed to be not suitable due to pipe run distances and costs.	No

Technology	Temperature of DHN	Fuel Costs	Comments	To Consider Further
Energy from waste - Anaerobic Digestion	High	Low – waste heat	There are no sites in the area close enough to connect and Otterpool itself will not produce enough waste food to power a suitable sized anaerobic digestion plant. The waste from the site would have to be integrated with waste from other local communities, which has been considered.	Yes
Air Source Heat Pump (ASHP)	Low	Low – electricity	While this technology is well developed it is generally considered a building scale technology, not a heat network scale one. ASHPs are used as one of the base case technologies for Otterpool. It is not expected that the marginal improvement in efficiency resulting from the scale of application would offset the infrastructure costs of a district energy solution.	No
Ground Source Heat Pump (GSHP)	Low	Low – electricity	Otterpool would require a large array to obtain a suitable amount of heat, but this might be suitable on a smaller scale within the site as the development has a lot of large open ground spaces around each potential village.	Yes
Water Source Heat Pump (WSHP)	Low	Low - electricity	There are no suitable rivers, canals etc. near the Otterpool site that could be used as a source for WSHP.	No
Deep geothermal	Low	Low - electricity	The south east of England is thought to have a very low source of geothermal energy so this is highly unlikely to be suitable for the Otterpool site.	No
Solar thermal	Low	Low - electricity	While the costs of the pipe network could be minimized through the use of a low flow/return temperatures, and therefore minimal insulation, the required area to meet the peak demands of the network would be very high, given the efficiencies of the panels. The peak demands of the network (morning and evening) would not be balanced with the peak output times of the solar array (midday and early afternoon), and would be subject to seasonal changes in weather.	No
Sewage Heat Recovery	Low	Low - electricity	Sewer heat recovery may be possible as for much of the site the sewerage system will need to be installed as part of the development. This should have the benefit of being separate from storm water drains (rainwater decreases the average temperature) and there may be benefits to installing into a new system rather than retrofitting.	Yes

Table 3: Summary of Technology Options Assessment

From this review it was established that gas CHP, biomass boilers, sewer water heat recovery, AD from food waste, and communal GSHP should be included in the study.

1.5 Social Impact Assessments

Financial, social and environmental benefits need to be taken into account to understand the wider value of potential investment delivered in areas other than simple returns. Investment in low carbon energy systems can help either directly or indirectly in areas such as fuel poverty, health, air quality and biodiversity. These other benefits should be recognised and possible financial values should be attached to them in order to deliver a more comprehensive assessment. Some of the additional benefits may include:

- **Reduced public and private spending on carbon taxes**: This releases extra funding to deliver higher quality Council services;
- **Reduction in fuel poverty and improved energy affordability**: This releases spending power into the local economy;
- **Health benefits**: Improved energy affordability can deliver health benefits by reducing the risks of illness associated with living in inadequately heated homes;
- **Infrastructure improvements**: With direct economic benefits from creation of construction and operation jobs;
- **Development of local skills and job creation, and wider economic regeneration**: For example, a planned geothermal district heat network in Stoke-on-Trent is projected to support more than 200 jobs directly and protect 1,350 jobs in the supply chain;
- **Enabling local development by providing a low cost approach:** To meeting increasingly challenging standards for carbon reduction in new buildings.

2. Identification and Review of Information

Any project of this type depends on collecting information on the buildings that are within the study area and those that are planned, the opportunities and constraints within the area, and the policies and aims of the local authority. This section covers the sources of information that we have used for the project.

On most other schemes there is a key part of this process to attempt to gather information about existing buildings. In this case there are no existing buildings across the development area, and so there is no data to collect and the National Heat Map is not of use.

2.1 Core strategy and masterplan

The proposed site is intended to include up to 10,000 new dwellings and a range of non-domestic buildings. The phasing map, as seen below, has been one of the key documents to inform this study (as well as the area and phasing schedules), particularly in terms of the potential layout of the site, and location, scale and density of housing developments, non-domestic buildings and public open spaces. This map indicates where phase boundaries and individual development plots would be situated, distinguished by housing density categories for domestic plots, and building type for non-domestic plots.

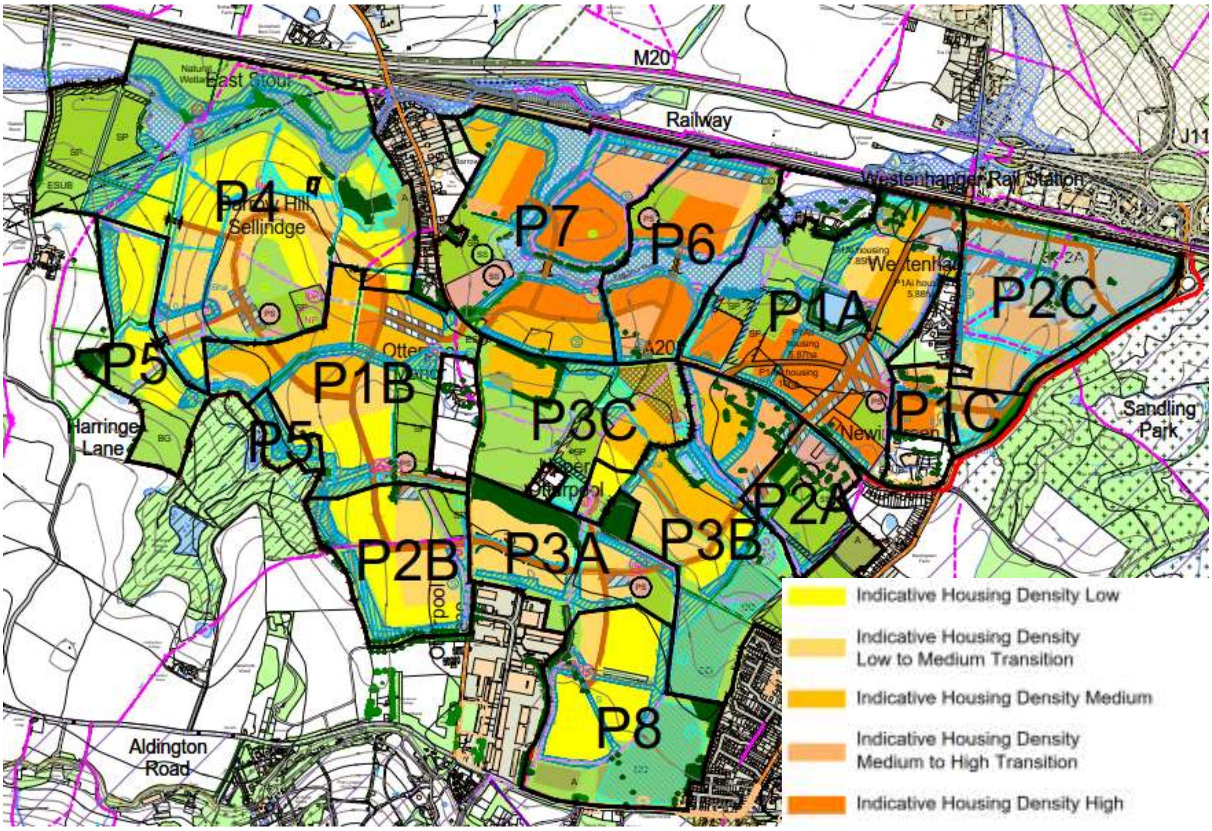


Figure 4: Otterpool Garden Town Proposed Phase Area Map

This phase map was the basis for the initial conceptual district heat network analysis, with the area/phasing schedules and housing densities used to decide where a DHN is most likely to be financially and technically viable.

From this map, it was decided that a conceptual heat network analysis should be completed on a group of the development in the early phases, in the North East of the site seen below, where there is an area of high housing density and non-domestic developments. This includes phases P1A, P1C, P2C, and the secondary school on the border of P2A and P1A.

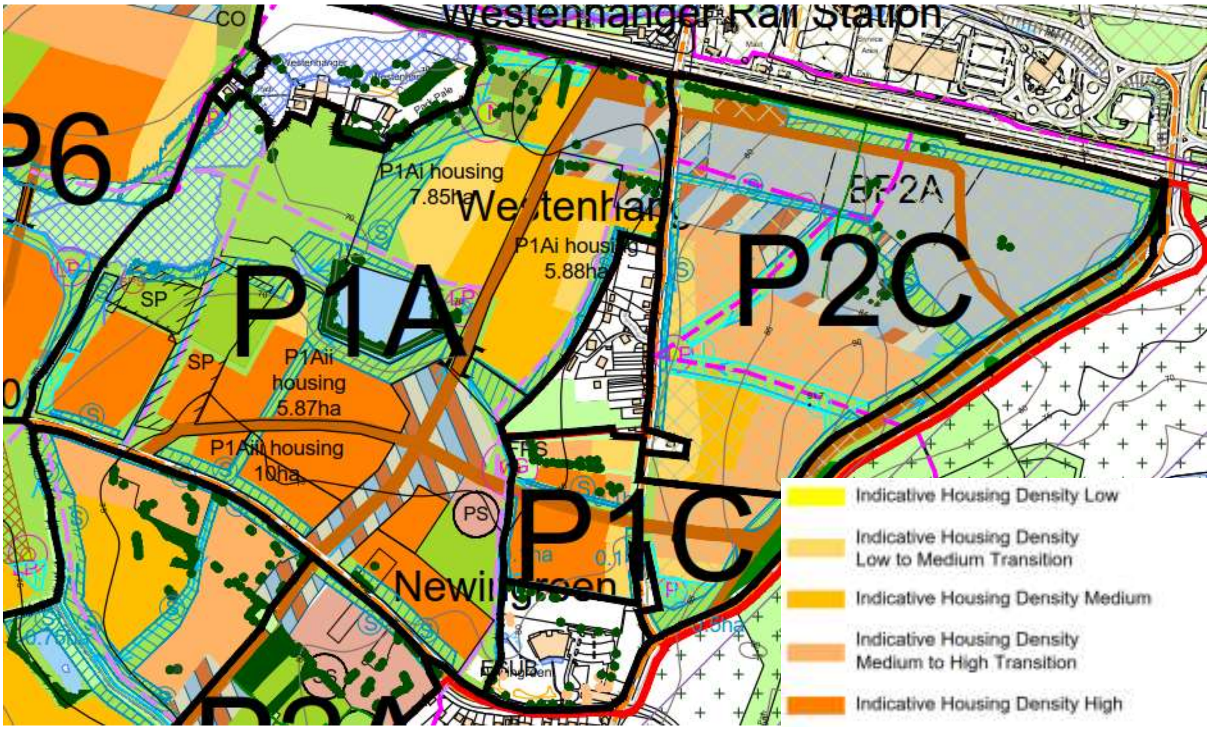


Figure 5: Allotted area for heat network analysis

This area is expected to have higher heat demand density compared to the majority of the rest of the site. Furthermore it should give an indication if the heat network could be expanded to further site locations in the future, where there is a lower housing density and a heat network would be less likely to be economically viable.

From the land-use phasing schedule supplied to AECOM for the Otterpool development, the chosen analysis area has the following buildings planned:

- 1,816 homes
- 1 primary school
- 1 secondary school
- 1 hotel
- 2 community centres
- 2 indoor sports halls
- 1 health centre
- 1 Nursery
- 1 Surgery
- Multiple retail areas
- Commercial business parks
- A light industrial park

2.2 Site Constraints

There are assumed to be very few constraints in terms of barriers for a heat network on this proposed site, other than some existing properties located in the centre of site (but not within any of the phase boundaries) and a body of water towards the centre of phase P1A. Whilst there is currently no gas network serving the site, it is possible to supply a new connection and the associated cost of this has been taken into account within the analysis where appropriate.

3. Data Collection and Heat Mapping

In DH projects in built up areas the task of data collection tends to focus mainly on the existing buildings. In this project there are no existing buildings and as such energy data is based on modelling and assumptions for the new developments being built and planned across the masterplan area.

3.1 Development plans

As previously mentioned, the scale of housing and non-domestic buildings within the chosen analysis area was predicted using the phase area map and the land-use / accommodation phasing schedules.

3.2 Energy Demands

The main focus of study in this project is the residential developments, and therefore the heat demand of houses is the dominant factor. It was agreed at the first project meeting that energy use equivalent to that required for Code for Sustainable Homes level 4 would be taken as the energy benchmark. To apply this we collated heat and hot water predictions from a range of different studies for homes which meet this performance level. The results of this analysis are shown below:

Type	Beds	Avg Area m2	Heat kWh/home/year	DHW kWh/home/year	Total kWh/home/year
Detached	3	93	3,859	1,995	5,854
Detached	4	124	5,171	2,674	7,845
Detached	5	170	7,067	3,654	10,720
Detached	Generic	121	5,038	2,605	7,642
SemiD	2	64	2,034	1,291	3,325
SemiD	3	79	2,533	1,608	4,141
SemiD	4	106	3,378	2,145	5,524
SemiD	5	95	3,043	1,932	4,975
SemiD	Generic	77	2,472	1,570	4,042
Terraced	2	71	1,885	1,818	3,703
Terraced	3	75	1,989	1,919	3,909
Terraced	4	115	3,066	2,958	6,025
Terraced	Generic	78	2,075	2,002	4,076
Flats	1	45	868	1,430	2,298
Flats	2	66	1,267	2,088	3,355
Flats	3	87	1,667	2,747	4,414
Flats	Generic	62	1,185	1,952	3,137
Generic	Generic	100	3,008	2,324	5,332

Table 4: Benchmarks used for Code for Sustainable Homes Level 4 domestic heat demands

The values used here are from SAP calculations and these use heat demand for an average UK location. Otterpool is in the SE region and has an average temperature which is slightly higher than the average, so no adjustments were made. Where there is a difference it would be appropriate to adjust these heat demand figures using a degree day correction factor.

For the new non-domestic buildings the following benchmarks have been used taken from work by AECOM for the GLA[1].

[1] Greater London Authority

Typology	Class	Total heat kWh/m^2
Shops/ Financial and prof. services	A1-A2	45
Restaurants and cafes/ Drinking establishments/ Food	A3-A5	67
Business	B1	36
General Industrial	B2 -B7	16
Storage and distribution	B8	12
Hotels	C1	115
Residential Institutions	C2	120
Non-residential Institutions – Education	D1.Edu	45
Non-residential Institutions – Health	D1.Hea	113
Non-residential Institutions – Others	D1.Oth	44
Assembly and Leisure	D2	100
Mixed (used for the main local centre)	MC1	62

Table 5: Benchmarks for new build non-domestic annual energy use

3.3 Heat Mapping

In order to produce a heat map for this selected area of the Otterpool development, the assumed annual energy demands benchmarks for domestic and non-domestic were used as shown before. The number of domestic dwellings per plot (coloured blocks on the phase map) for this site location was taken from the Land-use and phase development schedules provided to AECOM. These schedules show how many homes in each phase should be built for each housing density category. Therefore, using the net housing density for each indicative domestic plot (individual coloured block on the phase area map), the area of each domestic plot could be measured, and assigned a number of homes to it based on its dwelling net density, given by its colour. Each plot is labelled by their housing density and the number of homes predicted to be built in that area (for example ‘Medium 50’ suggests a domestic plot with a medium housing density and 50 dwellings in total).

The total numbers per phase area from this method appeared to coincide with the total number of dwellings from the phasing schedule, thus justifying the figures used.

The flat / house split for each domestic development plot with a given housing density was taken from the Land Use Phasing spreadsheet supplied to AECOM, with the following splits taken:

Housing density	Flat %	House %
Low	10%	90%
Low Medium	18%	82%
Medium	24%	76%
Medium High	27%	73%
High	32%	68%

Table 6: Flats and House Split by Housing Density Categories

The berthing split for flats and houses was then based upon the draft copy of the Folkestone and Hythe District Council Core Strategy Review 2018, which suggest the following targets (this was just taken for the berth split, and the tenure type did not affect the benchmarks used):

Housing supply will also be managed with an objective that provision should meet the following targets for new homes across the plan period:

- Owner-occupied - 55 per cent of new homes;
- Private rented - 23 per cent of new homes;
- Shared ownership - 7 per cent of new homes; and
- Social rented/affordable rent - 15 per cent of new homes.

Within these tenures the supply of homes will be managed and monitored to meet the following proportions in terms of sizes of new dwellings:

Tenure	One bed	Two bed	Three bed	Four bed +
Owner-occupied	5%	28.5%	39%	27.5%
Private rented	20%	32%	31%	17%
Shared ownership	22%	29%	28%	21%
Social rent/affordable rent	24%	16%	36%	24%

Table 5.1

Figure 6: Taken from Folkestone and Hythe District Council Core Strategy Review 2018 (Draft)

The non-domestic buildings proposed for these early phases could then be located in the non-domestic plot areas of the phase map. Whereas schools and commercial properties were indicated on the phase area map, the remaining non-domestic properties location had to be assigned to them within the phase boundary – they were positioned in what was assumed to be mix-use plots as implied on the phase area map provided.

Using the assumed annual energy demands for each property, the heat load per m^2 was calculated for each zone of the study area. An energy demand heat map was finally created within the GIS tool (ARCGIS). The outcome of this can be seen below:

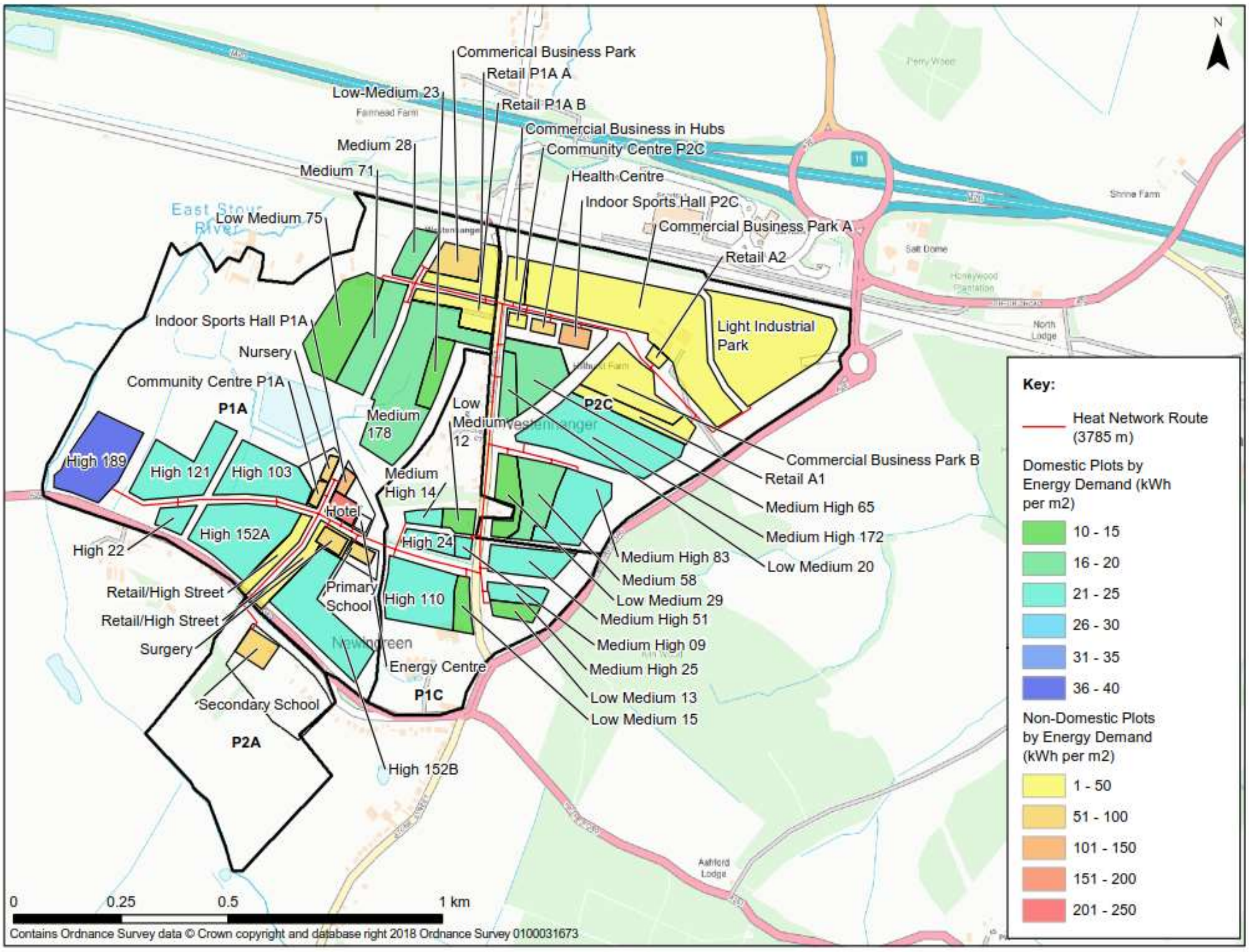


Figure 7: Heat density map

On the heat map the areas of highest heat density are shown in colours towards the blue end of the green-blue colour scale for domestic plots, and towards the red end of the yellow-red colour scale for non-domestic plots/buildings. The areas with no assumed heat load or excluded from the study coloured white.

4. Energy Distribution and Route Options

From the heat map the next step is to consider the possible district heating network options to prepare and analyse. This involves consideration of constraints to the possible schemes and opportunities that could assist them. From this thinking, potential routes for pipework to link the heat demands in the most efficient way can be drawn, allowing the techno-economic analysis to follow. This section introduces the issues involved, and leads to the proposed options and routes.

4.1 District heating network design considerations

Before considering potential network layouts, a number of factors need to be considered which may influence the heat network's layout and design. These include:

- The flow and return temperature difference
- The operating temperatures
- The choice of layout type
- The phasing of the network and future expansion
- The location of the energy centre
- Distribution of energy supply sources

These are discussed in more detail in this section, and help inform the analysis of network options.

4.1.1 Flow and return temperature difference and operating temperatures

The capacity of the network to transmit thermal energy is determined by the difference in flow and return temperatures. Modern networks typically operate with a flow of around 90°C and a return temperature of around 50°C – 60°C giving a temperature difference (a ΔT) of circa 30°C - 40°C. The ΔT determines the amount of thermal energy which can be extracted, with a larger ΔT allowing more thermal energy to be extracted for the same volume of water.

As this scheme is assumed all new build there could be options to work with a lower temperature system, for example 80/40^{o}C. This would have the benefit of reducing heat losses in the transmission network, and would help the efficiency of a heat pump option if this was taken forward. The down side to this option is that there would be a need to allow for this in the housing design, with standard radiator designs adjusted to work with the lower temperatures. The return temperature can be further lowered when domestic hot water is being generated, if the heat exchangers are designed appropriately.

All homes are assumed to have an indirect connection, which means that a heat exchanger is in place and there is hydraulic separation between the main network and the home. Using a direct connection can be more energy efficient and allow a lower return temperature. However there are also risks associated with this as damage to radiators in the home can result in a large flood of high temperature water. For this reason the current normal solution is to use an indirect solution.

In our base analysis we have assumed that the pipes are made of plastic. The overall costs are broadly similar to steel pipes, although plastic pipe can result in lower heat losses and can be quicker to install. It should be noted that plastic pipes are more vulnerable to failure over a shorter time period at high temperatures, and there can be resistance towards using them because of this. Whilst there is an 'all-in cost of installing steel pipes already estimated, an accurate cost for plastic is not – we have therefore assumed a cost for plastic at 80% that of the cost of steel for the initial analysis and then shown the effect of decreasing this further in the techno-economical assessment of the schemes.

4.1.2 Phasing and future expansion

In this study the impact of phasing is of less concern than the basic principle of whether there can be a viable scheme at all. However, in the potential delivery of a scheme the phasing is very important as the cash flow for the DH provider is critically affected by when the loads, and hence heat sales, become available. This issue will then be critical if a scheme in its best case scenario (i.e. all heat demand is immediately available) looks attractive and is taken forward to the next stage of study. Nevertheless, as previously discussed, the area of analysis was in part chosen due to it being schedules to be development within the earlier phases of the phasing schedule.

Allowing for future expansion at design stage is also important to allow the scheme to adapt to new opportunities that may arise. It can be expected that the Masterplan will evolve over time, and new opportunities may arise that are not on the agenda today. Therefore in the next stage of work it would be appropriate to consider whether the system has the capacity to allow for further expansion, for example by over-sizing distribution pipes and the energy centre. It is important to note that this brings additional initial cost, and so will only be considered if the initial analysis area is financially viable.

4.1.3 Energy centre location

Given that the Masterplan has considerable flexibility there are many potential locations for an energy centre. However the basic principle is that the best location for an energy centre is close to the largest loads, and ideally near the centre of the zone being served – for the analysis it has therefore been located in the centre of the area being analysed, near to the higher density non-domestic development and the higher density housing.

It is appreciated that if communal biomass boilers are to be used, as analysed later in this report, that the energy centre would more likely have to be located towards the edge of the development because of the associated emissions and to accommodate the logistics of delivering the large amounts of biomass fuel.

4.2 Network layout options

One key element of the analysis is to prepare a possible route for the heat network. In a developed area this generally follows existing roads, and can therefore be drawn relatively directly. There may be options to be considered where there are a number of possible routes to be taken, and work is usefully done to find the shortest route.

In this case however, the study area is only planned in outline with indicative groups of housing and non-domestic developments. To address this we have taken two steps, which are described more fully below:

1) The main ‘spine’ route has been assumed to take the shortest route to connect the planned developments.

2) The network within housing developments has been approximated based on existing layouts of modern housing developments with similar housing densities.

4.2.1 Main network spine

The aim of the network spine is to reach all of the potentially connected loads in an efficient way, whilst not impacting too greatly on the developments themselves in terms of restricting site layouts. The potential route is shown in the figure below.

As previously mentioned, the main pipe routes leading to non-domestic developments and up to the edges of but not within the domestic developments were found based on the shortest pipe routes from the energy centre location. To this end the route suggested and analysed has followed some of the indicative routes given in the Otterpool Masterplan, which allow them to reach the edge of the planned housing zones without crossing through the middle of them. Using the heat network map, three possible options were looked into, with increasing network branch lengths and lowering overall heat density.

The three options analysed were:

- Option 1: including the hotel, community centre, nursery, indoor sports hall, primary school, secondary school, and main retail high street.
- Option 2: including the high density housing in phase P1A near to Option 1.
- Option 3: including the rest of the development within this analysis area.

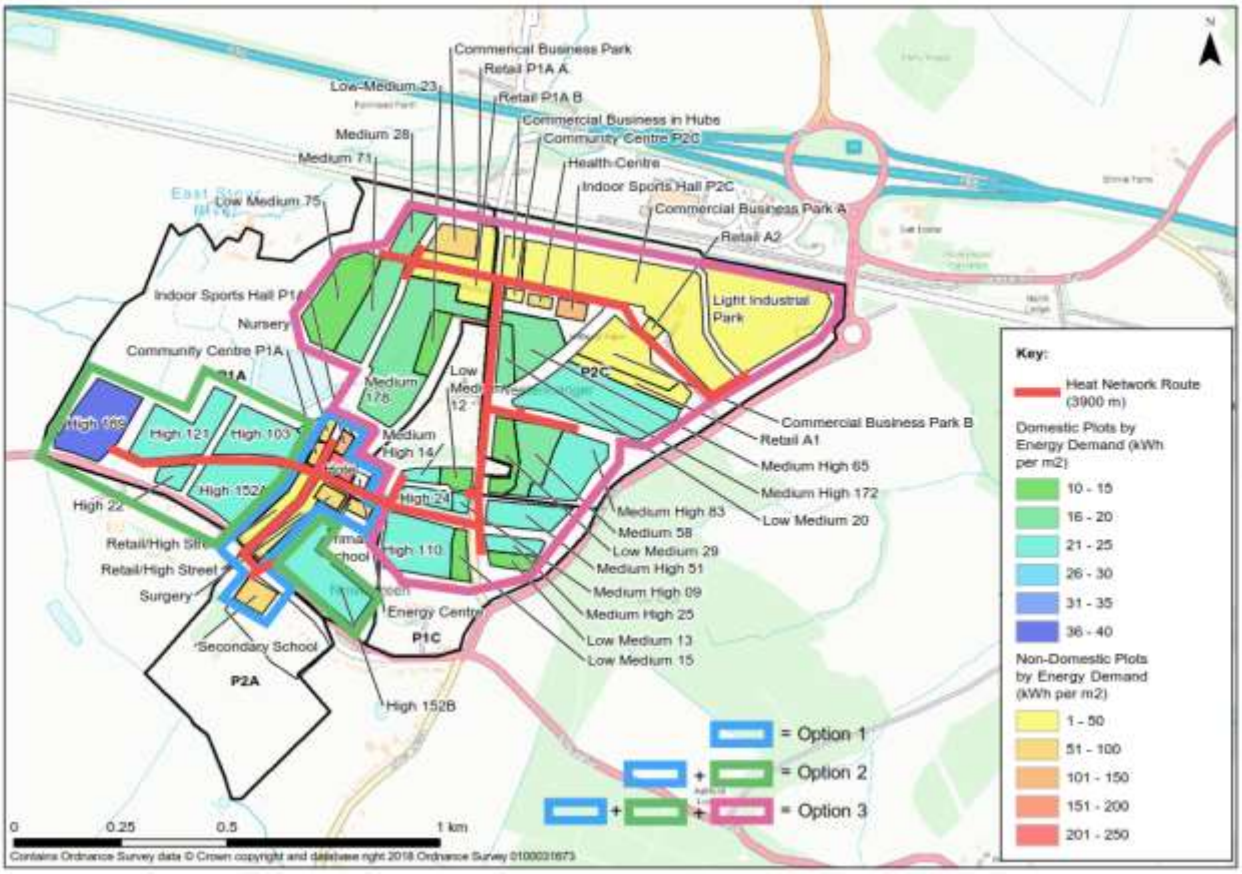


Figure 8: Potential Heat Network options for analysis

As drawn the lengths of these pipe routes are as follows:

Section of network	Main network spine (trench) length (m)
Option 1	621
Option 2	1,201
Option 3	3,900

Table 7: Main network lengths

4.2.2 Networks within housing developments

For the networks within the planned housing developments, no specific layouts were available to work from. Therefore we have used information from a range of other known site layouts in order to make reasonable estimates of the expected length of pipe networks within each that would be needed to reach the homes in a site with a given housing density.

In order to make reasonable estimates of pipe lengths within the un-planned housing developments, we examined a number of previous housing layouts from other studies. An example is given below. The green line is a possible route to link to the street for all the homes, the blue lines are the final spurs to each individual home.

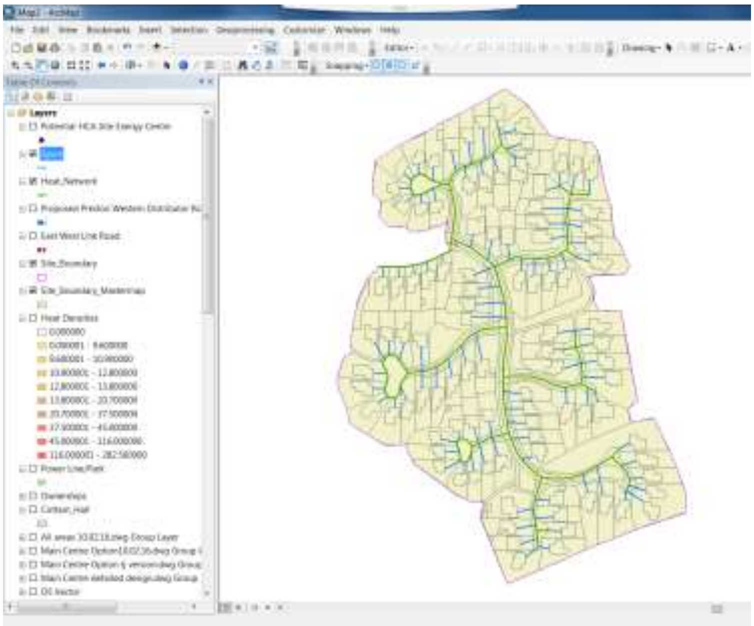


Figure 9: Example of housing development layout used for measuring network length

In this case there are 100 homes within 5.25 Hectares, making 19.05 homes/Ha. The main pipe length is given as 1065m, whilst the spurs are 1150m, making average lengths easily estimated as 10.5m and 11.5m per home. By examining a number of sites the following data were collected:

Location	Total area of site (Ha)	Number of Houses	Density	Main pipe length per home	Spur Length per home
Preston	5.25	100	19.0	10.6	11.5
Preston	7.22	124	17.2	10.3	12.4
Preston	6.5	137	21.1	9.4	13.5
Preston	6.3	138	21.9	8.1	12.3
Crowley Park. Alexander Road, Needham Market, Suffolk	4.68	120	25.6	8.1	
Peckham - terraced housing big gardens	2.5	50	20.0	14.4	
Peckham - terraced housing small gardens	1.4	85	60.7	7.4	
Average				9.8	12.4

Table 8: Data for existing developments

In these cases the areas were reduced to reflect that there are specific areas of each plot on which no homes are planned to be built, e.g. small local parks, and so the net density is higher. The main difference between the two groups of homes is that the spur lengths tend to be shorter, reflecting a move to smaller front gardens. However the typical layout for new developments has relatively long network lengths per home as the typical layouts have many curved roads.

It is also clear from the table above that these developments are delivering slightly less than 30 homes/Ha. Using a higher density will result in shorter pipe lengths, particularly when flats are included in the analysis. Based on analysing the different layouts, for the modelling work we have used the following standard lengths in generating the network lengths:

Spur length per home: **5m**
Main pipe length per home: **10m**

These values were chosen as the spur length is assumed to be lower than usual to assist in making the DHN financially viable, and this is otherwise accommodating the length of front gardens and the width of the road and pavement. As we have purposely chosen an area of high housing density, a smaller spur length is more acceptable, particularly as this is an average and there is expected to be a significant proportion (32%) of flats and apartments within the high density domestic developments.

The main pipe length is a function of the site layout and depends on the separation of homes along the street and the number of bends. Due to the lack of housing layouts for the proposed site, the average has been used in this analysis

Reviewing developments and policies more widely it is clear that although the 30 homes / Ha is typical for new sub-urban developments, in parts of the country much higher densities are being built. For example Woking Borough Council considers 25-50 to be medium density and over 50 to be high density. Increasing the density has the effect of making any development more cost effective for a heat network, particularly when it starts to include apartments.

4.2.3 Overall Network Length

Using the above methods for the main network spine and the network length within the domestic developments, the total network lengths for the 3 DHN options described previously can be seen below:

Section of network	No. of homes	Length of Main Network Spine (m)	Length of Network within Development Plot (m)	Total Network Length (m)	Heating Demand (MWh/yr)	Heat Demand per Metre (MWh/yr/m)
Option 1	0	621	301	922	1,559	1.69
Option 2	739	1,201	12,386	13,587	4,572	0.34
Option 3	1,814	3,900	30,416	34,361	11,383	0.33

Table 9: Summary of network trench length and heating demands for DHN options

4.2.4 Pipe size analysis

The difference in the flow and return temperatures (ΔT) of a heat network determines its capacity to transmit thermal energy. A larger ΔT allows for more thermal energy to be extracted from the same volume of water.

The heat network system initially assumed the following operating temperatures and flow variables:

Heat Network variable	Assumed Value
Supply Temperature °C	80
Return Temperature °C	40
Flow & Return Temperature Difference dT °C	40
Limiting max flow velocity m/s	3
Limiting pressure per meter pipe length Pa/m	250
Pipe Roughness coefficient k	0.001

Table 10: Heat Network variables assumptions

The domestic peak loads for heating were calculated using typical building dimensions and U values to meet 2018 regulations, and typical building dimensions for the different house sizes. No diversity was applied to the space heating loads. The hot water loads were diversified using the Danish Standard (DS439) to reduce the size of pipes needed to supply the peak load for instantaneous hot water supply (applied to flats up to 3 bed and houses up to 2 beds). Houses with more than 2 beds, or flats with more than 3 beds were assumed to have stored hot water.

Non-domestic properties were assumed to have a peak load based on 15% of their average load as is a typical rule of thumb.

Based on the previously explained assumptions and methods, the pipe sizes and lengths at each point of the heat network were estimated based on the heat load at each point, increasing in size as the network gets nearer the energy centre and the energy load accumulates.

The results of this are shown below for the three heat network options within the dedicated analysis area – it can be seen that the network is dominated by large amounts of the smallest diameter pipe for options 2 and 3 which include residential areas, representing the final lengths of the network connecting each home:

	Total Length at Ømm, m											
	16	*20*	*25*	*32*	*40*	*50*	*65*	*80*	*100*	*125*	*150*	*200*
Option 1	10	32	152	49	395	177	49	16	40	-	-	-
Option 2	7,385	2,082	2,121	169	282	238	376	514	227	135	57	-
Option 3	17,625	4,757	5,943	1,132	615	1,016	845	725	628	290	662	123

Table 11: Total pipe lengths for different pipe sizes of all network elements

5. Techno-economic Analysis

This section reports on the analysis of the expected financial and carbon performance of the different technology options for systems to meet the needs of the different heat network Options evaluated. Technology options are the different types of technologies which could be considered to generate through the proposed heat networks.

AECOM have developed a techno economic model of the different technology options identified, which provides analysis of the potential of the networks proposed under each technology. To analyse the network, data is added to the AECOM techno-economic model.

For each building a monthly heat demand profile was created based on the information available on the buildings existing and planned. From these and the physical layout of the site the length and size of pipes have been calculated, which also allows transmission heat losses to be estimated. This information allows the required size of heat generation plant to be chosen, to cover CHP (or other lead plant) and peak boilers. All of this information is then used to generate the expected capital cost of the whole system from the energy centre to the connections to the loads.

To assess the commercial viability of the network options, the total capital costs associated with the network and plant are combined with the costs associated with operation and maintenance, and the revenue from the sales of heat and electricity. All of these estimates are based on recent quotes from suppliers and AECOM's previous experience of delivering district heating projects. The costs are projected out from current prices for fuel and electricity, and to take account of expected maintenance and replacement costs. From all of these a wide range of outputs are derived, of which the key elements are:

- **Total capital cost**
- **Net Present Value (NPV)** – this is the yield of the investment based on the capital investment and the costs and returns over time together with the discount factor. We have reviewed the NPV for a 3.5% discount rate, based on the Governments recommendations for public sector funded projects, 6% as a mixed public sector / private funded project and a 10% discount, considered reasonable for the assessment of a private funded scheme. The NPV is a useful indicator as it shows, for any given discount factor and length of contract, how much gap funding may be required (if any) in order to make a project viable.
- **Internal Rate of Return (IRR)** – this shows the rate of return on the investment. A public sector funded project would typically look for an IRR of 6%, while a private funded project is likely to look for between 9% and 12% depending on the approach to investment.

These are based on the assumption of typical investment rates, which are typically 3.5% for public sector, and 6% and 10% for more commercial schemes. However in this project the returns are all so low that we have focussed on the 3.5% investment return level.

5.1 Technology options

The technology options considered are:

- Gas CHP (Combined heat and power)
- Biomass Communal Boilers (using local fuel supplies)

The following technology options have also been considered for a smaller domestic development of 100 homes which may be suitable for lower density housing to the West of the Otterpool Garden Town development:

- Heat Pumps: Based on
    - vertical bore holes,
    - sewer heat recovery

5.2 Counterfactual

The counterfactual for any analysis is the alternative solution assumed to be the default solution that would apply on a ‘normal’ project. In most district heating projects this is assumed to be a system based on a gas boiler in each home, with electricity from the grid. However in this case there is not yet gas on site, and there would be a significant cost to bring gas to the site and build out a gas network. The cost of this gas network needs to be considered as part of the analysis.

Given that the drive for low carbon in the UK means that we will need to move away from the use of fossils-sourced gas, it may be better to consider an individual ASHP as the base case for analysis for a home in the 2020s.

One consideration in deciding what the counterfactual might be in the future for the Otterpool site is the cost of providing the necessary utilities to the site. Initial investigations by Arcadis have indicated that the provision of gas for the full development would cost in the order of £8M and that providing the electrical load for the site is below 60 MVA then the cost of providing electricity to the development would be in the order of £8.5M. However, if the electrical demand for the site were to exceed the 60 MVA limit then a new supply would need to be provided at an additional cost in the order of £25M. In determining what the counterfactual would be it is therefore necessary to have a level of confidence that the site can be provisioned within the 60 MVA limit even when each dwelling is electrically heated. If not then the additional cost is likely to make it uneconomic to electrically heat the homes.

Based on rules of thumb a development of the size of Otterpool might be expected to require a supply of around 25 MVA assuming that gas is the main heating fuel for the development. This is based on an allowance of 0.5 kW per dwelling. If all the dwellings were electrically heated then a conservative allowance of 3 kW per dwelling could be applied suggesting that the site would require 50 MVA. This is close to the 60 MVA limit but still has sufficient spare capacity to give a level of confidence that electrical heating of dwellings is a reasonable possibility.

In other locations it is normal to use individual gas boilers as the counterfactual case for a heat network, as this is the most common solution adopted in the UK. However at this site there may not be any gas provided, and therefore an alternative counterfactual of individual ASHP’s has been considered. The analysis has been completed with both options: i.e. a gas boiler in each home with a typical gas network; and individual electric air source heat pump providing space heating and a proportion of the hot water, with direct electrical top up of the hot water to 60^{o}C.

5.3 Gas CHP

5.3.1 Individual gas boilers counterfactual

The table below shows the results from the economic and carbon analysis for the 3 different heat network route options. It can be seen that all 3 networks show a poor economic output. This can attributed to several key reasons including the high capital cost of the network, the amount of heat loss within the distribution of the network and the low income from electrical sales.

Due to the nature of the development, there is initially assumed to be no customers for the electricity produced by the CHP that could be supplied over a private wire. A low average figure of 5p/kWh revenue has therefore been used for the electricity produced.

The heat losses within the network also contribute to a poor carbon output, as carbon usage is wasted as losses compared to a traditional gas heating where the losses are much lower due to the heat being produced at the property. The poor outcome in terms of carbon can also be attributed to the falling grid carbon factor which is occurring due the ongoing decarbonisation of the grid. This means that any savings from the CHP in the early years reduces (to below zero in the case of options and 3) compared to using individual gas boilers for heating and grid electricity.

The schemes were not modelled at shorter life cycles (i.e. 25 and 30 years) or with higher discount rates (i.e. 6%, 9% and 12%) as this would only serve to make the results worse.

Gas CHP heat network with gas network Counterfactual		**Option 1: P1A Core High Street + P2A Secondary School**	**Option 2: P1A Core + P2A Secondary School + P1A High Density Housing**	**Option 3: P1A + P2A Secondary School + P1C + P2C**
Capital cost	£m	1.99	11.38	27.65
Total pipe length	m	922	13,587	34,361
Total network capacity (boilers capacity)	kW	1,204	3,926	9,820
CHP heat capacity	kW	362	1,316	3,147
CHP electrical capacity	kWe	220	980	2,707
Annual heat demand (ex. Distribution losses)	MWh	1,559	4,572	11,383
CHP proportion of heat delivered	%	75%	77%	75%
40 year life cycle analysis				
IRR (0% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-1.55**	**-9.96**	**-22.72**
IRR (30% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-0.96**	**-6.54**	**-14.42**
Average lifecycle annual carbon saving	T CO_2	**89**	**-11,946**	**-18,986**
Average carbon saving over first 15 years	T CO_2	**157**	**-3,938**	**-5,381**

Table 12: Results for gas CHP heat network vs gas boiler counterfactual

<u>Sensitivity Analysis</u>

In the model, each key input can be varied by a factor (percentage) chosen by the user. These factors are added to the parameter chosen, for example the sale price of electricity generated within the CHP. This was run for a range of percentage changes, to ascertain which factors the viability of the scheme is most dependent on.

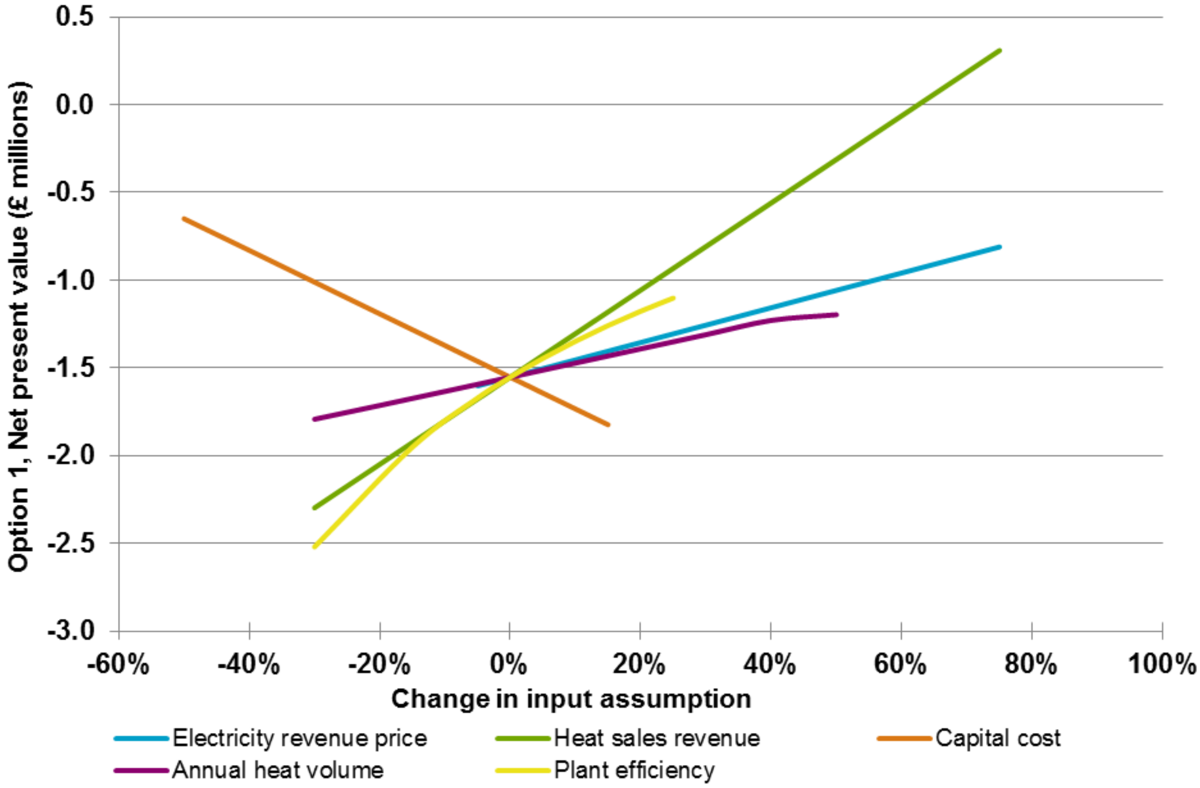


Figure 10: Sensitivity analysis for HN option 1 - gas CHP vs gas boiler counterfactual

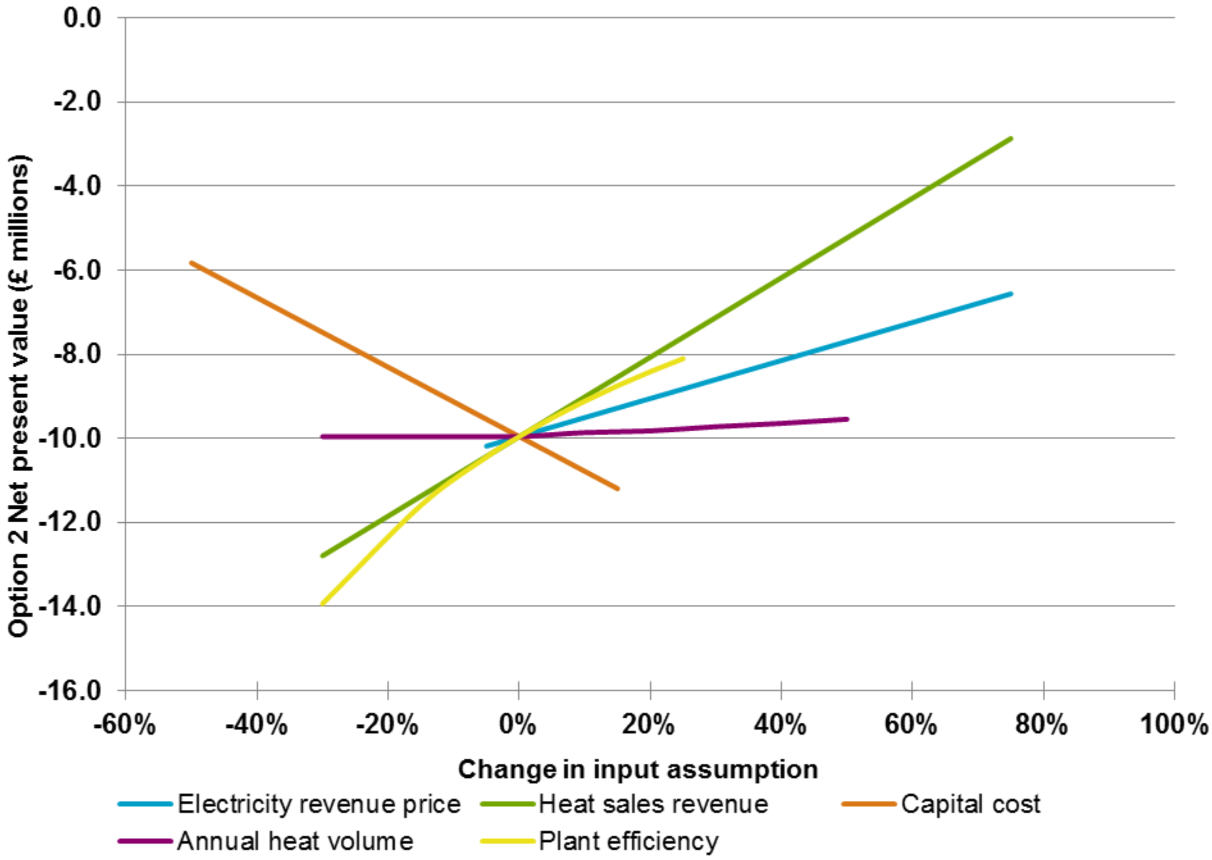


Figure 11: Sensitivity analysis for HN option 2 - gas CHP vs gas boiler counterfactual

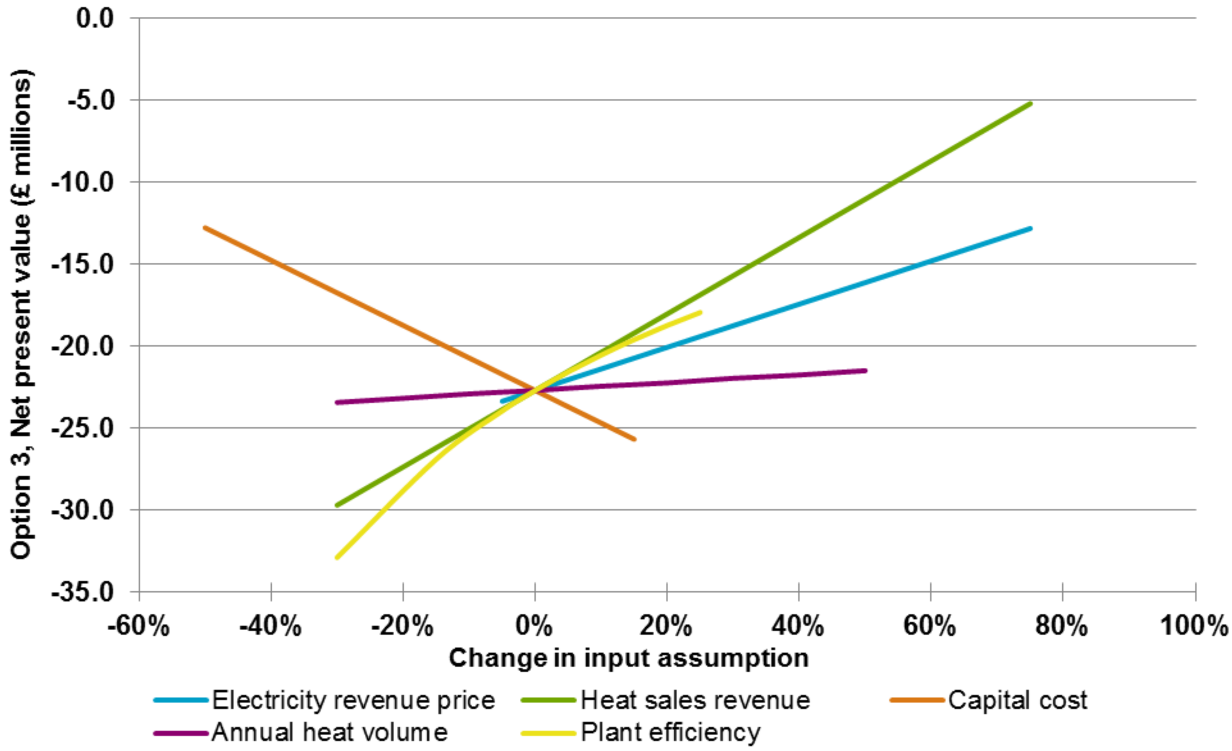


Figure 12: Sensitivity analysis for HN option 3 - gas CHP vs gas boiler counterfactual

It can be seen from the above sensitivity analysis that none of the three network options reaches a positive NPV under any reasonable changes to the key inputs. The magnitude that the sensitivity analysis suggests would be required of each of these factors means that they are extremely unlikely, without a much higher heat load density and a much smaller network length – based on the phase area maps and load schedules provided to AECOM, this will not likely be the case.

A further assessment was undertaken to see what impact reducing the district heating pipework costs and increasing the electrical sale price could have on the financial results. The cost of plastic pipes is, as mentioned previously, relatively unsure. The initial analysis assumed the cost of plastic pipes was 80% of the all in cost for steel pipes. This additional analysis has considered the impact of pipework costs that are 50% those of steel pipe. The electricity sale price would also need to increase significantly, and a private wire customer become available to buy the generated electricity at a premium price. Whilst such a customer is not known to currently exist at such an early stage of the development, a higher sale price of 12p/kWh (rather than 5p/kWh) has been modelled, independently and combined with a plastic pipe cost at 50% that of the all in steel pipe cost. The results of this additional assessment are given in Table 13.

Gas CHP heat network with gas network Counterfactual – Theoretical Improvements		Option 1: P1A Core High Street + P2A Secondary School	Option 2: P1A Core + P2A Secondary School + P1A High Density Housing	Option 3: P1A + P2A Secondary School + P1C + P2C
40 year life cycle analysis				
IRR – Higher Electrical Sale Price	%	**2.78%**	**-**	**1.80%**
NPV – Higher Electrical Sale Price	£m	**-0.17**	**-3.62**	**-4.28**
IRR – Lower Pipe Cost	%	**-**	**-**	**-**
NPV – Lower Pipe Cost	£m	**-1.45**	**-8.66**	**-19.38**
IRR – Higher Elec. Sale and lower pipe price	%	**3.23%**	**0.69%**	**3.08%**
NPV – Higher Elec. Sale and lower pipe price	£m	**-0.06**	**-2.33**	**-0.94**

Table 13: Results for gas CHP heat network vs gas boiler counterfactual with improved inputs

It can be seen from the results that the much increased value of electricity sales are critical to make the CHP option closer to viable, as a significant revenue is needed to overcome the high capital costs. However, even with this and a reduced pipe cost, these schemes would still not appear to be economically attractive.

5.3.2 ASHP Counterfactual

When comparing the same gas CHP schemes to the ASHP counterfactual, the results portray a better IRR, due to the higher costs of electricity for running the ASHP compared to gas for the CHP and backup boilers. However these are still not economically attractive due to much of the same reasons as for the gas CHP against the individual gas boiler counterfactual.

The NPV's against ASHP's are worse than for individual gas boilers on the 40 year life cycles, which will largely be due to the savings the ASHP solution gains from not needing to have a gas network. This removes the large initial cost to bring gas to site (estimated at £8 million by Arcadis). This cost should however not all be attributed to a scheme that only represents a small proportion of the site. What amount should be attributed is unclear, as whilst some gas is clearly needed, the proportion of the £8m price is not easy to allocate considering the cost would not be linear to the size of the scheme. This cost is included in the subsequent sensitivity analysis, by looking at a reduction in capital cost (which this extra cost to bring gas to site is included in – note the capital cost of the scheme in the table below does not include this cost as it is not part of the heat network).

The results also show a very poor (negative) carbon saving, due to the much lower carbon factors from the electricity required to run the ASHP's with a higher working efficiency to deliver the heat, compared to the gas CHP and gas boiler back up. This is shown by the decreasing carbon savings with increasing network capacity.

The schemes were not modelled at shorter life cycles or with higher discount rates as this would only serve to make the results worse.

Gas CHP heat network with ASHP Counterfactual		**Option 1: P1A Core High Street + P2A Secondary School**	**Option 2: P1A Core + P2A Secondary School + P1A High Density Housing**	**Option 3: P1A + P2A Secondary School + P1C + P2C**
Capital cost	£m	1.99	11.38	27.65
Total pipe length	m	922	13,587	34,361
Total network capacity (boilers capacity)	kW	1,204	3,926	9,820
CHP heat capacity	kW	362	1,316	3,147
CHP electrical capacity	kWe	220	980	2,707
Annual heat demand (ex. Distribution losses)	MWh	1,559	4,572	11,383
CHP proportion of heat delivered	%	75%	77%	75%
40 year life cycle analysis				
IRR (0% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-8.09**	**-13.21**	**-18.69**
IRR (30% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-7.50**	**-9.80**	**-10.39**
Average lifecycle annual carbon saving	T CO_2	**-10,954**	**-43,710**	**-97,751**
Average carbon saving over first 15 years	T CO_2	**-2,186**	**-14,710**	**-31,978**

Table 14: Results for gas CHP heat network vs ASHP counterfactual

Sensitivity Analysis

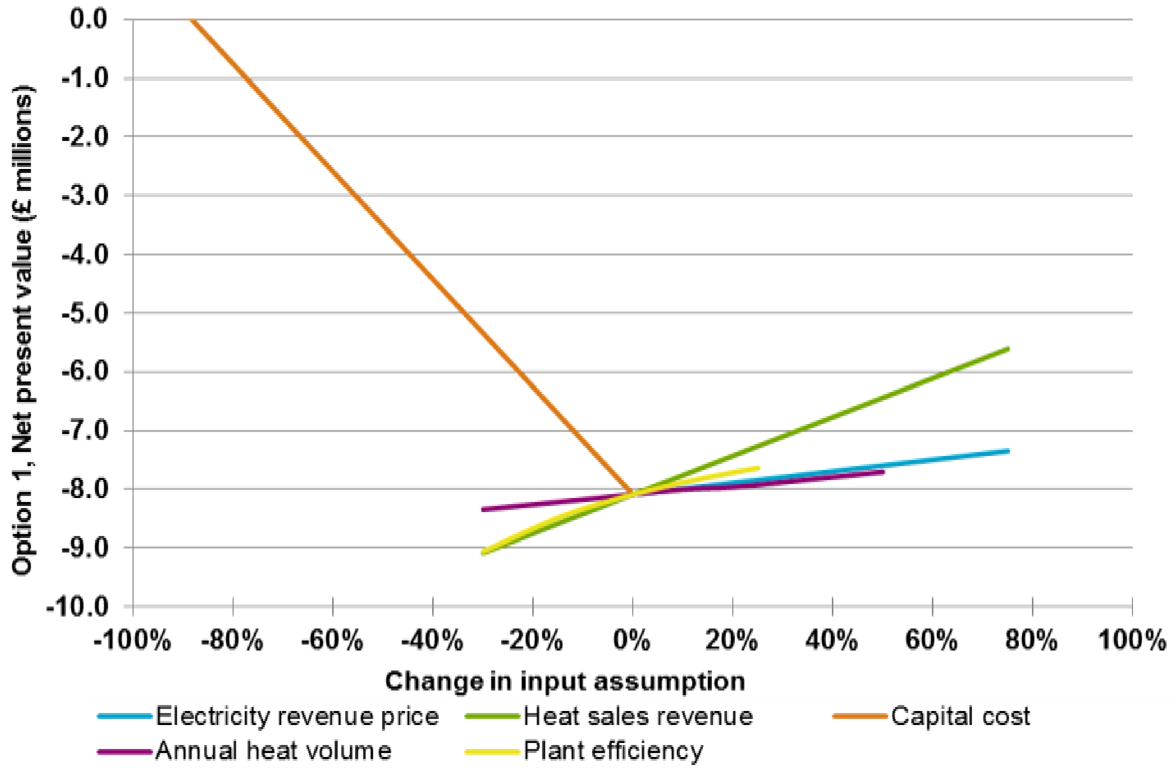


Figure 13: Sensitivity analysis for HN option 1 - gas CHP vs ASHP counterfactual

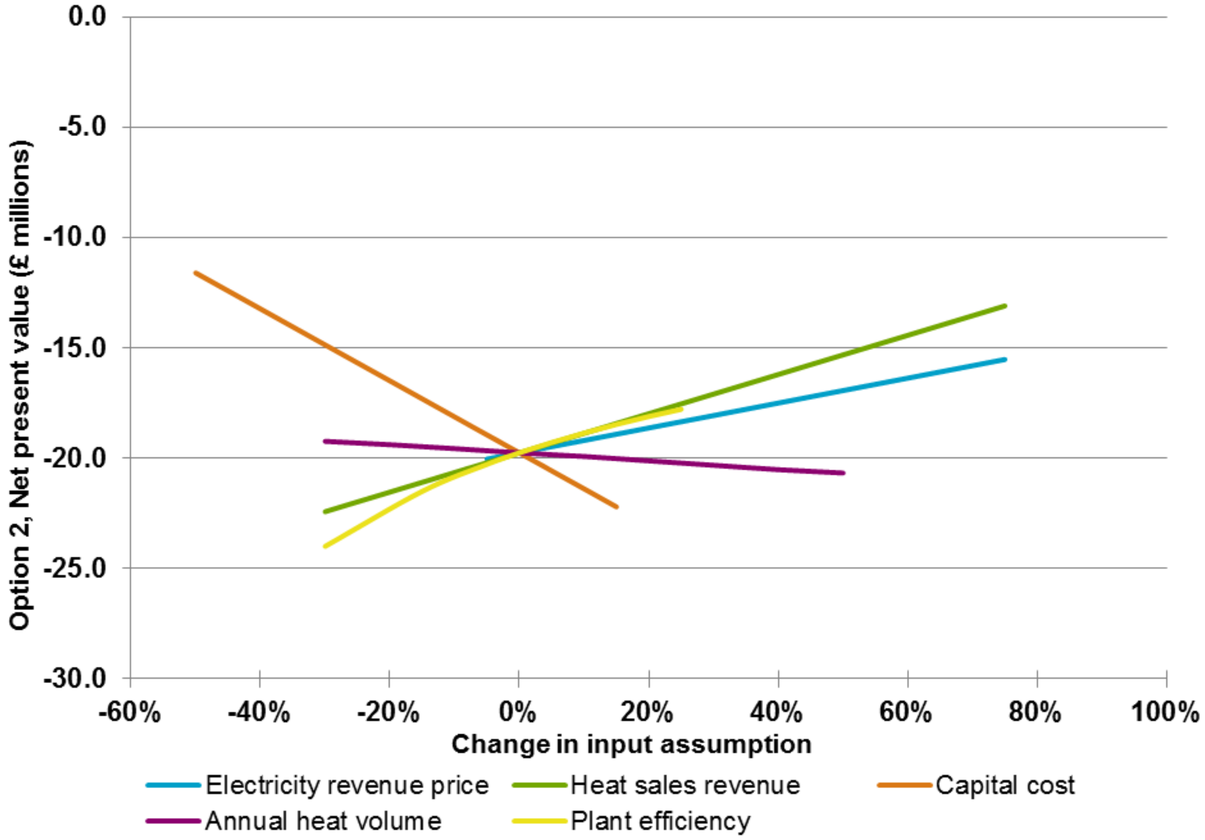


Figure 14: Sensitivity analysis for HN option 2 - gas CHP vs ASHP counterfactual

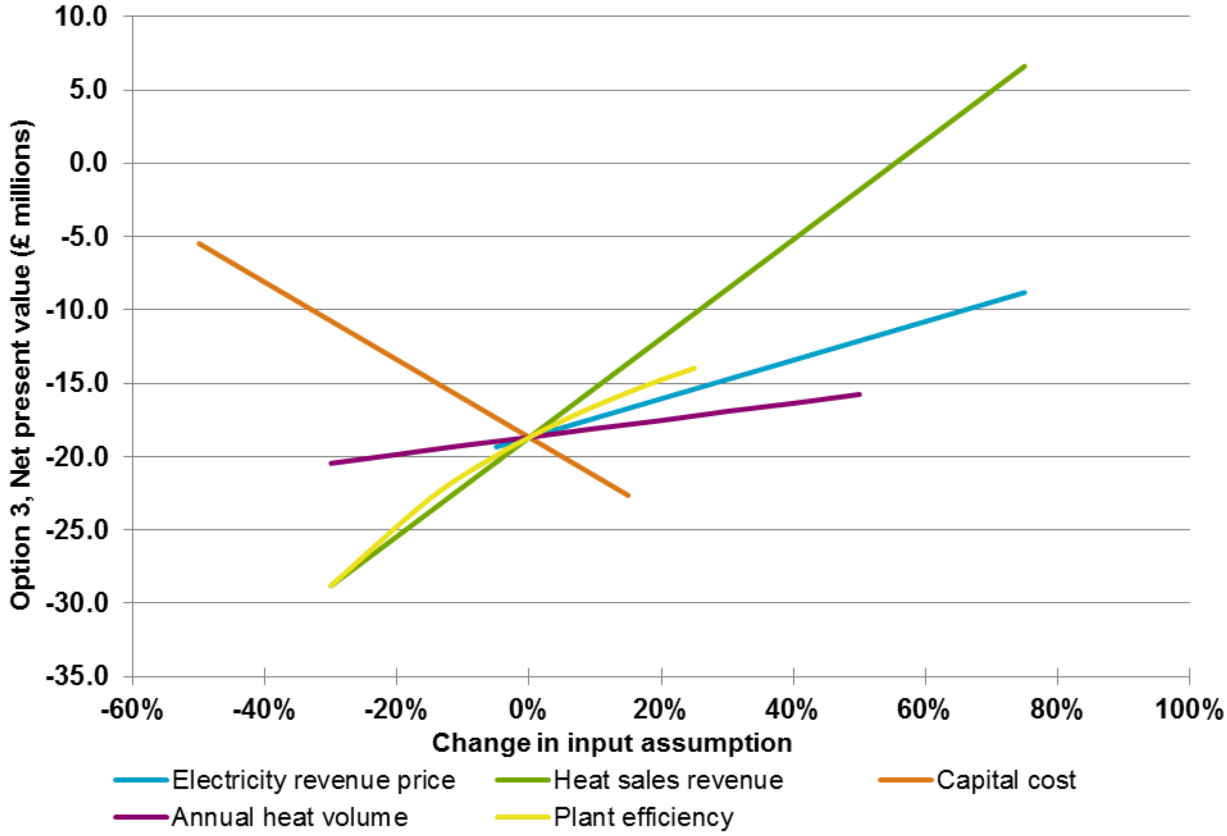


Figure 15: Sensitivity analysis for HN option 3 - gas CHP vs ASHP counterfactual

For each of the three heat network options 1 to 3, the £8m cost (included in the capital cost for the sensitivity analysis) represents 87%, 51% and 30% of the capital cost respectively. Following the line representing the change in capital cost for each scheme, it can be seen that none of the schemes reach a positive NPV over 40 years, but option 1 does nearly break even if we do not take into account any of this cost for bringing gas to site.

Once again an increase in heat sale revenue, decrease in capital cost and a much increased electricity sale price would be required to make any of the three schemes financially attractive. This has again been analysed further with the same pipe cost reductions and electricity sale price increase as for the individual gas boiler counterfactual:

Gas CHP heat network with ASHP Counterfactual – Theoretical Improvements		Option 1: P1A Core High Street + P2A Secondary School	Option 2: P1A Core + P2A Secondary School + P1A High Density Housing	Option 3: P1A + P2A Secondary School + P1C + P2C
40 year life cycle analysis				
IRR – Higher Electrical Sale Price	%	-	-	3.43%
NPV – Higher Electrical Sale Price	£m	-6.71	-6.88	-0.25
IRR – Lower Pipe Cost	%		-	-
NPV – Lower Pipe Cost	£m	-7.99	-11.92	-15.35
IRR – Higher Elec. Sale and lower pipe price	%	-	0.37%	4.42%
NPV – Higher Elec. Sale and lower pipe price	£m	-6.60	-5.58	3.09

Table 15: Results for gas CHP heat network vs ASHP counterfactual with improved inputs

The higher electricity sale price has significantly improved the economic output of the modelled schemes. Clearly with the bigger scheme and therefore bigger CHP and electricity production, there are greater benefits to this. However gaining such a price for all the electricity produced is unlikely, and even with this combined with the improved pipe costs, the IRR is still lower than the benchmark of what would be considered attractive to investors – i.e. at least 6%.

5.4 Biomass boiler

5.4.1 Individual gas boilers counterfactual

When the low carbon heat technology is a biomass boiler the results continue to be poor, but marginally better than the gas CHP schemes. This is because despite assumed benefit from the RHI the biomass boilers do not have the benefit of generating and selling electricity as is part of a CHP solution. In addition biomass fuel is typically no cheaper than gas. Therefore the benefits of the biomass boiler compared to the gas CHP is almost cancelled out by these disadvantages. Biomass CHP is a high cost option that is currently not commercially available at the scale of this development, and so has not been included at this stage. The calculations below include the renewable heat incentive (RHI) payments based on current rates set by Ofgem at:

- Tier 1: 3.05p/kWh (for the first 1,314 hours of the biomass boilers rated load)
- Tier 2: 2.14p/kWh for all heat produced over the tier 1 limit.

The carbon saving is improved because of the low carbon nature of the fuel. There is a significant carbon saving against the baseline, even when the share of heat from biomass is 50%.

The schemes were not modelled at shorter life cycles or higher discount rates as this would only serve to make the results worse.

Biomass heat network with gas network counterfactual (RHI tariffs incl.)		**Option 1: P1A Core High Street + P2A Secondary School**	**Option 2: P1A Core + P2A Secondary School + P1A High Density Housing**	**Option 3: P1A + P2A Secondary School + P1C + P2C**
Capital cost	£m	1.87	10.89	26.04
Total pipe length	m	922	13,587	34,316
Total network capacity (boilers capacity)	kW	1,204	3,926	9,820
Biomass heat capacity	kW	200	600	1,600
Annual heat demand (ex. Distribution losses)	MWh	1,559	4,572	11,383
Biomass proportion of heat delivered	%	53%	51%	52%
40 year life cycle analysis				
IRR (0% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-1.18**	**-8.45**	**-22.12**
IRR (30% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-0.62**	**-5.19**	**-14.3**
Average lifecycle annual carbon saving	T CO_2	**4,398**	**5,587**	**14,473**
Average carbon saving over first 15 years	T CO_2	**1,661**	**2,113**	**5,474**

Table 16: Results for biomass boilers heat network vs gas boiler counterfactual

Sensitivity Analysis

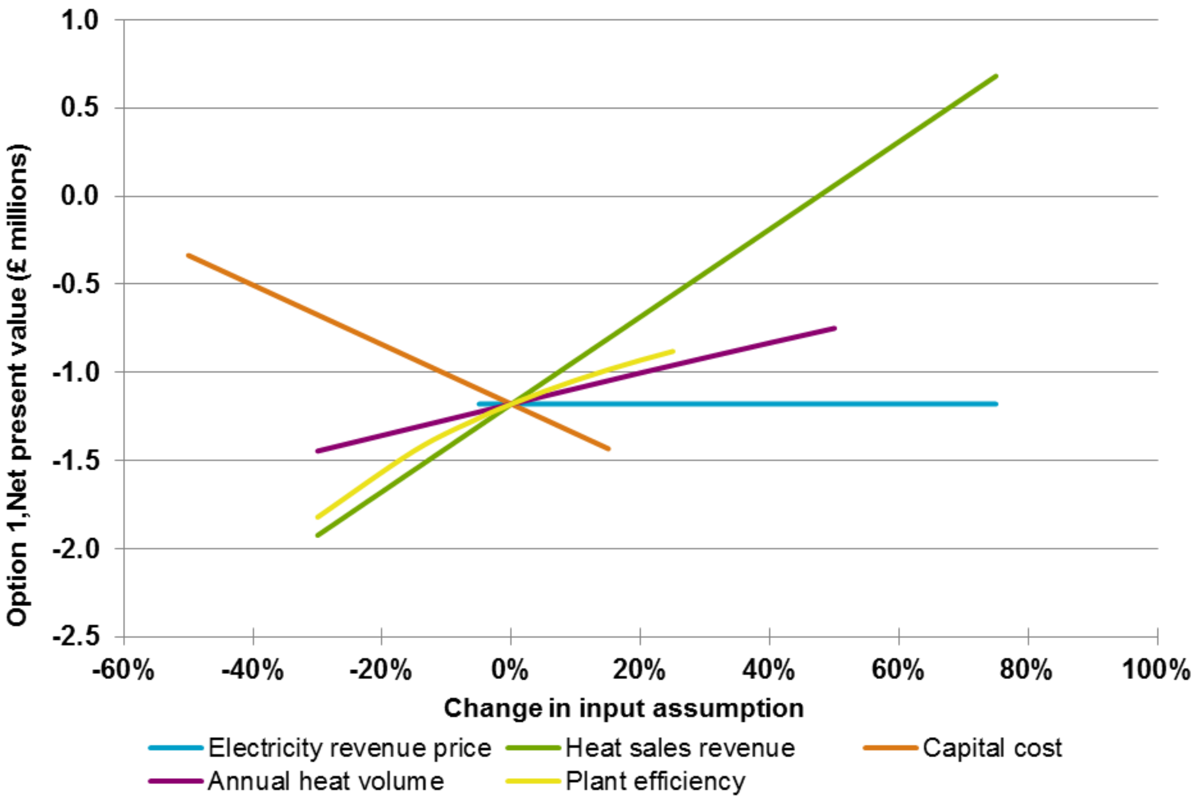


Figure 16: Sensitivity analysis for HN option 1 - biomass boiler vs gas boiler counterfactual

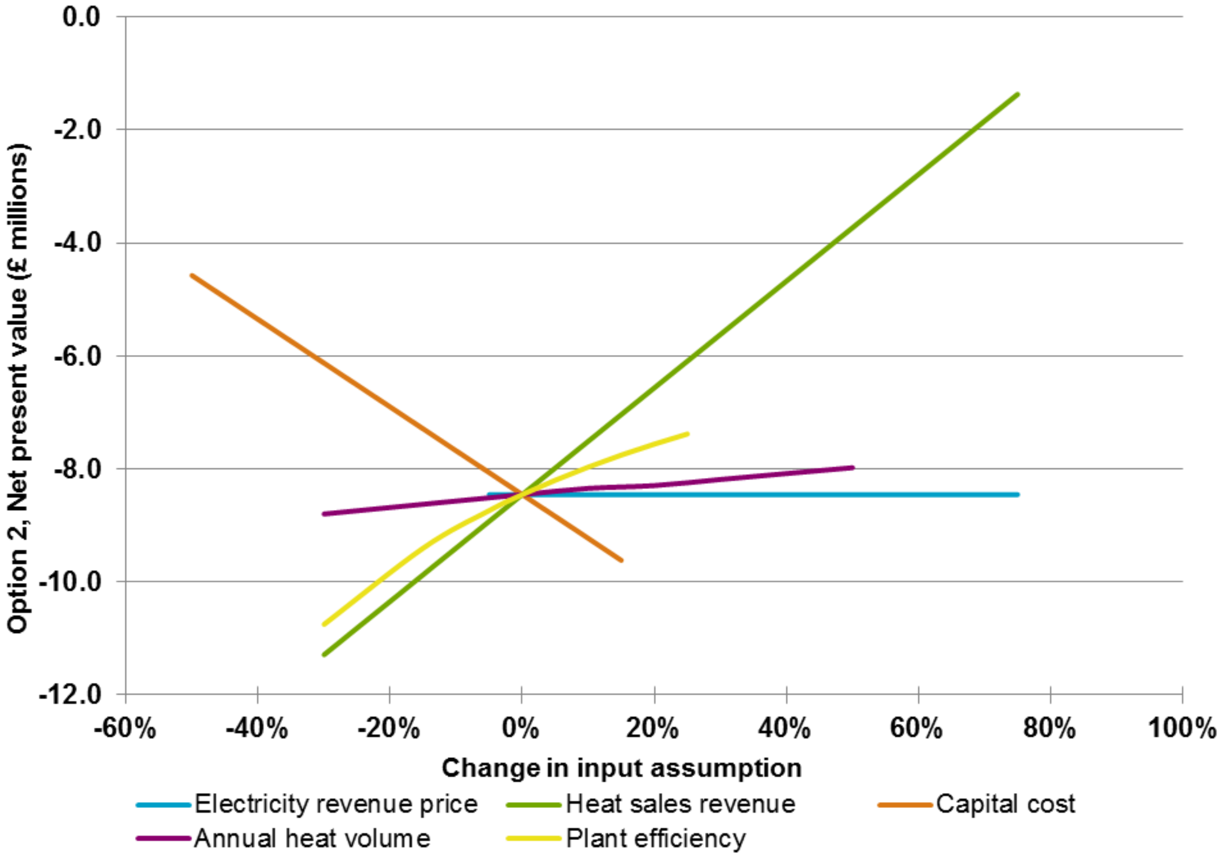


Figure 17: Sensitivity analysis for HN option 2 - biomass boiler vs gas boiler counterfactual

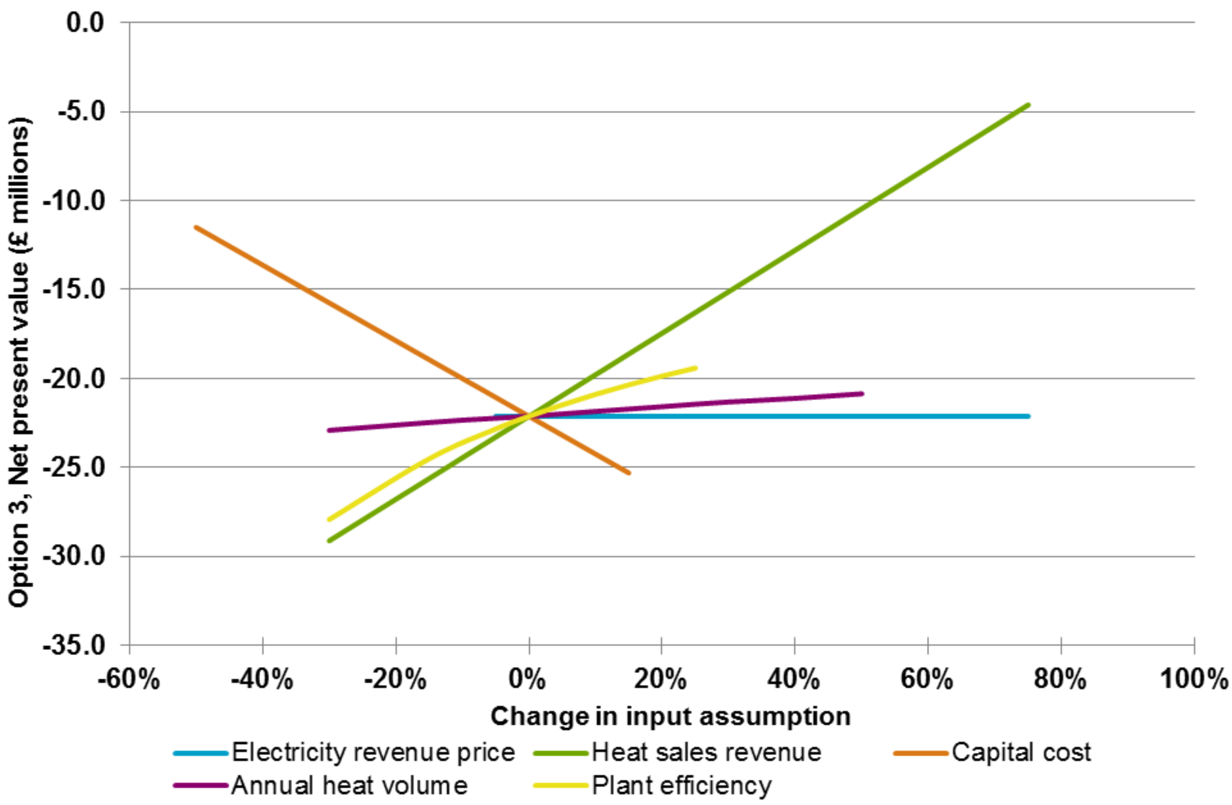


Figure 18: Sensitivity analysis for HN option 3 - biomass boiler vs gas boiler counterfactual

Like the gas CHP sensitivity analysis, the biomass boiler scheme would require a significant increase in heat sales and a significant unrealistic reduction in capital costs to reach a positive NPV. However it does not have the possibility of higher electricity sales to benefit from. Because of this there are limited options to make the scheme viable (particularly as we have seen from the previous analysis that reducing the cost of pipes does not have a big enough impact alone), and the biomass option is not recommended to be taken forward.

5.4.2 ASHP counterfactual

As with the gas CHP heat network against the ASHP counterfactual, the biomass communal boiler heat network produce a worse NPV than against a gas boiler counterfactual. This is again due to the requirement of gas for the back-up boilers alone, accounting for a high initial cost in bringing gas to the site; whilst the high cost of electricity means the rate of return is slightly improved compared to against gas boilers.

There is a negative carbon impact also, due to the higher gas carbon factors used for the gas boilers (which produce just under half the heat demands) and the high efficiency attributed to heat pumps.

Once again the schemes were not modelled at a higher discount rate as this would only serve to make the results worse.

Biomass heat network with ASHP counterfactual (RHI tariffs incl.)		**Option 1: P1A Core High Street + P2A Secondary School**	**Option 2: P1A Core + P2A Secondary School + P1A High Density Housing**	**Option 3: P1A + P2A Secondary School + P1C + P2C**
Capital cost	£m	1.87	10.89	26.04
Total pipe length	m	922	13,587	34,316
Total network capacity (boilers capacity)	kW	1,204	3,926	9,820
Biomass heat capacity	kW	200	600	1,600
Annual heat demand (ex. Distribution losses)	MWh	1,559	4,572	11,383
Biomass proportion of heat delivered	%	53%	51%	52%
40 year life cycle analysis				
IRR (0% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-9.28**	**-16.24**	**-15.30**
IRR (30% Grant)	%	**-**	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-8.72**	**-12.97**	**-7.48**
Average lifecycle annual carbon saving	T CO_2	**-6,611**	**-26,176**	**-64,629**
Average carbon saving over first 15 years	T CO_2	**-1,241**	**-8,660**	**-21,351**

Table 17: Results for biomass boilers heat network vs ASHP counterfactual

As when comparing the CHP schemes to the ASHP counterfactual, this initial analysis assumes the full £8m to bring gas to site has been accounted for in the cost of the biomass scheme compared to the ASHP's. Once again, how much of this cost should be attributed to the scheme is unclear and therefore the sensitivity analysis is used to see what effect this would have on the NPV. In the sensitivity analysis the £8m accounts for 88%, 53% and 32% for heat network options 1 to 3 respectively, and therefore we can use the line representing capital cost to see what effect reducing the capital cost by the percentages stated has on the NPV of the scheme after 40 years.

Sensitivity Analysis

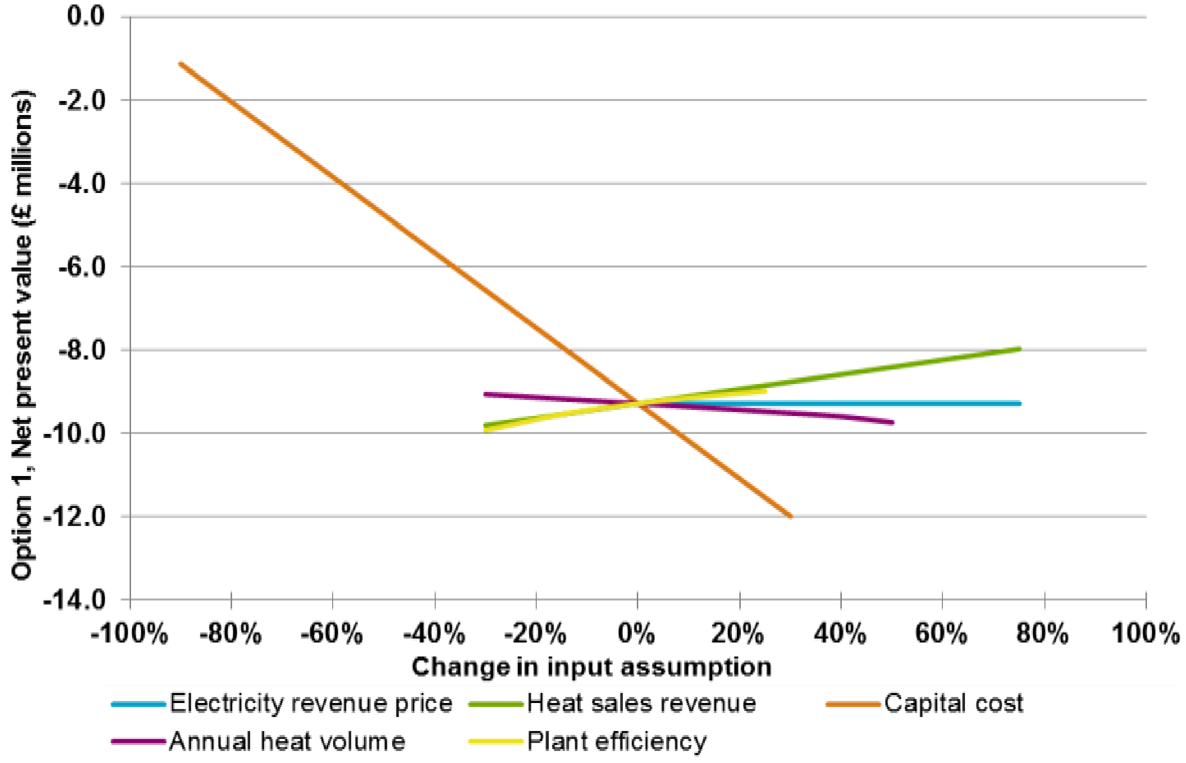


Figure 19: Sensitivity analysis for HN option 1 - biomass boiler vs ASHP counterfactual

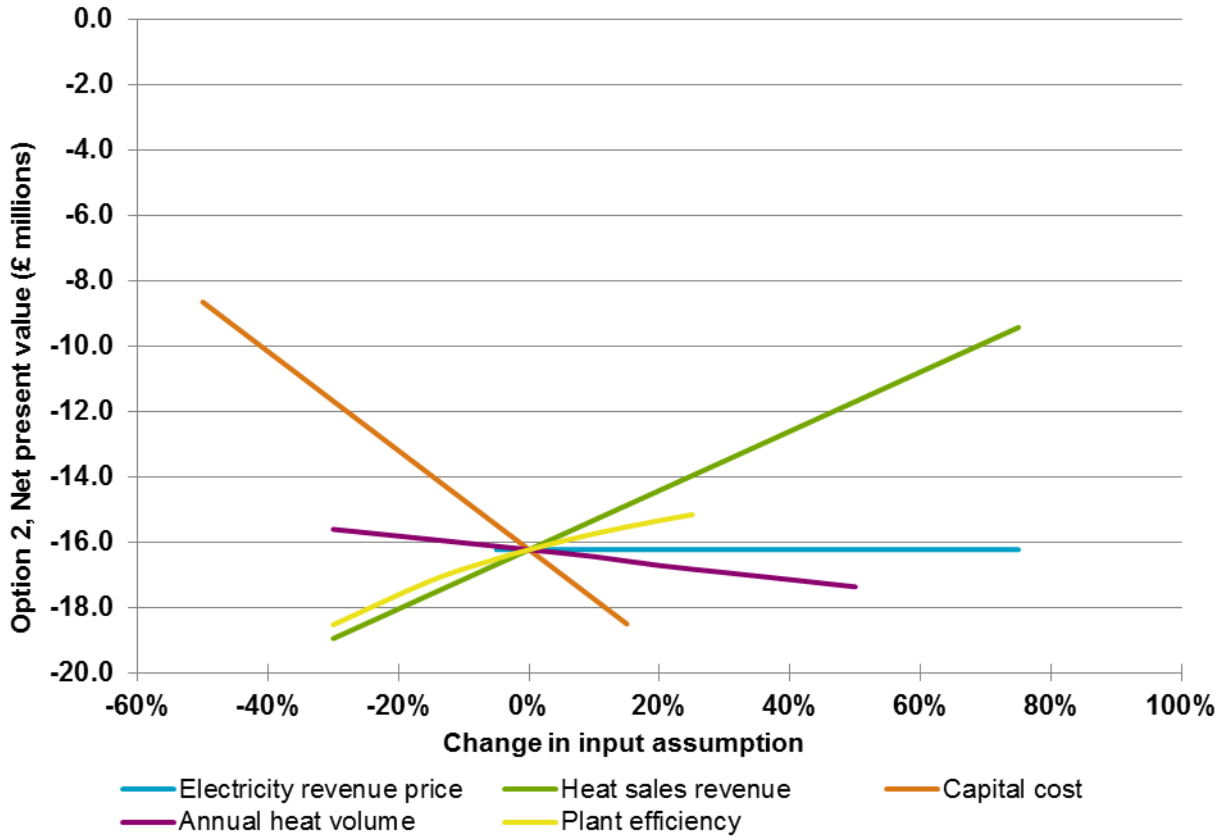


Figure 20: Sensitivity analysis for HN option 2 - biomass boiler vs ASHP counterfactual

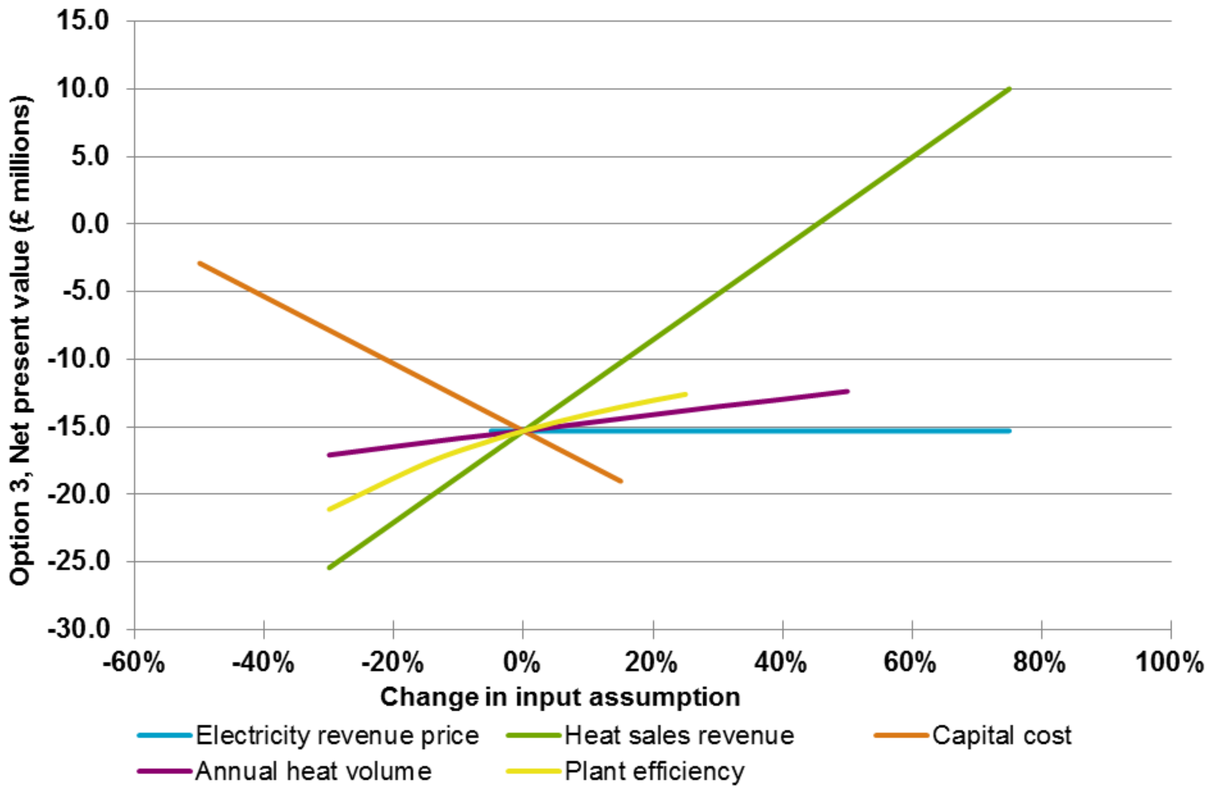


Figure 21: Sensitivity analysis for HN option 3 - biomass boiler vs ASHP counterfactual

Due to the poor economic outlook, it can be seen that the scale of improvements required to make these schemes economically viable would not be realistic. This includes discounting the cost to bring gas to site, with none of the schemes breaking even over the 40 year lifecycle even when the capital cost does not include this cost.

5.5 Comparison with other schemes

The load per metre of heat network is a key metric that affects the cost effectiveness of any scheme. Clearly the longer the network the more it will cost, and the load that it carries is the key input to the income that a network can earn. In the Otterpool case the cost per metre of delivering the network is relatively low, as the expectation is that it would be built in soft ground before the roads are built, and the pipe diameters are small. However this is not enough to overcome the very low load per metre that is found in this study. AECOM have worked on a number of other district heating schemes, including through HNDU studies in other cities. The table below lists some examples of schemes that returned a positive IRR against the three Otterpool networks.

Scheme	Total length m	Total load MWh	Load per m MWh/m
Otterpool (HN Option 1)	922	1,559	1.70
Otterpool (HN Option 2)	13,587	4,572	0.34
Otterpool (HN Option 3)	34,361	11,383	0.33
Southend High Street Cluster	2,800	23,500	8.39
Southend Victoria Avenue Cluster	1,600	10,800	6.75
Tottenham Scheme	2,100	23,900	11.38

Table 18: Comparison of heat load per metre of heat network for Otterpool and other schemes

This supports the findings of the study that it would take a very large increase in heat demand density (i.e. a higher heat demand in a smaller area) to make this scheme viable, particularly when connecting developments that are very spread out such as in options 2 and 3.

5.6 Heat pump options

All heat pumps operate in the same way, in that they use electricity to drive an evaporation / condenser cycle to move heat from one side of the system to another. They are in basic operation identical to a chiller that provides cooling in a building or a fridge. They differ in terms of the way in which they are used. When a heat pump is used only for heating they require a heat source. This can be from the air, the ground, water, sewers or other waste heat. Heat pumps are often referred to by the source of energy that they use.

For this study heat pumps have been considered to heat a smaller heat network than for the main part of the study. There are no obvious water sources (i.e. river or lake) and no advantage can be seen for connecting air source heat pumps into a network over their use in individual buildings, as for the counterfactual. Therefore the solutions considered were:

- Ground source through close loop boreholes, and
- Sewer heat recovery.

Although in principle the whole site could be served by heat pumps it would be likely in practice, if this option was pursued, to deliver it through a series of separate smaller networks. This is because unlike with CHP, heat pumps do not benefit significantly from economies of scale in either efficiency or cost. For this reason the analysis presented here has focussed on the planned lower density housing area to the west of the whole Otterpool site as an example of where it could be implemented, and also near to where the sewer flows are more concentrated.

5.6.1 Ground Source Option

A GSHP system uses the same basic type of heat pumps as an ASHP, but it is connected to one of two main types of system to collect heat from the ground:

- Open loop, or
- Closed loop.

In an open loop system a borehole is drilled down to reach a large body of water (aquifer), and water is then pumped up to the surface and heat extracted by the heat pump. The cooled water is then re-injected into the ground through a second borehole at sufficient distance from the first to avoid a 'short-circuit' with the same water being made colder and colder.

In a closed loop system a number of boreholes are drilled and pipes are inserted into them. A fluid is passed through these to extract warmth from the ground, and this fluid is used to warm the cold side of the heat pump. There is no direct contact with ground water. A typical borehole can recover around 5 to 7 kW depending on the ground conditions and depth of borehole. The pipes to these boreholes need to be linked together to allow all of the useful heat to be brought to the energy centre where the heat pump(s) are located. Boreholes are typically spaced at least 6m apart from centre to centre of boreholes to avoid thermal linkage and loss of efficiency.

The main benefit of an open loop system is that when there is good availability of water, it can be more cost effective than a closed loop system, particularly at larger scales. There are risks however in the availability of water, and in gaining permissions for its extraction due to the small risk of contamination of ground water.

Closed loop systems have the benefit of not having the same requirement for permissions, and they don't require the availability of ground water. The disadvantage is that a relatively large area needs to be available for the boreholes as there is a limit to the heat that can be extracted from a single borehole, and this is much less than can be achieved from groundwater in an open loop system.

GSHP for Otterpool

An open loop system requires the availability of ground water which has not been thoroughly analysed (though it is not thought there is a large source of ground water in the area).

A closed loop system requires enough free land for the boreholes to be drilled and connected to a network. As previously mentioned, no housing layouts have been provided for the Otterpool development. In order to gauge how much space within gardens could be available for (communal or private) a typical housing layout has been used as seen below:

From this typical layout for a lower density housing development, as is expected in the western areas of the Otterpool site, there is approximately 135m^2 of garden per home, which is enough for at least one borehole (i.e. 5-7kW) per a home – sufficient to meet the majority of the heating load for a home. There is also communal parkland available as an alternative (although the proximity of this free land to the 'average home' is difficult to establish and therefore the land for each shared GSHP would have to be established on a case by case basis). It is expected that there is the required land space for a closed loop GSHP to be technically possible due to the nature of a 'garden' town.

Figure 22: Example Housing Layout and Garden Sizes (ha)

In order to compare the feasibility of a shared Ground Source Heat Pump network, it has been compared to the two original counterfactual options (individual gas boilers and ASHP's), to evaluate its economic feasibility. The costs of the counterfactual are the same as for the DHN analyses before. A company called GI energy give a ball park figure for the expected cost of a vertical borehole system between £1,020/kW for a 3000kW heat output system, to £1,700/kW for a 50kW system. Approximately half of this cost is attributed to the heat pumps and plant installation, and the other half to the civil works for the ground loop. The following is said to be included in this cost:

- Boreholes
- Pipework/pumps etc.
- Heat pumps
- Controls
- Commissioning
- O & M manuals
- Delivery
- Plate Heat Exchangers
- Dry coolers
- Buffer Vessels

The land requirements have been taken from 'GI energy' who assumes boreholes are 150m deep and 6m apart, with 45 W/m of heating.

5.6.2 Sewer Water Heat Recovery

The water that leaves a home is at a higher temperature than the ground, because of the effect of heating in the home and because part of the flow is from domestic hot water (bath or shower water). From previous case studies, wastewater is typically available at temperatures between 14-22°C. Sewer water is therefore a potentially useful resource for a heat pump system as the temperature is higher than the air or ground, resulting in better heat pump system performance. There is also the added benefit as a new development will have newly laid sewage and storm water drains separated, which will minimise temperature reduction in the waste water from rain water. A maximum temperature drop of approximately 5°C is allowed to the waste water so as to not impact the microbial processes at treatment works further along the sewage system (for example Thames Water advises wastewater at a minimum of around 11°C)[2].

<u>Sewage water heat recovery for Otterpool</u>

There is thought to be the most potential for sewage heat recovery to the west of the Otterpool site, near to where the waste water treatment plant is expected to be located. This will allow the sewage foul water from the site to accumulate to a large enough volume to allow heat to be effectively extracted.

To undertake the analysis, the average water consumption per person was taken from the Building Regulations 2010, part G, at 125 l/day. An average of 2.4 persons per a dwelling was used, as taken from the Wastewater Loading Calculations provided to AECOM for the proposed development. 90% of wastewater was assumed to pass into the sewer system, as has been typically taken for such analysis[3]. From these assumptions an average volume per dwelling per day and an average volume per dwelling per second (the latter required for system sizing) was calculated: 281 l/day or 0.00325 l/sec. Figure 6 is a graph showing how the housing development is expected to accumulate (as from the phasing schedule) and the cumulative sewage flow rate from their connected drains:

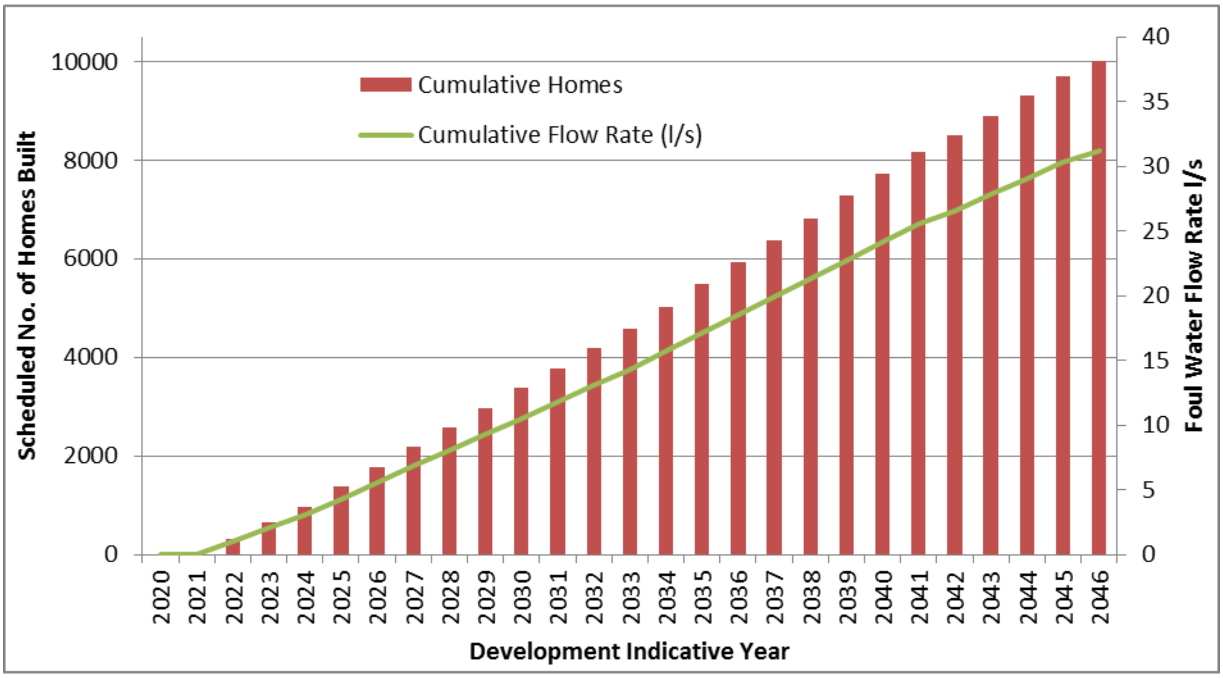


Figure 23: Graph showing cumulative housing numbers and corresponding foul water rates for Otterpool phase schedule.

By looking at basic heat transfer principles, it is clear that more many more homes will need to supply a sewage heat recovery system than would be supplied by the resulting heat network. Taking the recommended maximum

$$Q = m \times Cp \times \Delta T$$
$$Q = 281 \times 4200 \times 5$$
$$Q = 5{,}901{,}000\, J$$
$$= 1.64 kWh/day$$
$$= 598\ kWh/year$$

[2] https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/031250%20GLA%20Secondary%20Heat%20-%20Summary%20Report_0.pdf
[3] https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/031250%20GLA%20Secondary%20Heat%20-%20Summary%20Report_0.pdf

temperature drop of 5°C, the average daily flow rate per home of 281 l/day and assuming the sewage water has a heat capacity similar to that of water (4200 J/kg.K), we can see that it is in theory possible to extract approximately 10% of a home's average heat demand from the water it uses (5332 kWh/year from the benchmarks used previously).

In-line sewage heat recovery technology

When reviewing actually installations, there are products available that recover heat from the sewer without affecting flow (i.e. in-line technology), and these are best installed at the same time as the sewers. These either line the sewer or form part of it, and contain pipes through which a liquid is pumped capturing heat from the sewer. A company called Suez has such an 'in-line' system called 'Degres Blues', in which heat exchangers are laid within the bottom of the sewage pipe over a maximum of 200m lengths, and typically achieve heat outputs of around 1-2kW/m of installation. An average flow rate of at least 12 l/s[4] is required (which could be supplied by approximately 3850 homes and could be installed around the year 2031), and a typical 200m unit could provide heating and hot water for approximately 100-200 homes. There would be capacity for 2 such systems from the 10,000 dwelling Otterpool development based on these assumptions.

There are only a few such installations in use at present, so the real performance is not yet known, and the costs of these systems are not well established.

Off-line sewage heat recovery technology

In the UK a company called 'SHARC' [5] who installed sewage heat recovery systems on several sites across the UK. This system is an off-line technology, in that the sewage water is taken from the sewage pipe to a separate heat exchanger and then returned to the sewage pipe, and is usually used for individual buildings. To ascertain what heat the available SHARC equipment could recover, the equipment data table below was used - it can be seen what minimum flow rate is required for the use of different sizes of SHARC equipment:

Equipment	Energy Capacity (kW)	Min Flow (l/s)
SHARC 440	462	6.3
SHARC 660	703	18.9
SHARC 880	937	25.2
SHARC 1010	1172	50.5

Table 19: SHARC Equipment Data[6]

From this it was possible to estimate that a minimum of 1,950 dwellings would be required to serve the smallest possible equipment size. For example, assuming an average 5kW diversified peak load for each dwelling as explained previously, this 462kW capacity equipment would supply the full load requirements for 92 homes – approximately 5% of the homes serving the heat recovery equipment. From previous experience with SHARC equipment, the capital cost of this equipment is approximately £750/kW, which includes:

- Interface with sewer
- Infrastructure for collecting material from the sewer
- Macerator
- Filtration systems
- Heat exchangers
- Heat pumps

For the smallest equipment size available, the SHARC 440, this would give a cost (excluding external costs for the network) of £346,500 (£3,750 per home with full peak load met). Applying the same methodology to the other possible equipment sizes:

[4] http://www.energy4powerlive.co.uk/sites/default/files/Heat%20Recovery%20from%20sewers_Energy4PowerLive%202016.pdf
[5] http://www.sharcenergy.com/projects/
[6] http://www.sharcenergy.com/downloads/student-accommodation-white-paper.pdf,

- The SHARC 660 would require 5,862 dwellings to serve it, providing the full peak load for 140 homes – this could be implemented in year 18 of the phase plan (2037), at a cost of £527,250.
- The SHARC 880 would require 7,764 dwellings to serve it, providing the full peak load for 187 homes – this could be implemented in year 22 of the phase plan (2041), at a cost of £879,000.
- The SHARC1010 would require 15,528 dwellings, which is more homes than is planned for the development, and is therefore not feasible without sewage wastewater from other sources being utilised as well.

To achieve similar heat outputs to the in-line technology, the minimum flow rate required is less for the 'SHARC' equipment, and therefore this could be implemented at an earlier date than for the in-line technology, and more installations could be feasible around the Otterpool site (up to 5 installations of the SHARC 440 serving 460 homes in total) by the end of the entire site development. For calculating the required flow rate for a scheme, the smallest SHARC equipment size has been used, and then scaled up depending on how many installations of this would be required.

5.6.3 Heat pump performance

Heat pump performance is governed by the Carnot cycle of the refrigerants within it, and affected mainly by:

- The temperature required of the hot side of the heat pump
- The temperature of the cold side of the heat pump, which varies with the source, and
- The quality of the heat pump.

For both the GSHP and Sewage Heat recovery options, an ambient loop system (i.e. the hot side of the main heat pump at 20°C) has been analysed due to the much improved efficiencies, compared with raising the temperature of the system to say 70°C, and the much reduced heat losses. For each house, heat is provided at the required temperature via a second heat pump within the dwelling. For non-domestic properties, the space heating and 2/3 of the domestic hot water is assumed to come from the buildings heat pump with the remaining 1/3 of the hot water coming via direct electric top up. A blended COP for each scheme was calculated based on these assumptions. Both schemes are assumed to use direct electric back-up heating (using electricity at an assumed 100% efficiency) to the main heat pumps and both are assumed to benefit from the heat pump RHI with the following rates (as taken from the Ofgem website for water / ground source heat pumps at the time of this report):

- Tier 1: 9.36p/kWh
- Tier 2: 2.79p/kWh for all heat produced over the tier 1 limit.

The costs of heat collectors and central heat pumps have been based on the assumed price mentioned previously (£1,020/kW and £750/kW for the vertical borehole GSHP and sewage heat recovery technologies respectively). The cost of the heat network has been analysed with the same costing and assumptions as for the previous heat networks, but with in-building heat pumps replacing the HIU's. However, It is appreciated that the sewage heat recovery scheme in particular is only really possible in the lower density areas to the west of the Otterpool site, due to the likelihood of this being the only location with a high enough foul water flow rate. Both the heat pump heat networks have therefore been modelled for a low density (20 homes/ha) domestic development of 100 homes to analyse their feasibility for the proposed development to the west of the Otterpool site.

5.6.4 Techno-economic Results:

5.6.4.1 Heat pump heat networks vs. gas boiler counterfactual

Low density 100 home example – Individual gas boiler counterfactual		**GSHP heat network**	**Sewage heat recovery heat network**
Capital cost	£m	1.77	1.72
Total HN pipe length	m	1,871	1,871
Annual heat demand (ex. Distribution losses)	MWh	403.6	403.6
Heat pump proportion of heat delivered	%	87%	87%
Total heat pump capacity	kW	118	122
Overall heat pump system COP		3.09	3.52
40 year life cycle analysis			
IRR (0% Grant)	%	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-1.55**	**-1.40**
IRR (30% Grant)	%	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-1.02**	**-0.89**
Average lifecycle annual carbon saving	T CO_2	**2,397**	**2,456**
Average carbon saving over first 15 years	T CO_2	**824**	**858**

Table 20: Results for heat pump heat network vs gas boiler counterfactual

The results have been optimised to a certain extent, to achieve a better NPV after the 40 year lifecycle. This has been done through a balance of the size of heat pump(s) required, and the size of the thermal store to take some of the heat during periods of lower demand and to supply a proportion of the heat in peak periods. Therefore the size of the heat pumps (which are comparatively expensive) can be significantly reduced to minimise the capital costs.

From the results, the heat networks show a generally poor economic output. Against the gas counterfactual, the system benefits from the significant RHI tariff applied. Even so, the extra efficiency gained from the heat pump over a gas boiler would not be enough to offset the larger difference in energy prices between gas and electricity, and pay off the high capital costs of the heat pumps and borehole heat collectors. There are however reasonable carbon savings for the heat network compared to the gas counterfactual, which would be anticipated from the greater efficiency of the heat pumps compared to the gas boilers, and the favourable electricity carbon factor.

As would be expected the results, both financially and in terms of carbon savings, from the sewage heat recovery technology are marginally better due to the better heat pump COP (due to the higher temperature of the heat source) and the lower cost for the heat collector equipment. This still does not look economically favourable, even when a 30% grant is included. It is important to be reminded that the likelihood of having a higher enough flow rate to serve the sewage heat recovery equipment for the larger schemes is highly unlikely.

5.6.4.2 Heat pump heat networks vs ASHP counterfactual

Low density 100 home example – ASHP Counterfactual		**GSHP heat network**	**Sewage heat recovery heat network**
Capital cost	£m	1.75	1.72
Total HN pipe length	m	1,871	1,871
Annual heat demand (ex. Distribution losses)	MWh	403.6	403.6
Heat pump proportion of heat delivered	%	85%	86%
Total heat pump capacity	kW	112	119
Overall heat pump system COP		3.09	3.52
40 year life cycle analysis			
IRR (0% Grant)	%	**-**	**-**
NPV (3.5% discount rate & 0% Grant)	£m	**-1.07**	**-0.98**
IRR (30% Grant)	%	**-**	**-**
NPV (3.5% discount rate & 30% Grant)	£m	**-0.55**	**-0.46**
Average lifecycle annual carbon saving	T CO_2	**-397**	**-322**
Average carbon saving over first 15 years	T CO_2	**-42**	**-12**

Table 211: Results for heat pump heat network vs ASHP counterfactual

Against the ASHP counterfactual, the heat pump networks do not have the complete benefit of the RHI which has been offset by the RHI that would also apply to the ASHP. This has also resulted in slightly smaller heat pumps (compared to the networks against the gas counterfactual) as there is less benefit from the RHI. The slightly higher efficiencies of the GSHP system compared to the ASHP do not overcome the higher capital costs associated with the GSHP network.

Once again the sewage heat recovery units give slightly better results. However this still does not return a positive IRR and a higher heat demand and lower capital cost would be required to make this economically viable. If this was to be achieved there is clearly potential for using such technology to the west of the site if, as thought, the sewage network will reach a high enough flow rate.

Nevertheless, the solution based on sewage heat recovery is not cost effective based on the use of fully insulated pipes buried relatively deeply, which is the normal approach taken to District Heating. However if a more radical approach could be taken, with pipes with much less insulation the cost effectiveness improves. A reduction in the installed cost of pipes of at least 70% is estimated to be needed to achieve an IRR of around 3-4% with a 30% grant included. Whilst this reduction is not likely, it could be possible with the more radical solution outlined, although this is not tested.

Of the district energy solutions introduced in this study it appears to be the most promising, and could be developed into an interesting demonstration scheme to showcase the Otterpool development.

5.7 Further Technology Considerations

5.7.1 Food waste and anaerobic digestion

Anaerobic Digestion of biological material is a process for converting waste materials into a methane rich gas mix that can then be used for the generation of green energy. As the gas can be burnt in a CHP engine it can generate both heat and electricity although most installed plant are only exporting electricity.

The typical scale of a commercial AD plant is 2 MWelectric, which requires around 40-45,000 tonnes of food waste per year. The plant near Baldock, Hertfordshire, of this scale cost around £12 million, and has a footprint around 16,000 m^2 although this includes landscaping areas.

Photo from http://www.toureengroup.co.uk/biogen-plant-baldock : they were the contractor for the Baldock scheme.

The average UK home generates around 0.27 tonnes of food waste per year, and so a single plant would be able to process the food waste from up to 170,000 homes, far in excess of the planned development at Otterpool. Therefore a scheme would only work if it also received food waste from a large enough area; in March 2017 there were around 660,000 dwellings in all of Kent[7], so depending on the success rate in collecting food waste, up to 4 sites could be needed to serve the whole county. However food waste can also be sourced from food processors and retail, and so only a proportion needs to come from housing.

Up to 20,000 MWh of heat might be generated by the plant over a year, which might support around 4000 homes. However the cost of a network to distribute this heat would be significant.

It would therefore be possible to site an AD plant at Otterpool if there is interest in the allocation of land for it, and the need across the wider county for a site to process food wastes. Siting the plant there would provide a significant offset to carbon emissions for electricity, and it could also form the basis of a heat network for at least part of the development. Whilst this would appear a viable option, further research would be needed to ensure the required waste could be reliably delivered to ensure the working of the scheme.

[7] https://www.kent.gov.uk/about-the-council/information-and-data/Facts-and-figures-about-Kent/Land-and-property#tab-3

5.8 Other issues

5.8.1 Social impacts

In most cases one of the aims of the heat network is to enable consumers to receive reliable, affordable heat. In this analysis the heat sale price is taken to be tied to the cost of providing heat through a conventional solution with gas boilers at a standard residential tariff. This also assumes that the householder maintains their boiler annually, and it results in an initial heat tariff of 8.9p per unit. Given the very poor economic return of this network it is hard to see that this cost could be reduced to benefit the users further.

A general benefit of a heat network is that there is reduced need for maintenance of the systems within the home, particularly those linked to gas appliances. A further benefit is that it also removes one potential source of fire.

5.8.2 Future energy supply

One of the main benefits of a heat network is to bring flexibility for future energy supply. Once the network is in place then any source of heat could be used to supply it, and this would allow great flexibility. Besides the systems considered, this would mean that emerging technologies could be used, for example heat pumps fuelled with hydrogen from renewable sources, or energy from waste.

Another longer term option would result from any really large scale heat source that might emerge to serve in the area. The network could then connect to this at a later date. Examples could be a large-scale energy from waste plant, or a conventional or nuclear thermal power station.

These options could provide heat if available; however none of them may bring cost savings to the scheme.

6. Risk assessment

The development of heat network schemes can be complex and require the collaboration of a number of parties. During all stages of the scheme development, from feasibility to operation, a number of risks may be encountered which will need to be managed and overcome. The lack of regulation of heat supply can be a particular issue, alongside the perceived immaturity of heat network schemes in the UK. The risk analysis presented here identifies key project risks in the delivery of the proposed scheme, focussing on technical risks as these dominate the process.

6.1 Types of risk

The risks associated with developing a heat network scheme can be categorised a number of ways depending on the focus of the risk assessment process. The following categories of risk have been identified in this section:

- **Technical viability.** Risks associated with identifying and delivering a scheme which is technically viable.
- **Economic viability.** Risks associated with the economic performance of a scheme, and the ability to deliver a rate of return.
- **Commercial.** Risks associated with customers, lease agreements, and suppliers.
- **Regulatory / policy.** Risks associated with uncertainty around future regulation and policy at national and local level.
- **Development and construction.** Risks associated with the development and construction of a scheme – these may cover a range of technical, economic, and commercial issues.
- **Future strategy.** Risks associated with the ability of the scheme to be future proof and have a long term strategy.
- **Other general risks**. Any other risks not falling into the above categories.

Given the outcome of this study, only the risks that present significant challenges likely to mean that a scheme will not proceed are presented here.

6.2 Measuring risk

The consideration and measurement of risk requires an understanding of two properties:

- **Impact -** The impact of the risk is the outcome that may occur if the risk is not properly managed. E.g. if sufficient economic analysis is not conducted and sensitivities assessed, the impact of economic viability risk may be that a scheme is not economic once developed.
- **Probability -** This is the chance that a risk may occur and is independent of the impact.

The outcome of impact and probability is an overall measure of risk. If the impact and probability are both deemed to be high, the overall level of risk is high. If the impact and probability are both deemed to be low, then the overall risk is low. For intermediate situations, a matrix is used to assess the overall risk. For example a high impact combined with a low probability results in a medium risk.

Rating		Probability				
		1	2	3	4	5
Impact	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Figure 24: Risk assessment matrix taking into account probability and impact

6.3 Risk Assessment for Otterpool

Using the above categories of risk and risk assessment matrix the following risk register was produced for the proposed Otterpool development heat network:

Risk Category	Specific Risk	Probability	Impact	Risk Rating	Mitigation / Action	Revised Probability	Revised Impact	Revised Risk Rating
Technical viability	Lack of suitable loads for producing a diverse heat load profile for a DH scheme (e.g. what to do with heat in summer).	2	4	8	Assess the viability of loads in a full feasibility study, including sensitivity of the assessment to the inclusion or exclusion of each load.	1	4	4
Technical viability	Uncertainty of heat demands as based on benchmarked data for future buildings, without specific details on the configuration or composition of the site.	3	3	9	Confirm loads and layout for site as part of future planning application process.	2	2	4
Technical viability	Viability of gas connection at the energy centre.	2	5	10	There is a new supply planned, so it will need to be confirmed that there is sufficient information available before the supply is designed, to ensure a connection is possible and that the supply will come to the energy centre location.	1	4	4
Technical viability	Connection to DNO may not be possible, grid already fully utilised.	2	5	10	There is a new supply planned, so it will need to be confirmed that there is sufficient information available before the supply is designed, to ensure a connection is possible and that the supply will come to the energy centre location.	1	4	4
Technical viability	Network is not flexible enough to allow future energy demands (extra to what is currently planned) to connect to the network.	2	3	6	Designs need to be future-proofed to ensure the network could allow future energy supply options. Will need to assess risks of different future supply options and interconnections at later stage. Consider potential future energy centre locations and oversizing pipe to allow for future potential connection to heat pumps, or expansion of network	1	3	3
Technical viability	Inability to secure energy centre site for initial network phase(s).	2	4	8	Potential energy centre sites to be identified and reviewed. Further analysis required including need to explore further with Planning and Legal. However, because the site is being masterplanned there should be suitable space available.	1	3	3
Technical viability	Incorrect installation of plant or network elements leading to underperformance or failure.	2	5	10	Ensure provisions in procurement/delivery contracts to protect the investors' interests in this eventuality.	1	4	4
Technical viability	Network design or incorrect installation giving rise to excessive heat losses from the network.	2	4	8	A full feasibility study will account for heat losses when considering the heat source and distribution pipework to be used. Case studies of recently completed district heating schemes where post completion monitoring has been undertaken should be reviewed and the lessons learnt fed into the detailed design process. Designers should consider ways to reduce the heat losses as far as practical such as by adopting standards for insulation above the regulatory minimum (CIBSE Heat Networks Code of Practice).	1	4	4

Regulatory / policy	Local political risk. Changes to council administrations results in lower priority for DH schemes.	3	3	9	Continued engagement with the Council senior management is essential for the scheme to be given the resources and priority required. [Currently the scheme has high level support].	2	2	4
Regulatory / policy	National political risk. Changes to national administration or strategy results in move away from promotion and support for DH schemes or reduction/withdrawal of powers which allow local authorities to develop and invest in DH schemes.	2	3	6	Place a greater emphasis on schemes being economically attractive for commercial investment. Prioritise publically funded investment whilst support is strong. Engage with national government to communicate benefits.	1	2	2
Environmental / social	Negative visual impact from energy centre on local residents.	3	3	9	A full feasibility study should take into account the potential for visual impacts and seek to minimise these during the selection of a location for the energy centre. Examples of sympathetically designed energy centres in dense urban areas exist (e.g. Islington Bunhill scheme), and lessons learned from these should be considered in designing the energy centre.	1	1	1
Environmental / social	Energy centre - environmental impacts e.g. air quality and ecology.	3	2	6	Environmental constraints, such as Air Quality Management Areas and Conservation Areas, have been considered when identifying potentially appropriate locations for an energy centre. The energy centre should be designed to minimise emissions (air and noise). The full feasibility study will consider this issue in further detail.	2	1	2
Economic viability	Inability to secure electricity sales price	3	5	15	This remains a major risk, however the study has assumed a lower price of 5p/kWh rather than what might be achieved through a private wire wholesale price. Potential customers would need to be established going forward.	3	3	9
Economic viability	Inability to secure funding for project development work.	3	5	15	This remains a major risk. Use evidence from this study to seek HNDU or other grant funding.	3	4	12
Economic viability	Cost of plastic pipework is more than the assumed value.	3	4	12	This is still not known as an all in cost. If the network was to be advanced; this would need to be more carefully researched. The effect of decreasing this price is analysed in the report. However, as none of the schemes analysed in this report seem economically viable as they stand, an increase in price is not of immediate concern but this would remain a risk going forward.	3	3	9
Economic viability	Increased capital costs of network.	2	5	10	This study includes a sensitivity analysis of schemes economic viability to capital costs as part of the economic analysis. To be investigated further during a full feasibility study, when more detail is known about the development.	2	2	4

Table 22: Risk Register for proposed Otterpool Garden Town Heat Network

7. Conclusions and recommendations

7.1 Overview

This study has examined the technical and economic aspects of heat network options for the proposed Otterpool Garden Village, Kent. Whilst it would be technically possible to deliver a heat network to meet the needs of the housing developments, this analysis suggests it is not a strong candidate for progression. With either a gas CHP or biomass boiler providing the heat, the financial case for it is very weak, and the carbon case not sufficiently strong to justify taking it forward. This is because the energy demands of the site are too spread out and not large enough. This means there is a high capital cost in serving them, with a limited financial return from doing so. Whilst a significantly increased income from private wire CHP electricity sales does improve the scheme to a positive IRR in some instances, the rate of return is still too low to be financially attractive.

By testing a more innovative approach to the design of the network, using flexible plastic pipe throughout, an improved outcome may be achieved. However the rate of return is not enough to create a financially attractive heat network, even if the CHP could sell the electricity it generates at retail prices and the cost of the heat network pipework installation was considerably less. Whilst, due to the early stages of the this planned development, there is uncertainty over the power, heating and cooling loads for the site, it seems highly improbable that these could be increased to produce a high enough energy demand density for a heat network to be economically attractive for the site.

In order for any of the schemes to achieve a positive IRR, essentially the whole initial capital cost of the scheme would need to be grant funded. This would not be acceptable to the funding potentially offered by HNIP. With the rest of the Otterpool site appearing to have an even smaller heat demand density due to even lower density housing, a domestic heat network appears to not be viable for the whole site.

In terms of using heat pumps to serve a heat network of low density housing, it appears as though the high capital cost of vertical borehole GSHPs means they are not economically favourable without significant funding. It is expected that the space for the boreholes would be available, due to the nature of a 'garden town' having lots of green space. However the system COP's are not high enough to overcome the large capital cost of the heat collecting system. A sewage heat recovery based heat pump has a more favourable economic output, because of a higher possible COP due to the higher heat source temperature, and the smaller capital costs associated with this solution. Whilst their main negative point is the large sewage flow rate required, it is thought this may be possible in later phases, when the Otterpool development has been built out to the west, and a collective Sewage system is fed this way.

Large scale use of sewage heat recovery technology seems highly unlikely unless the sewage network is integrated with the surrounding area – the viability of which is highly doubtful. Similarly, the large scale use of anaerobic digestion from food waste could only be made feasible for the site if food waste was also collected from the surrounding area, and would therefore require a regional integrated strategy.

7.2 Recommendations

It would require significant change to the plans for the site or to the current rules for operating electricity networks to make this scheme viable financially. Unless one of these things happens then it would make sense to focus efforts on encouraging developments to achieve really good carbon performance, and incorporate on-site renewables.

The project team could consider revisiting the Masterplan with the option to increase density, but it is recognised this is a major change to current plans. The focus would need to be on more flats and fewer houses.

There does seem potential to use sewage recovery technology to provide heat to developments to the west of the Otterpool site, where the new sewage network is expected to accumulate to a high enough flow rate for the technology to be used. Whilst the cost of this is not accurately known, the higher COP achievable due to the higher source temperature suggest the system may be able to pay back the high capital costs with a more radical solution of minimally insulated pipes installed

Appendix A Modelling inputs and assumptions

DHN Assumptions:

Modelling Inputs and Assumptions	Amount	Units
Energy centre		
Energy centre building capital cost	£2000	£/m^2
Energy centre building size	100	m^2/MW LZCT
Energy centre boilers		
Efficiency	88%	
Capital cost	£300	£/kW
Maintenance cost	£8.00	£/kW/yr
Lifetime	30	years
Thermal store		
Capital cost	£1,000	£/m^3
Lifetime	50	years
CHP		
Capital cost	Varies by CHP size	£/kWe
Maintenance cost	0.99	p/kWhe
Lifetime	15	years
Electricity sale price	5.00	p/kWh
Biomass Boilers		
Capital cost	(Varies by boiler size) 300-600	£/kWe
Maintenance cost	4%	% of Boiler Capex
Lifetime	15	Years
Heat Pumps		
GSHP Heat collectors + HP capital cost	£1,020	£/kW
Sewage Heat Recovery + HP capital cost	£750	£/kW
Maintenance cost	4%	% of HP Capital cost
HIU – commercial		
Capital cost	£100	£/kW
Operation maintenance cost	£1	£/kW/yr
Lifetime	20	years
HIU – domestic		
Capital cost	£2,000	£/home
Operation maintenance cost	£140	£/home
Lifetime	15	years
District Heating Network		
Pumping Energy	1%	kWh of heat delivered
Maintenance	1%	% of CAPEX / year

Lifetime	50	Years
Development Cost	20%	% of CAPEX

DHN Pipe costs:

Spec Pipe Size (DN)	Civil work (Soft Dig)	Supply & installation		Soft-dig TOTAL	Heat losses per pipe length @ ΔT 65°C		Heat losses per pipe length @ ΔT 55°C	
	flow & return	flow	return					
[mm]	**[£/m]**	**[£/m]**	**[£/m]**	**[£/m]**	**[W/m]**	**[kWh/m]**	**[W/m]**	**[kWh/m]**
16	150	80	80	310	11.9	105	1.83	16.15
20	150	84	84	318	14.6	128	2.25	19.69
25	156	90	90	381	17.3	151	2.66	23.23
32	182	97	97	377	18.8	164	2.89	25.23
40	208	109	109	427	21.2	186	3.26	28.62
50	214	115	115	443	23.7	208	3.65	32.00
65	224	125	125	474	26.6	233	4.09	35.85
80	234	132	132	499	27.8	244	4.28	37.54
100	245	154	154	553	29	254	4.46	39.08
125	252	173	173	598	33.4	292	5.14	44.92
150	261	193	193	646	37.8	331	5.82	50.92
200	287	206	206	699	39.8	349	6.12	53.69
250	307	264	264	836	38.8	340	5.97	52.31
300	313	282	282	877	44.2	387	6.80	59.54
350	365	336	336	1036	42.6	373	6.55	57.38
400	417	371	371	1160	44.1	387	6.78	59.54
450	469	397	397	1263	58.4	511	8.98	78.62
500	521	578	578	1676	56.5	495	8.69	76.15
600	573	867	867	2307	11.9	105	1.83	16.15
700	625	1171	1171	2968	14.6	128	2.25	19.69
800	834	1356	1356	3545	17.3	151	2.66	23.23
900	938	1525	1525	3988	18.8	164	2.89	25.23

Counterfactual:

Modelling Inputs and Assumptions	Amount	Units
Commercial ASHP		
ASHP efficiency	240%	
Capital cost for replacement	£1,000	£/kW
Maintenance cost	£15	£/kW/yr
Lifetime	15	Years
Domestic ASHP		
ASHP efficiency	250%	
Capital cost for replacement	£4,000	£/house
Maintenance cost	£90	£/house/yr
Lifetime	15	Years
Commercial Gas Boiler		
Boiler efficiency	88%	
Capital cost for replacement	£138	£/kW
Maintenance cost	£8.00	£/kW/yr
Lifetime	20	Years
Domestic Gas Boiler		
Boiler efficiency	90%	
Capital cost for replacement	£2,000	£/house
Maintenance cost	£140	£/house/yr
Lifetime	15	Years
Counterfactual Gas Network cost	120	£/m
Electrical connection	£100,000	£/MW electrical peak
Electrical substation	£100,000	£/MW import

Energy Prices

Retail fuel prices for customers:

	Gas price (p/kWh)	Elec price (p/kWh)
Domestic	3.720	14.70
Commercial	2.235	13.00
Public sector	2.235	13.00

Source: Downloaded July 2018 - DECC quarterly energy prices for South East (Table 2.2.4, 2.2.4) and for small non domestic developments (Table 3.4.2)

Energy centre fuel prices:

Prices used in modelling (p/kWh)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Natural gas	2.60	2.70	2.80	3.00	3.10	3.30	3.40	3.70	3.90	3.90	4.00
Electricity	11.80	12.70	13.10	13.40	13.50	13.60	13.90	14.70	14.80	14.40	14.40

Prices used in modelling (p/kWh)	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Natural gas	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
Electricity	14.30	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50

Prices used in modelling (p/kWh)	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
Natural gas	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
Electricity	14.30	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50

Prices used in modelling (p/kWh)	2053	2054	2055	2056	2057
Natural gas	4.20	4.20	4.20	4.20	4.20
Electricity	14.30	14.50	14.50	14.50	14.50

Source: Interdepartmental Analysts Group projections – downloaded July 2018. Central energy price scenario for Commercial/Public sector

Biomass:

Wood pellet price: 3.5 p/kWh

Carbon Emissions Factors

Gas Carbon Emission Factor:

Gas Carbon emissions factor: 0.184 p/kWh
Source: Interdepartmental Analysts Group projections – downloaded June 2017. Central energy price scenario for Commercial/Public sector

Electricity Emission Factors:

Emissions Factors ($kgCO_2/kWh$)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Elec supplied	0.224	0.213	0.198	0.187	0.162	0.158	0.164	0.154	0.125	0.131	0.119
Elec marginal	0.349	0.349	0.332	0.329	0.381	0.319	0.338	0.326	0.341	0.341	0.304

Emissions Factors ($kgCO_2/kWh$)	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Elec supplied	0.105	0.114	0.104	0.085	0.081	0.073	0.060	0.060	0.055	0.051	0.053	0.054
Elec marginal	0.318	0.299	0.301	0.303	0.305	0.300	0.309	0.305	0.312	0.309	0.301	0.298

Emissions Factors ($kgCO_2/kWh$)	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
Elec supplied	0.051	0.048	0.046	0.043	0.041	0.038	0.035	0.033	0.030	0.028	0.028	0.028
Elec marginal	0.296	0.297	0.296	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299

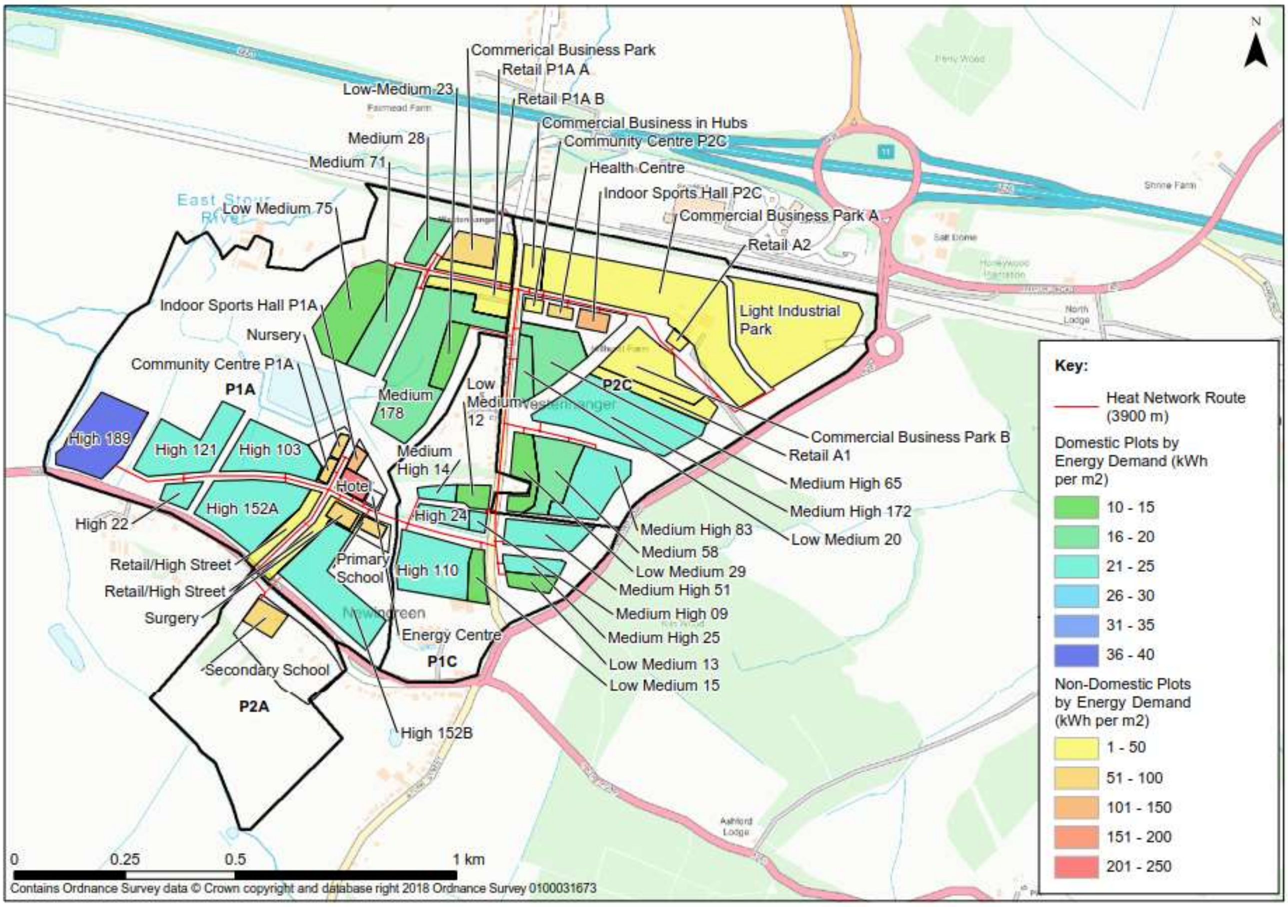
Emissions Factors ($kgCO_2/kWh$)	2053	2054	2055	2056	5057
Elec supplied	0.028	0.028	0.028	0.028	0.028
Elec marginal	0.299	0.299	0.299	0.299	0.299

Source: Interdepartmental Analysts Group projections – downloaded July 2018. Central energy price scenario for Commercial/Public sector

Biomass:

Wood pellet carbon emissions factor: 0.039 $kgCO_2/kWh$
Source: Part L 2013 carbon emission factor for biomass wood pellets

Appendix B Heat map



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