Contents

1. Project Methodology

In order to meet local requirements the project was divided into two work packages A, and B. This report addresses the outputs from work package A only; a report covering work package B is available separately.

a **Heat** mapping **and energy Masterplanning** covering sites including but not limited to Basing View, Basingstoke Town Centre and Council owned properties;

b **Opportunities and advice on the feasibility and deliverability of district heating** at the Leisure Park, Manydown, and other potential sites including Chineham Energy Recovery Facility.

This study was broadly split into two key stages; these steps, and the project methodology has been set out below.

1. Heat mapping

    a Review and agree study boundary

    b Energy modelling of existing energy and future demands

    c Identification of potential heat supply opportunities

2. Energy master planning

    a Techno-economic assessment of opportunities

    b Project prioritisation

1.1 Work Package A: Heat mapping

1.1.1 Review and agree study boundary

The first step was to establish the boundary for the study. This took place in discussion with the local authority considering a number of different criteria including:

- Indicative area from tender specification
- Initial view of total heat demand from energy benchmarks
- Local strategic development plans
- Inclusion of local authority estate
- Inclusion of large heat users identified by the local authority or Encraft

This was combined with data input from some preliminary heat demand analysis to come up with a red line boundary for the area.

Energy demand mapping was carried out using the Ordnance Survey (OS) Mastermap topological layer provided by Deane and Basingstoke Borough Council's System

Administrator. This was combined with the Basic Land and Property Unit (BLPU) and Unique Property Reference Number (UPRN) for each building in the study area.

This was spatially linked to OS topographical data to associate a value for the total footprint area of the building with each address. These footprint areas were then adjusted by building type and using local knowledge, to account for varying number of stories across the building stock to give a total area for each building.

Building stories were assessed through use of street view tools, such as Google street view and Microsoft street side.

An energy benchmark given in kWh/m^2/annum for heating, cooling and electricity was then associated with each address point and used to calculate the total annual usage of each building.
The majority of energy benchmarks were sourced from the Chartered Institute of Building Services Engineers (CIBSE) Guide F. Some were taken from CISBE TM46. To avoid over-estimating energy demand, good practice (rather than typical) values were used where possible.

Heat maps were produced and used to identify possible geographic clusters of local heat networks. As the project progresses, these clusters will be examined in increasing detail to understand whether any potential clusters may be technically and financially feasible.

The heat maps were validated against both BEIS'(Department for Business, Energy and Industrial Strategy) National Heat Map, and actual electricity and gas consumption data for LSOA's (Lower layer super output area) and MSOA's (Middle layer super output areas) across the study boundary.

1.1.1.1 Energy data input

Whilst benchmarked heat demand data gives a good initial guide to energy usage, it can be improved by the addition of more accurate data. Potential data sources were ranked by their utility.

1. Data supplied by building operator
2. Data supplied by Council
3. Display Energy Certificate (DEC) data
4. Benchmarked energy data from CIBSE guide F and CIBSE TM46.

To this end, real data was pursued on key heat loads in the area:

Table 1: Addresses modelled using real energy data

Cluster	Building	Heating data	Electricity data
Cluster E14	Civic Offices	Meter data	Meter data
Cluster E14	Costello School	Meter data	Meter data
Cluster E14	Magistrates Court	Meter data	Meter data
Cluster E14	Fairfields Primary School	Meter data	Meter data
Cluster E14	The Anvil Trust	Meter data	Meter data
Cluster E14	Haymarket Theatre	Meter data	Meter data
Cluster E14	Festival Place Communal Heating	Meter data	Meter data
Cluster E15	NHS Property Services	DEC	DEC
Cluster E15	Hospital (Ward Block, Sherborne, Firs, Acute Assessment Unit, ARK, Lasham Building)	Meter data	Meter data
Cluster E15	Candover Clinic	Meter data	Meter data
Cluster E15	Viridian Residential	Meter data	Meter data
Cluster E15	Homefield House	Meter data	Benchmark
Cluster E15	Ambulance	Meter data	Benchmark
Cluster E15	Headway Place	Meter data	Benchmark
Cluster E15	Fairway House	Meter data	DEC
Cluster E15	Firvale	Meter data	Meter data
Cluster E15	Parklands Hospital	Meter data	Meter data
Cluster E15	Just Learning Nursery	Meter data	Meter data
Cluster E16	Basingstoke Aquadrome	DEC	DEC
Cluster E16	Johnsons Apparel Master	DEC	DEC

A list of the data used for modelling is provided in the appendices.

Supplied energy data
Basingstoke and Deane Borough Council provided energy data on council owned properties, and contacts to follow up on others.

Where specific buildings or companies were identified as potential anchor loads or high volume customers, endeavours were made to get real data from the building managers. Where this was not possible, data on Display Energy Certificates (DECs) was sourced; energy benchmarks were used where neither of the aforementioned was available.

Where a commercial building's space heating and hot water energy demands were not metered separately, the energy demand over the summer months taken to be representative of the typical hot water consumption patterns year-round. For residential properties, this assessment was undertaken using the methodology prescribed by the Government's Standard Assessment Procedure (SAP).

This process allowed space heating energy consumption to be degree day adjusted to take into account of weather variations.

Heating Degree Day (HDD) - Degree days are a simplified form of historical weather data. HDD are the number of degrees that a day's average temperature is below 18° Celsius, the temperature below which buildings need to be heated. In this study they were *used to normalise buildings' energy consumption based on weather variations.* [2]

DEC data
In October 2008 a requirement was introduced for certain public buildings to show a Display Energy Certificate (DEC) detailing gas and electricity use. Since July 2015 a DECC and advisory report are required for buildings with a total useful floor area over 250m^2 that are occupied in whole or part by public authorities and frequently visited by the public.

These records are accessible online and provide a good check on benchmark figures for public buildings. These figures are typically degree day adjusted to provide a typical value, so can be significantly different from real data from previous years.

Energy benchmarks
Using several data sources a series of energy demand benchmarks were created.

Chartered Institute of Building Services Engineers (CIBSE) Guide F was a source of the majority of energy benchmarks. Some were taken from CISBE TM46.

To avoid over-estimating energy demand good practice (rather than typical) values were used where possible, and calibrated against known values for similar buildings.

1.1.2 Identification of potential heat supply opportunities

For each cluster an assessment was conducted to identify and map the most suitable heat supply technologies which could be used to feed a district heat scheme, including energy from industrial processing plants, existing CHP plants and district heating schemes.

1.2 Energy Master Planning

1.2.1 Techno-economic assessment of opportunities

In order to understand whether any potential heat networks in the study area are technically and financially feasible, a number of activities were undertaken. These steps eliminated all obviously non-viable projects, ensuring those taken forward aligned with the requirements of the stakeholders.

1.2.2 Project prioritisation

To reduce the number of schemes considered for detailed techno economic modelling a prioritisation exercise was carried out, taking into account constraints, high level economic modelling and the local community's priorities as identified in the workshops. A project prioritisation workshop was integral to this exercise, and was carried out with stakeholders to understand the outcomes required from the study for each stakeholder. This guided the clustering and technological choices whilst providing a good opportunity to engage stakeholders in the process.

A number of priorities were identified and ranked for each set of interested parties.

- Fuel poverty reduction
- Local economic growth
- Carbon savings
- Make money on an investment
- Community engagement
- Fuel/Energy security
- Political Influence

1.2.2.1 Clustering

Based on the project prioritisation and heat mapping exercise, a number of potential projects were identified to be subjected to detailed analysis. These clusters are based around geographic groups of existing infrastructure, major (anchor) loads, heat sources and strategic developments.

1.2.2.2 Energy Profiles

Each of the building types was given a load profile to calculate the peak heating and electrical loads, and the changes in load throughout each day. Profiles were taken from real data from similar buildings from the project team's past experience and adjusted to reflect operation and modelled energy consumption; unless half-hourly data could be sourced from the building manager. These profiles were consequently aggregated for each identified cluster.

1.2.2.3 Modelling

Financial modelling was carried out using an in-house Excel model which enabled a variety of clusters and heating energy options to be evaluated, alongside a sensitivity analysis to explore the impact of variations to operating and capital expenditure to the project business case/s. In order to calculate Internal rates of return (IRR) and Net Present Value (NPV), project lifetimes of 25 years, 30 years and 40 years were modelled. A discount rate of 3.5% was used as recommended in the Treasury green book for public projects. Cost assumptions are referenced in the appendices.

Capital costs (CAPEX)
An assessment was made of the high level project lifecycles costs for each cluster to help inform the business case for progressing opportunities, taking into account the following:

Table 2: CAPEX assessment criteria

Plant	Pipework	Connection	Professional services
• Primary heat raising plant • Auxiliary heat raising plant • Plant room building works • Plant room pumps, controls	• Spine pipework • Secondary pipework • Thermal Store	• Heat interface units (HIU) • Metering • Private Wire	• Commissioning (2%) • Design (5%) • Project Management (5%) • Contingency (10%)

Operational costs (OPEX)
OPEX costs were developed for each cluster that took into account the following:

Table 3: OPEX assessment criteria

Revenue	Expenditure
• Heat Sales • Renewable Heat Incentive (RHI) • Electricity Sales • Exported Electricity • Standing charges	• Electricity Import • Fuel (Gas, Biomass, Electricity) • Network, energy centre, plant, HIU and heat meter maintenance • Climate Change Levy • Business rates • Annual staff costs for metering, billing and revenue collection

RHI – The renewable heat incentive is a government financial incentive scheme that pays per unit of low carbon heat generated; designed to promote the uptake of renewable heat.

Climate Change Levy - The Climate Change Levy (CCL) is a tax on energy delivered to non-domestic users in the United Kingdom. Its aim is to provide an incentive to increase energy efficiency and to reduce carbon emissions.[1]

[1] https://www.gov.uk/green-taxes-and-reliefs/climate-change-levy

2. Energy benchmarks

Where real meter data was unavailable, industry energy benchmarks were used. A comprehensive list is detailed below.

BLPU Classification	Heating Benchmark – Good Practice (kWh/m^2 building GIA)	Electricity Benchmark – Good Practice (kWh/m^2 building GIA)	Class Description
CA01	54	3	Farm / Non-Residential Associated Building
CB	79	33	Ancillary Building
CC02	125	31	Law Court
CC04	125	22	Public / Village Hall / Other Community Facility
CC04YR	125	22	Youth Recreational / Social Club
CC05	125	22	Public Convenience
CC06CR	80	10	Chapel Of Rest
CC07	125	22	Church Hall / Religious Meeting Place / Hall
CC08	125	22	Community Service Centre / Office
CC12	97	128	Job Centre
CE	100	67	Education
CE01	100	67	College
CE01FE	100	67	Further Education
CE01HE	100	67	Higher Education
CE02	113	22	Children's Nursery / Crèche
CE03	113	22	Preparatory / First / Primary / Infant / Junior / Middle School
CE03FS	113	22	First School
CE03IS	113	22	Infant School
CE03JS	113	22	Junior School
CE03MS	113	22	Middle School
CE03NP	113	22	Non State Primary / Preparatory School
CE03PS	113	22	Primary School
CE04	108	25	Secondary / High School
CE04NS	108	25	Non State Secondary School
CE04SS	108	25	Secondary School
CE05	100	67	University
CE06	108	25	Special Needs Establishment.
CE07	100	67	Other Educational Establishment
CH	240	80	Hotel / Motel / Boarding / Guest House
CH01	240	80	Boarding / Guest House / Bed And Breakfast / Youth Hostel
CH01YH	240	80	Youth Hostel
CH02	260	80	Holiday Let/Accommodation/Short-Term Let Other Than CH01
CH03	240	80	Hotel/Motel
CI01	92	0	Factory/Manufacturing
CI03	96	0	Workshop / Light Industrial
CI03GA	96	0	Servicing Garage
CI04	103	53	Warehouse / Store / Storage Depot
CI05	103	53	Wholesale Distribution
CI06	96	0	Recycling Plant
CI07	96	0	Incinerator / Waste Transfer Station

CI08	283	37	Maintenance Depot
CL01	440	190	Amusements
CL02HA	260	80	Holiday Accommodation
CL02HO	260	80	Holiday Centre
CL02YC	260	80	Youth Organisation Camp
CL03	113	32	Library
CL03RR	113	32	Reading Room
CL04	96	57	Museum / Gallery
CL04AC	96	57	Art Centre / Gallery
CL04AM	96	57	Aviation Museum
CL04HG	96	57	Heritage Centre
CL04IM	96	57	Industrial Museum
CL04MM	96	57	Military Museum
CL04NM	96	57	Maritime Museum
CL04SM	96	57	Science Museum
CL04TM	96	57	Transport Museum
CL06	158	64	Indoor / Outdoor Leisure / Sporting Activity / Centre
CL06FB	141	93	Football Facility
CL06LS	158	64	Activity / Leisure / Sports Centre
CL06RF	141	93	Rugby Facility
CL07	440	190	Bingo Hall / Cinema / Conference / Exhibition Centre / Theatre / Concert Hall
CL07CI	515	135	Cinema
CL07TH	420	180	Theatre
CL10	140	60	Licensed Private Members' Club
CL10RE	140	60	Recreational / Social Club
CM	174	0	Medical
CM01	174	0	Dentist
CM02	174	0	General Practice Surgery / Clinic
CM02HC	174	0	Health Centre
CM02HL	174	0	Health Care Services
CM03	401	48	Hospital / Hospice
CM03HI	401	48	Hospice
CM03HP	339	86	Hospital
CM04	339	86	Medical / Testing / Research Laboratory
CM05	339	86	Professional Medical Service
CN01	174	0	Cattery / Kennel
CN02	174	0	Animal Services
CN04	174	0	Vet / Animal Medical Treatment
CN05	174	0	Animal / Bird / Marine Sanctuary
CO	97	128	Office
CO01	97	128	Office / Work Studio
CO01EM	97	128	Embassy /, High Commission / Consulate
CO01GV	97	128	Central Government Service
CO01LG	97	128	Local Government Service
CO02	97	128	Broadcasting (TV / Radio)
CR01	63	71	Bank / Financial Service
CR02	150	55	Retail Service Agent
CR02PO	140	45	Post Office
CR04	80	400	Market (Indoor / Outdoor)
CR05	80	400	Petrol Filling Station
CR06	140	60	Public House / Bar / Nightclub
CR07	140	60	Restaurant / Cafeteria
CR08	194	237	Shop / Showroom
CR09	80	400	Other Licensed Premise / Vendor
CR10	140	60	Fast Food Outlet / Takeaway (Hot / Cold)
CS01	54	3	General Storage Land

CT04	103	53	Goods Freight Handling / Terminal
CT08	317	20	Station / Interchange / Terminal / Halt
CT10	317	20	Vehicle Storage
CU06	79	54	Telecommunication
CX	295	45	Emergency / Rescue Service
CX01	295	45	Police / Transport Police / Station
CX01PT	295	45	Police Training
CX02	385	55	Fire Station
CX03	350	50	Ambulance Station
CX03AA	385	55	Air Sea Rescue / Air Ambulance
CX04	385	55	Lifeboat Services / Station
CX05	385	55	Coastguard Rescue / Lookout / Station
CX06	385	55	Mountain Rescue Station
CX08	295	45	Police Box / Kiosk
CZ02	96	57	Tourist Information Signage
LB99PI	141	93	Pavilion / Changing Room
MA	187	34	Army
MB	187	34	Ancillary Building
MF	187	34	Air Force
MG	187	34	Defence Estates
MN	187	34	Navy
R	50	As per SAP	Residential
RD	50	As per SAP	Dwelling
RD01	50	As per SAP	Caravan
RD02	50	As per SAP	Detached
RD03	50	As per SAP	Semi-Detached
RD04	50	As per SAP	Terraced
RD06	50	As per SAP	Self-Contained Flat (Includes Maisonette / Apartment)
RD08	314	46	Sheltered Accommodation
RI01	247	44	Care / Nursing Home
RI02	240	85	Communal Residence
RI03	240	85	Residential Education
ZW	80	10	Place Of Worship
ZW99AB	80	10	Abbey
ZW99CA	80	10	Cathedral
ZW99CH	80	10	Church
ZW99CP	80	10	Chapel
ZW99GU	80	10	Gurdwara
ZW99KH	80	10	Kingdom Hall
ZW99LG	80	10	Lych Gate
ZW99MQ	80	10	Mosque
ZW99MT	80	10	Minster
ZW99SU	80	10	Stupa
ZW99SY	80	10	Synagogue
ZW99TP	80	10	Temple

The following benchmarks were used for mapping cooling demand.

Sector	Energy for Cooling as fraction of space heating
Commercial Offices	16%
Communication and Transport	18%
Education	1%
Government	3%
Health	0%
Hotels and Catering	8%
Other	3%
Retail	21%
Sport and Leisure	9%
Warehouses	4%

3. Heat mapping and validation

The following are full size copies of the small key heat maps provided in the report, for ease of reading.

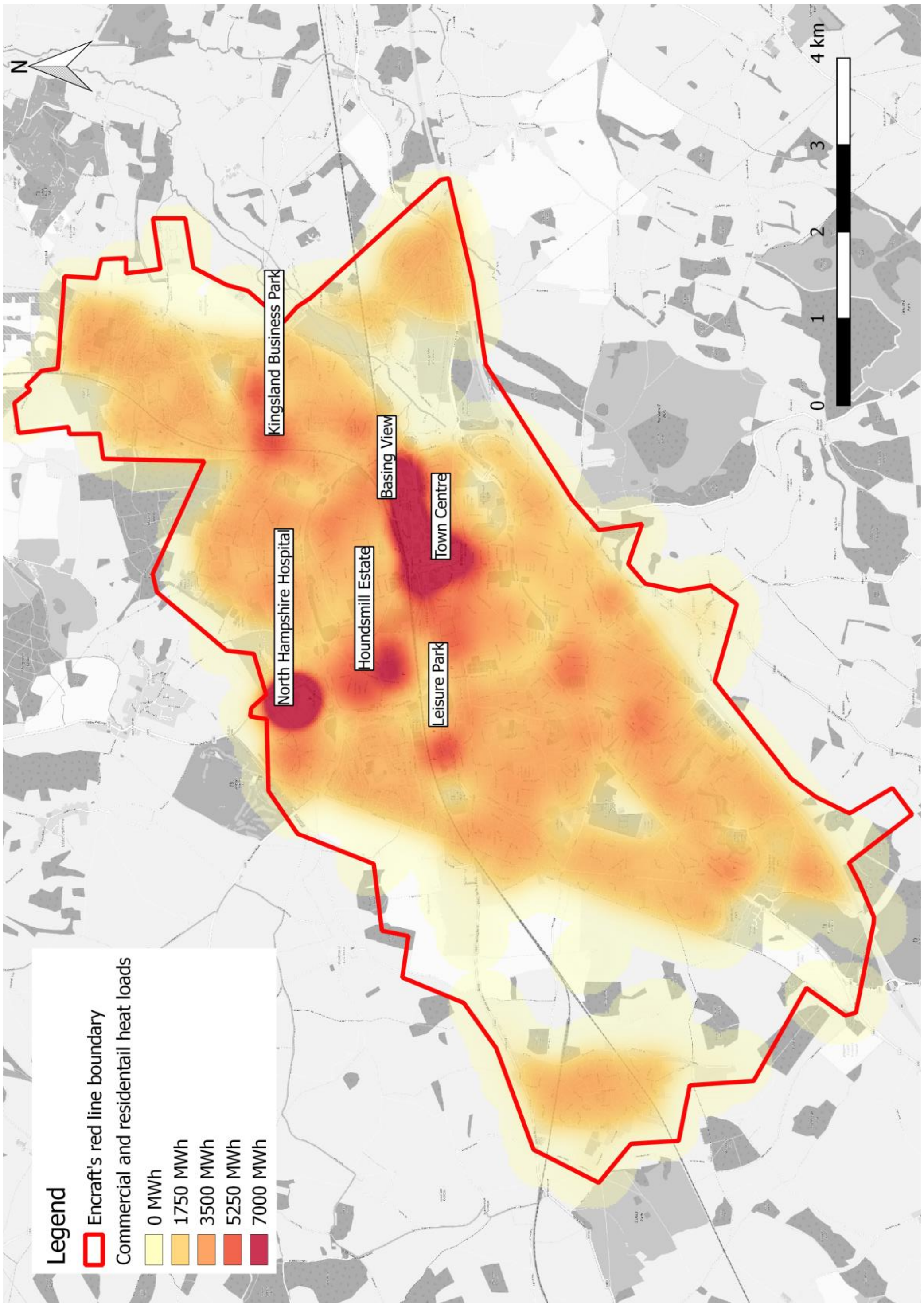


Figure 1: Total commercial and residential heat energy (MWh/year) [Benchmarked data]

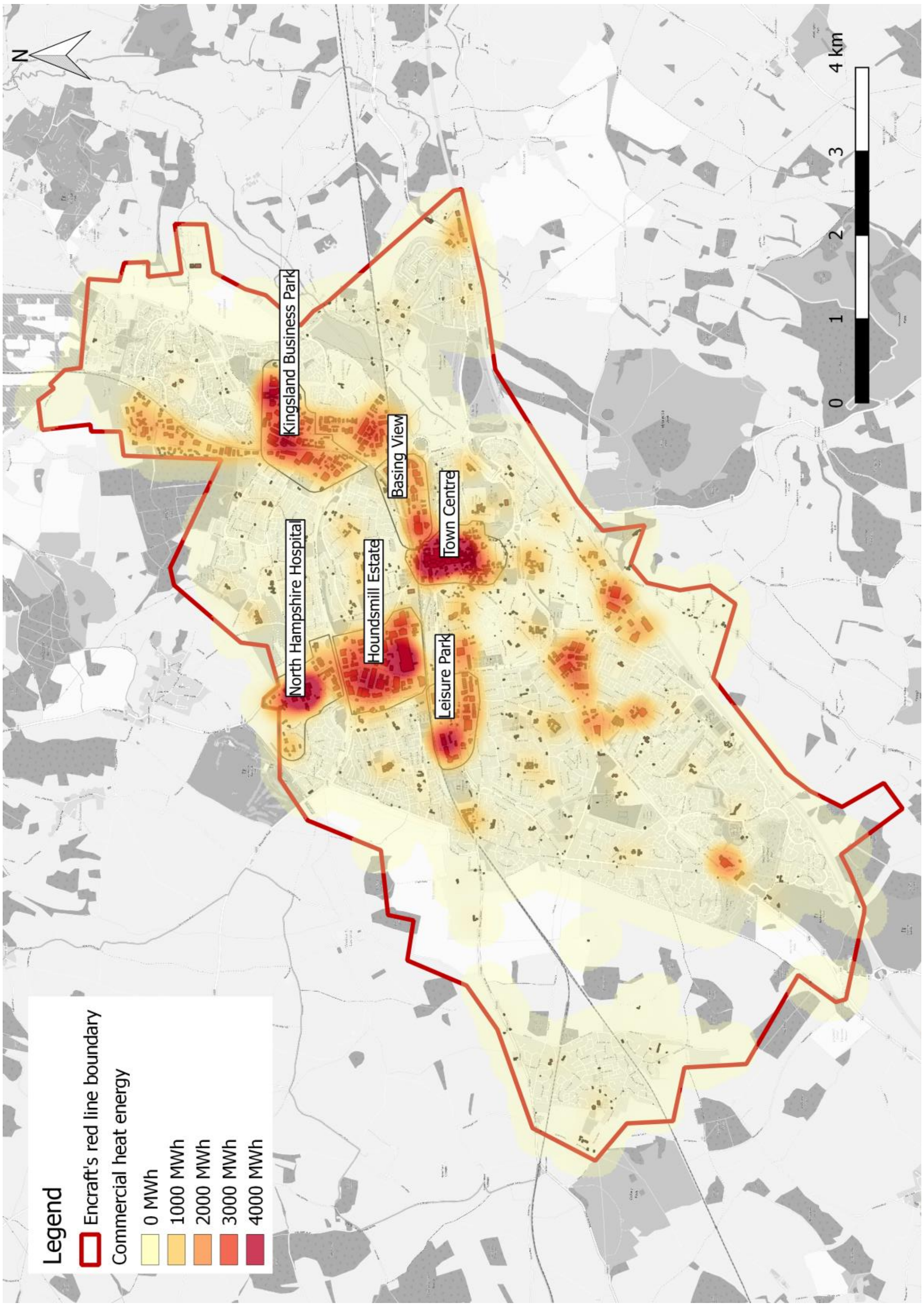


Figure 2: Commercial heat energy (MWh/year) [Benchmarked data]

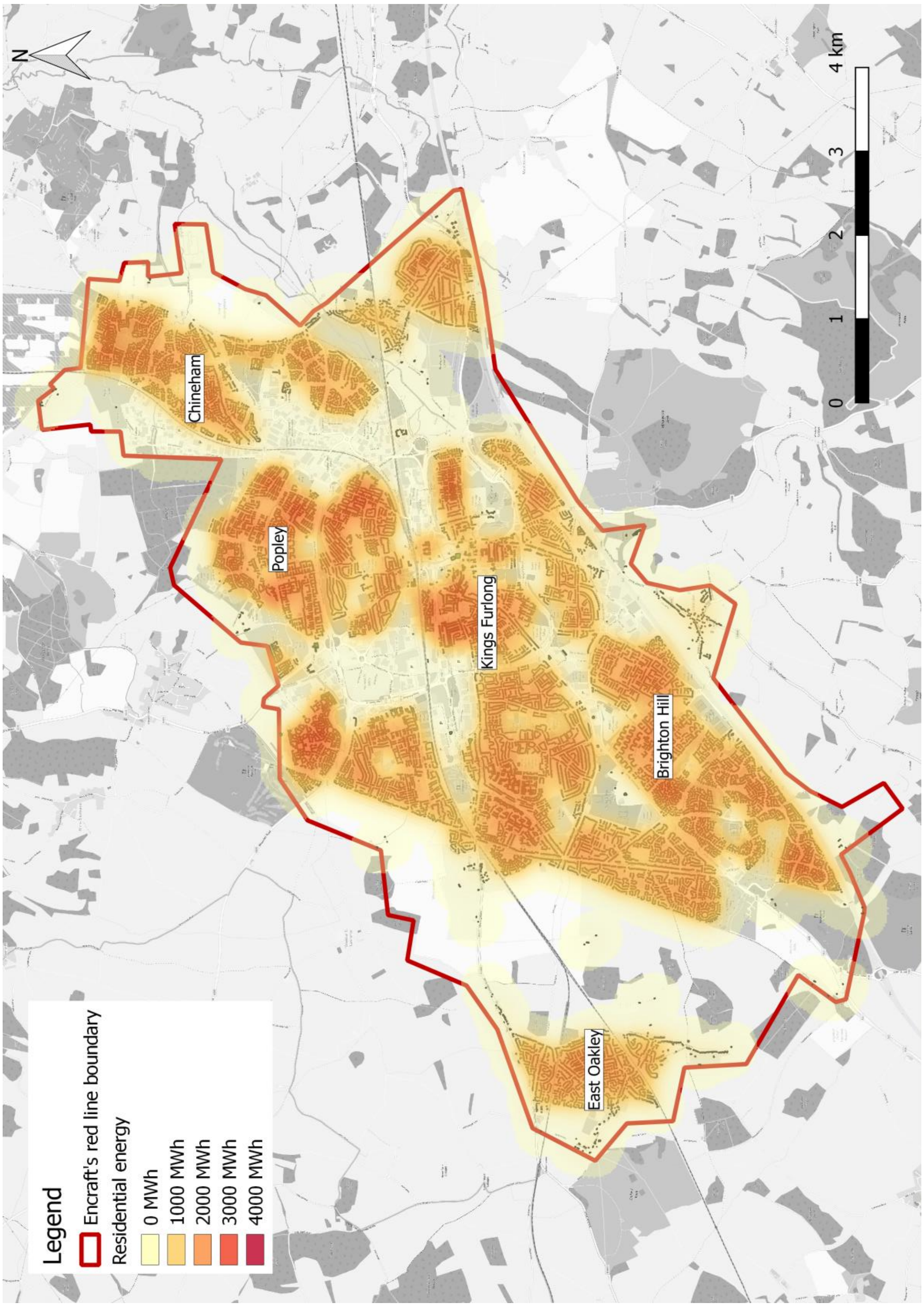


Figure 3: Residential heat energy (MWh/year) [Benchmarked data]

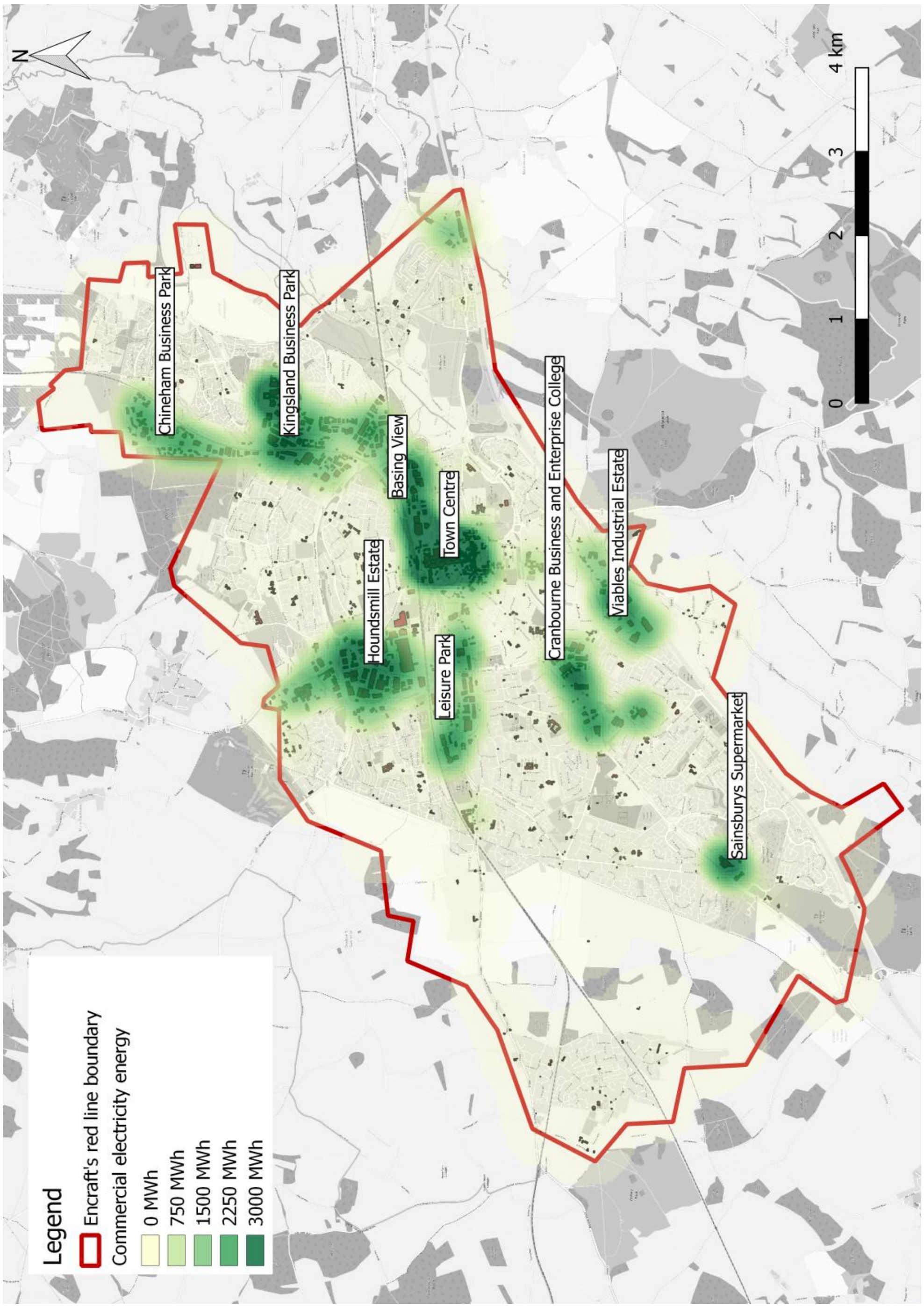


Figure 4: Commercial electricity energy (MWh/year) [Benchmarked data]

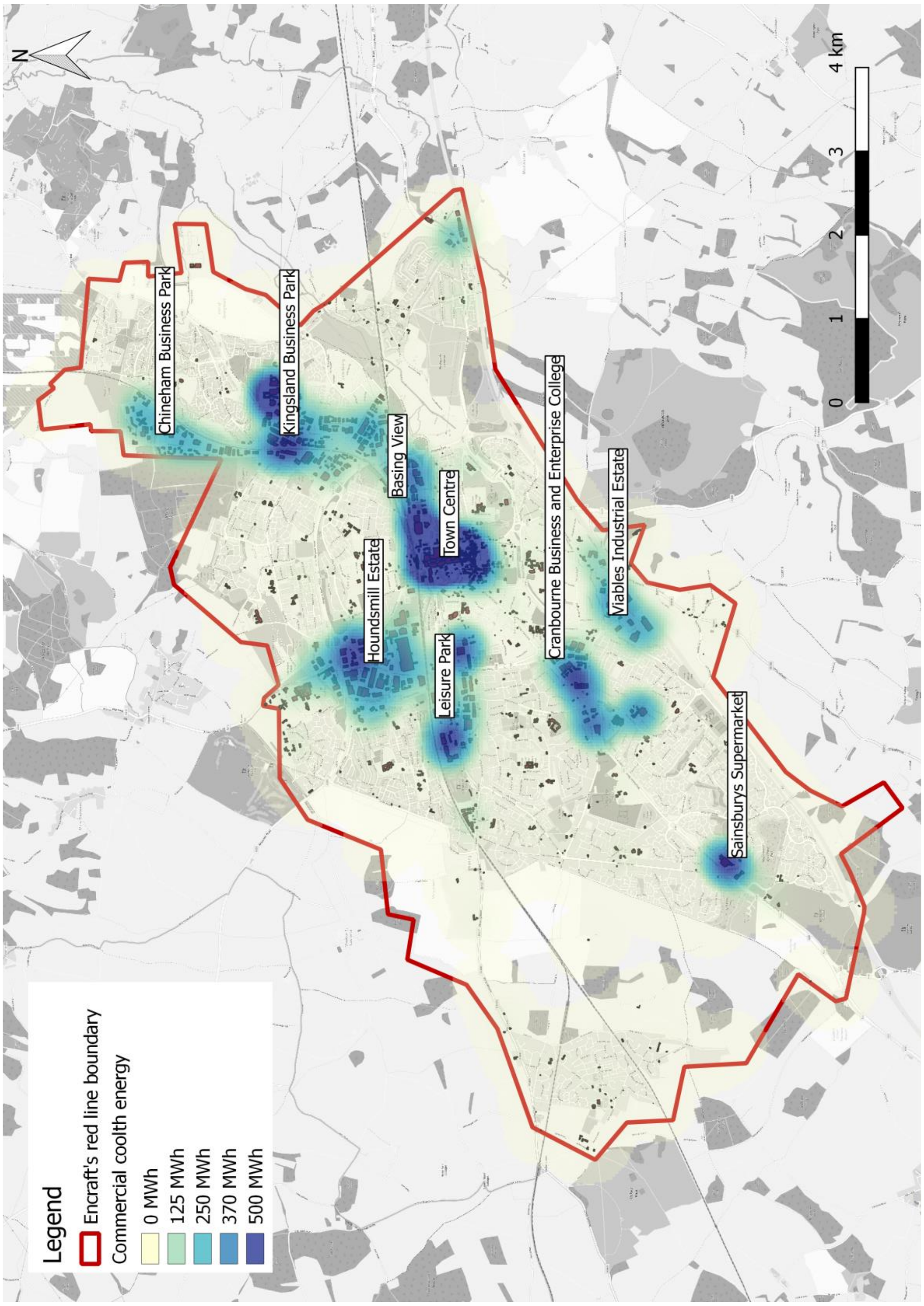


Figure 5: Commercial cooling energy (MWh/year) [Benchmarked data]

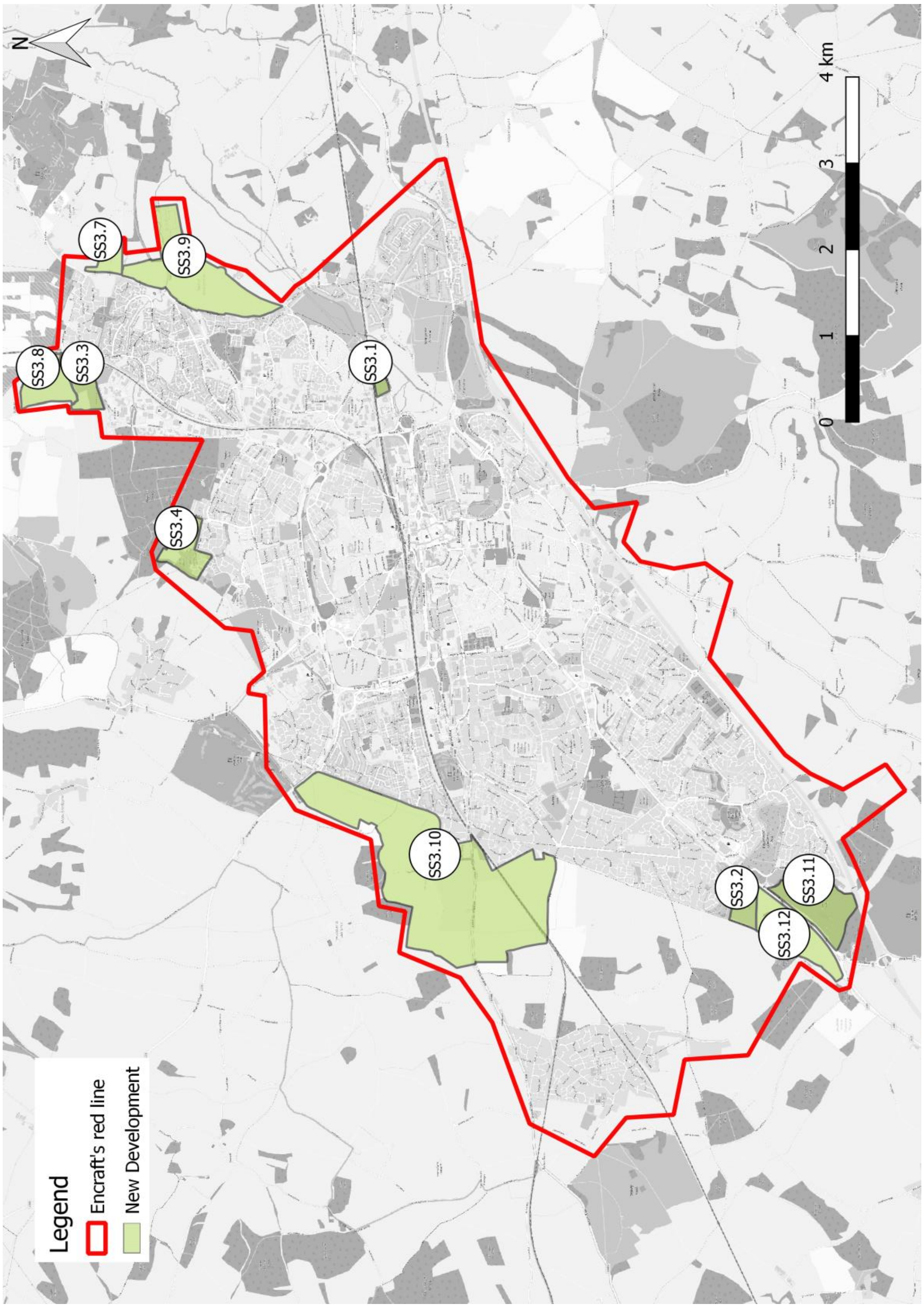


Figure 6: Strategic development sites

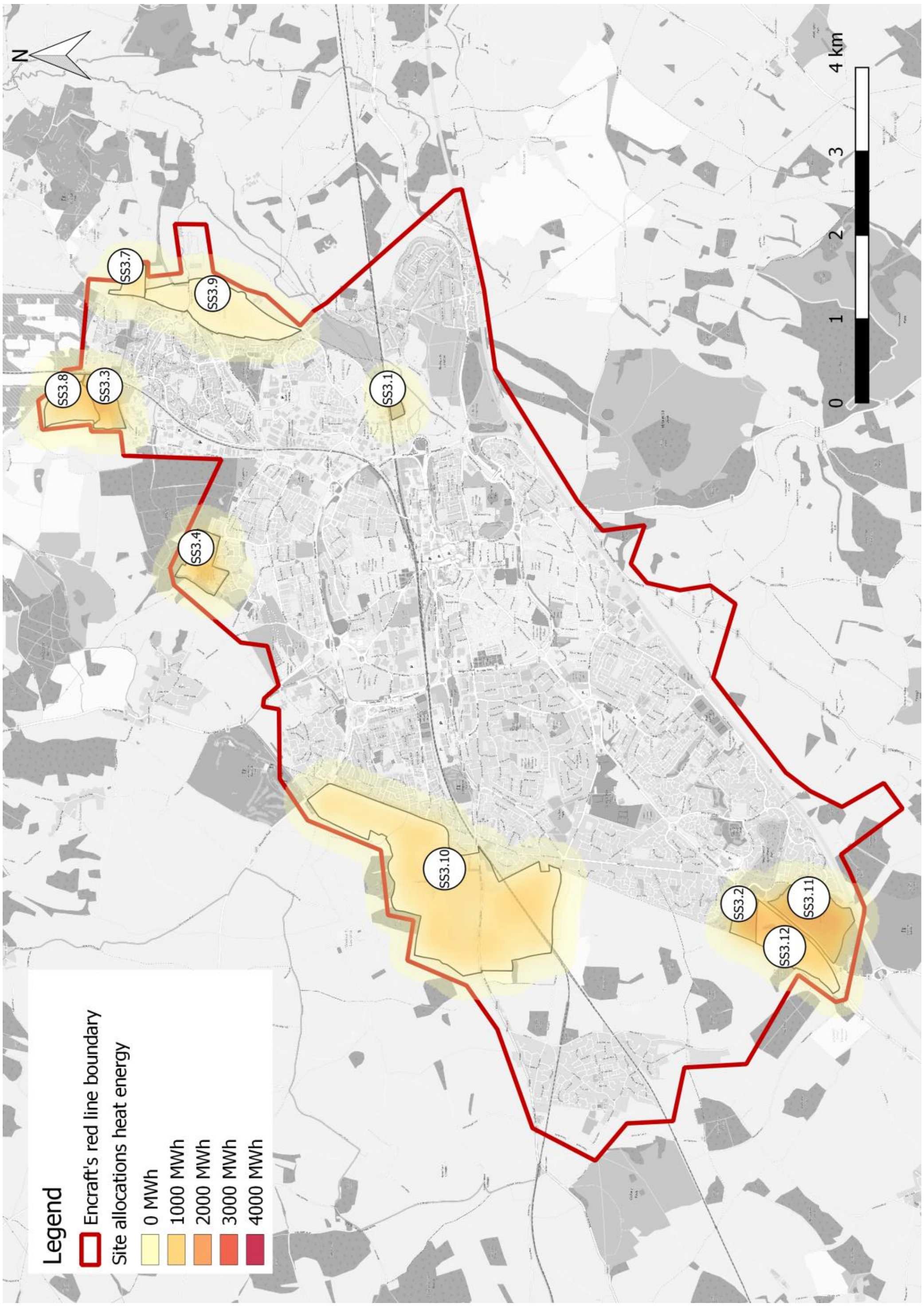


Figure 7: Heat energy density for the strategic development sites (MWh/year) [Benchmarked data]

Heat mapping validation

To provide confidence of the outputs from Work Package 1-Phase 1, the heat maps produced from benchmarking were validated against heat maps publically available from BEIS, and also electricity and gas consumption data collated by the Department for Business, Energy & Industrial Strategy for LSOAs (Lower layer super output area) and MSOAs (Middle layer super output area) across the project boundary. [Figure 8 - Figure 13]

A quantitative assessment of commercial and residential and commercial energy consumption across local LSOAs and MSOAs has shown that the benchmarked loads are within 30% of actual consumption. This is acceptable given the use of high-level benchmarks and the role of this data at this preliminary stage in the project.

Energy benchmarks for key loads will be replaced with real energy data wherever possible, to give increasing confidence in the modelling outputs.

Table 4: Evaluation of benchmarked loads vs. actual data

Benchmarked Commercial Electricity Consumption (MWh)	Actual Commercial Electricity Consumption (MWh)	Benchmarked Commercial Fossil Fuel Consumption (MWh)	Actual Commercial Gas Consumption (MWh)	% difference between measured and actual electricity consumption	% difference between measured and actual gas consumption
143,156 Includes cooling load	103,447	232,573	219,750	32%	6%

Benchmarked Residential Electricity Consumption (MWh)	Actual Residential Electricity Consumption (MWh)	Benchmarked Residential Fossil Fuel Consumption (MWh)	Actual Residential Gas Consumption (MWh)	% difference between measured and actual electricity consumption	% difference between measured and actual gas consumption
191,246	203,116	439,063	589,583	6%	29%

3.1.1 Validation against BEIS heat maps

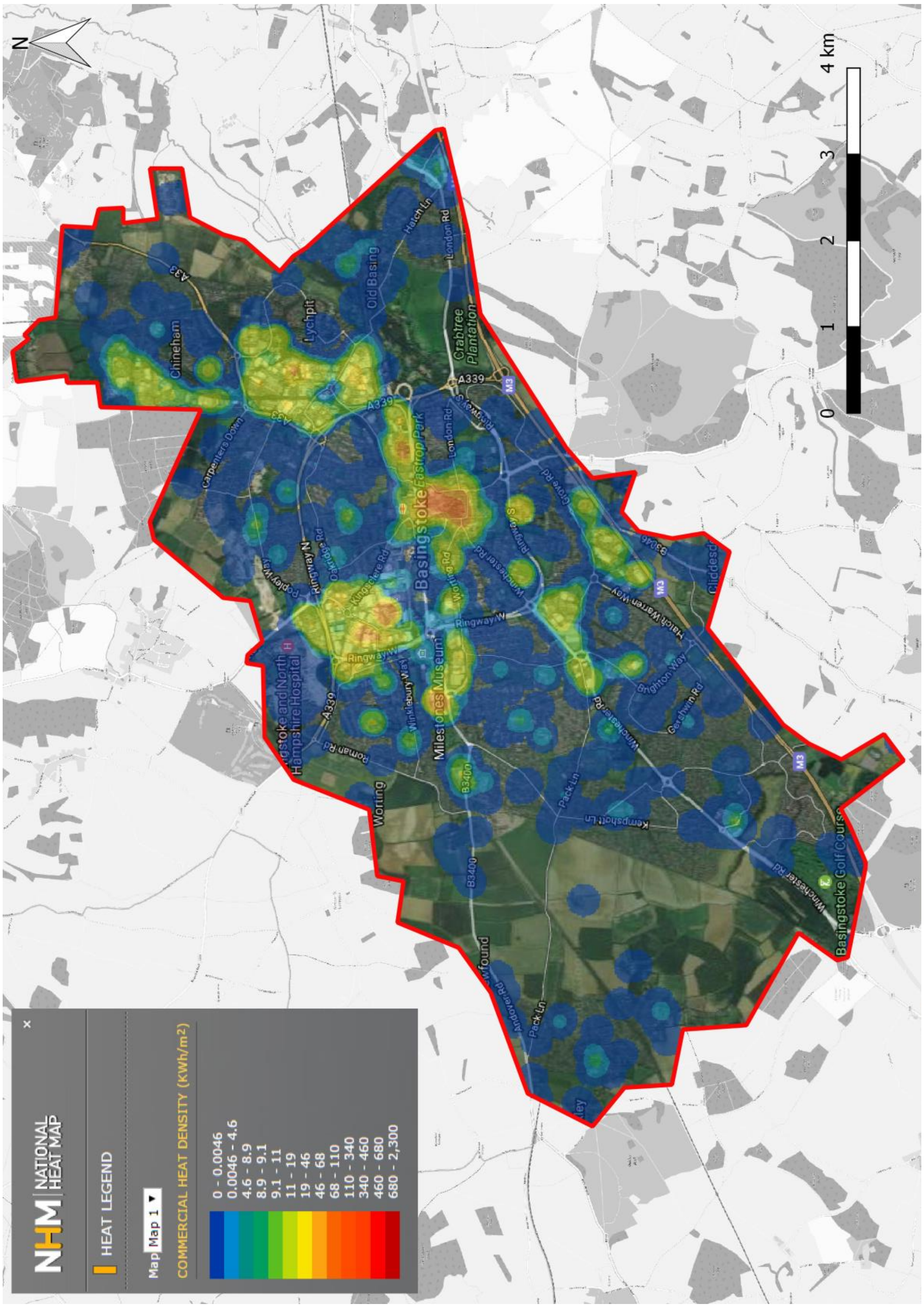


Figure 8: BEIS commercial heat energy (http://csembaa1.miniserver.com/index.html)

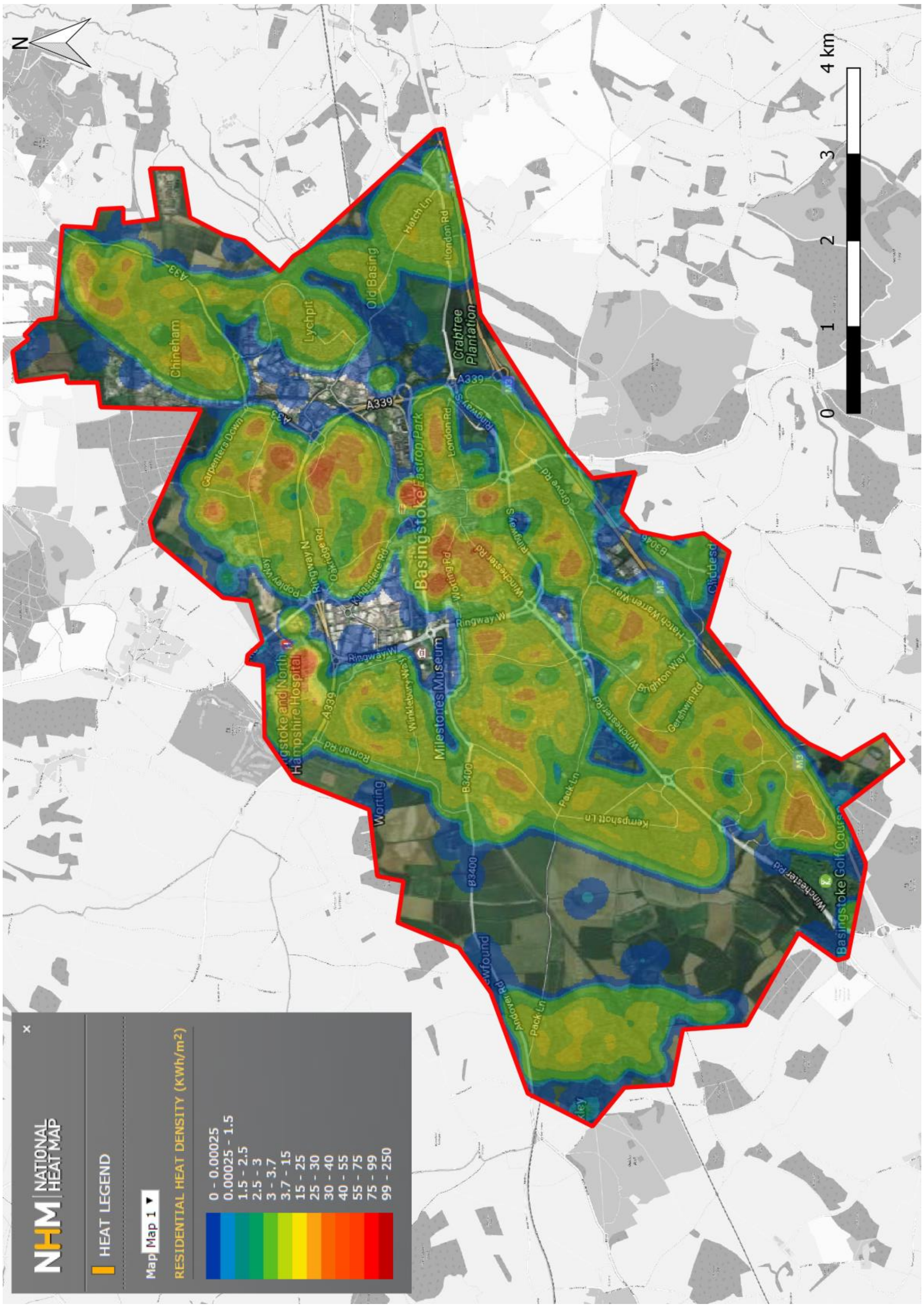


Figure 9: BEIS residential energy density (http://csembaa1.miniserver.com/index.html)

3.1.2 Validation against actual electricity and gas data across LSOAs and MSOAs

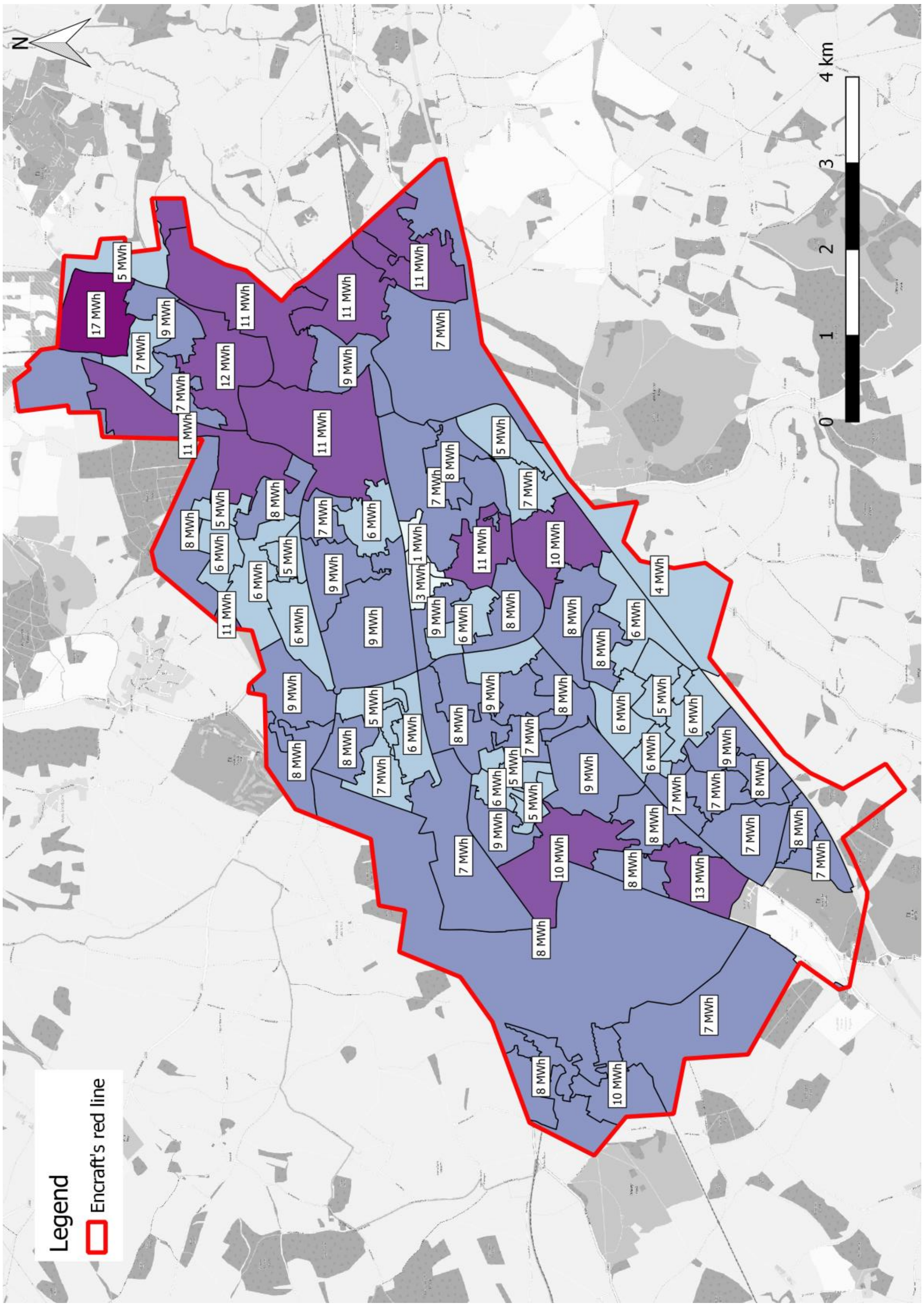


Figure 10: Actual residential gas consumption by LSOA (MWh/year)

*No gas data available for some non-critical LSOAs, which have been left as a transparent layer

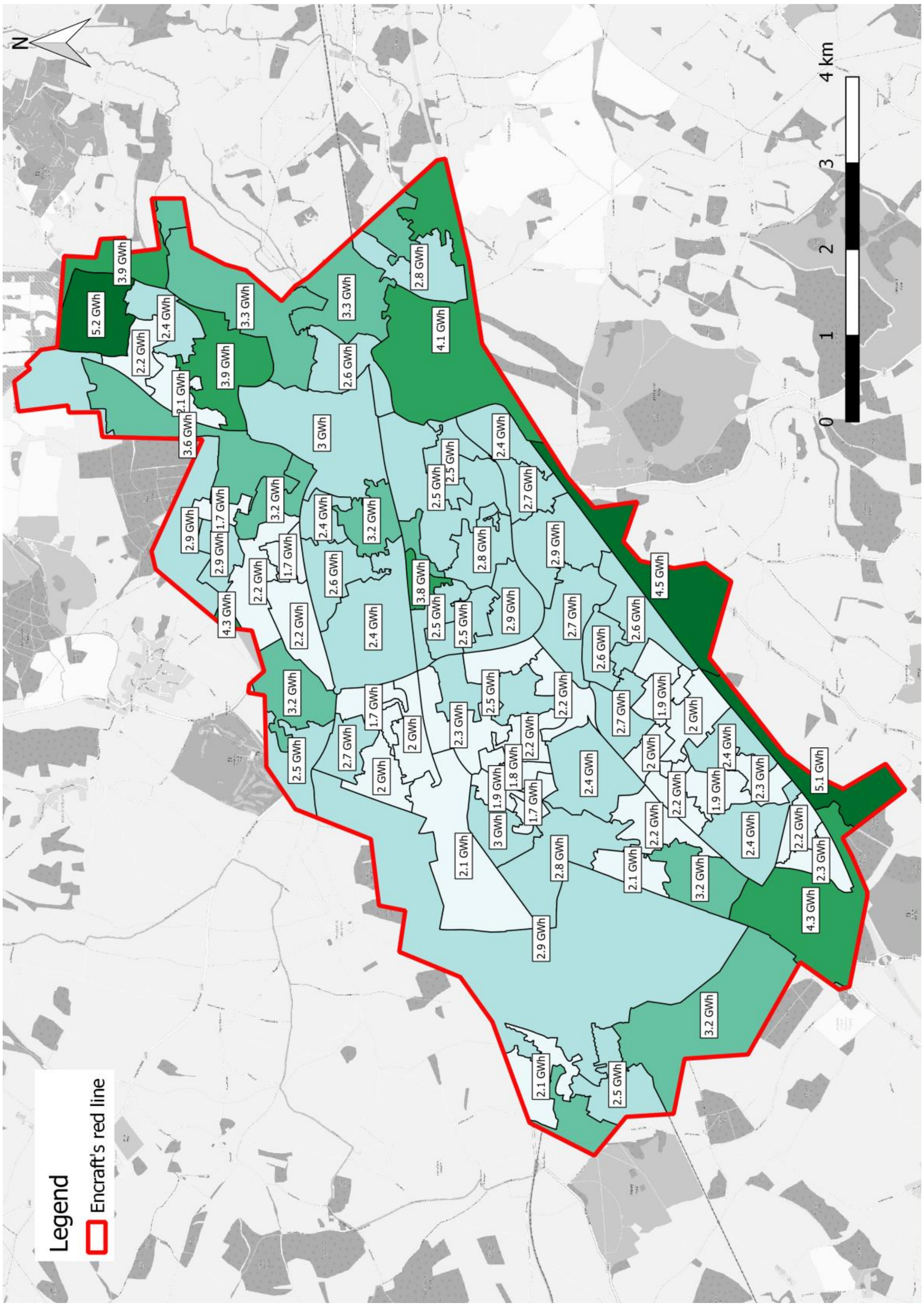


Figure 11: Actual residential electricity consumption by LSOA (MWh/year)

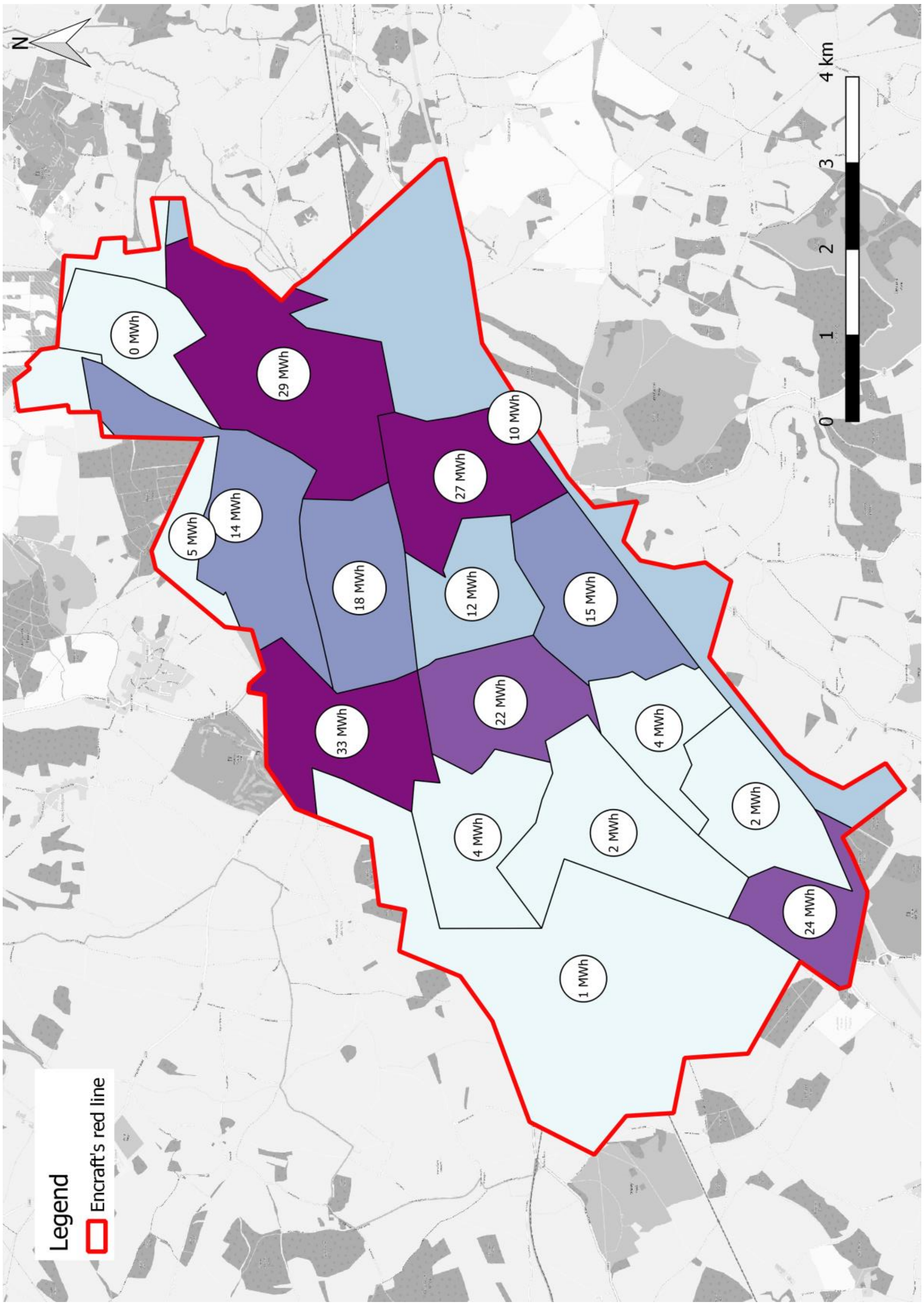


Figure 12: Actual commercial gas consumption by MSOA (MWh/year)

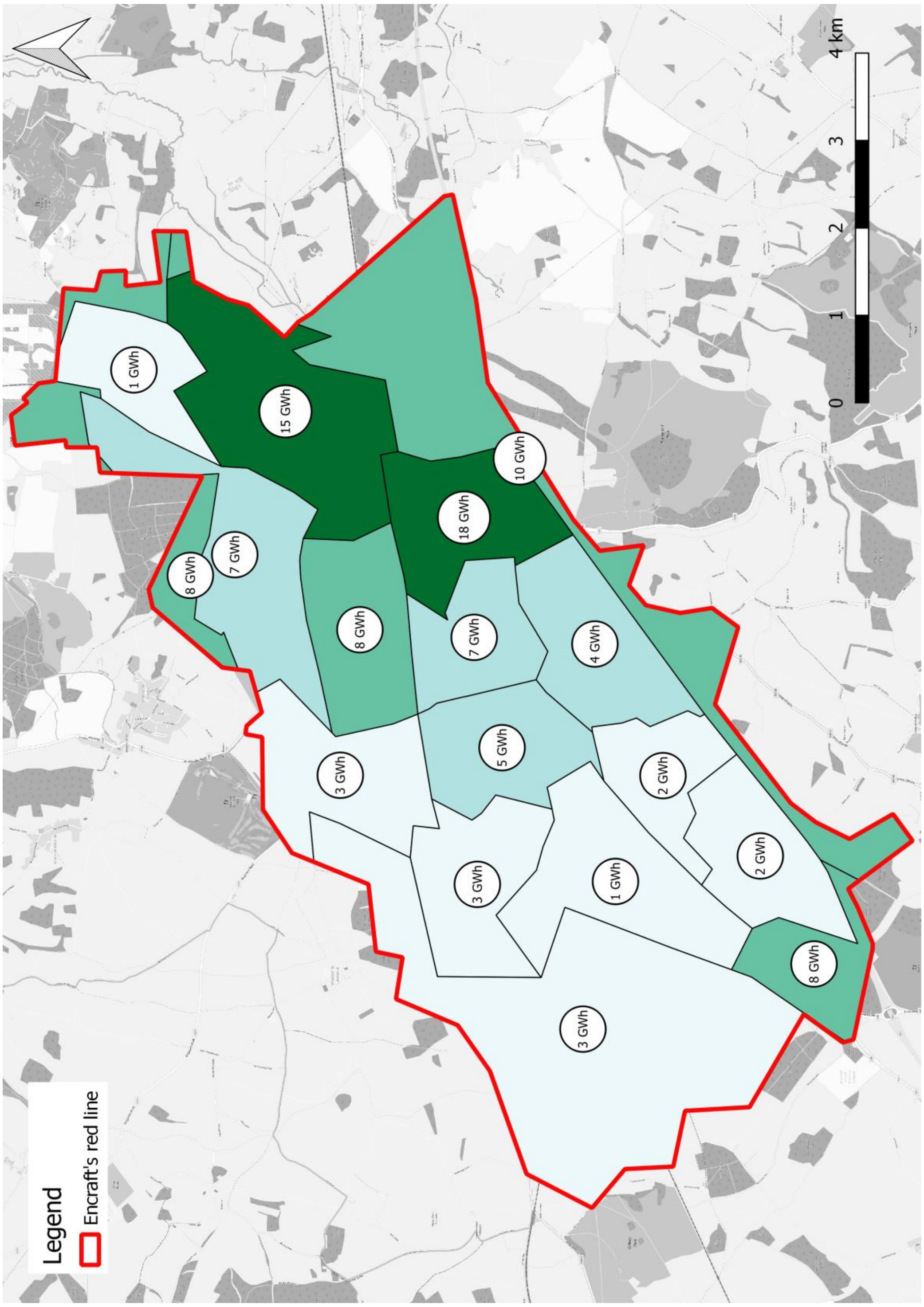


Figure 13: Actual commercial electricity consumption by MSOA (MWh/year)

4. Physical Constraints

In prioritising potential loads, a number of factors had to be considered. These are broadly discussed below; the major physical network constraints specific to the core clusters are discussed in detail later in the report.

Physical constraints
Railway crossings are very expensive and difficult to attain permission for, due to the critical infrastructure nature of the railway network. Unless there are very advantageous reasons or existing crossing points, railways are not considered feasible to cross with a heat network.

Major roads can also prove very expensive to cross and difficult for many of the same reasons, although less so. Bridges or underpasses can be used if the locations are beneficial and structural conditions can be met.

Rivers can be difficult to cross, although often less of a constraint than rail. Crossing points tend to be defined by existing bridges, as it is rarely economically viable to build a crossing structure purely for a heat network.

Ease of connection
Where large loads are available, these are considered 'easy to connect' due to the availability of a central plant room and also the existing systems and fuel use.

Where there are a number of smaller loads, such as the high street and existing residential properties, these are considered 'hard to connect' due to the existing infrastructure, tenancy and ownership arrangements. Existing residential is particularly difficult to connect in large numbers, although not impossible in the right circumstance, for example high-density social housing.

Finding the most efficient routes for pipework will drive the project priorities as 'hard dig', along existing roadways and infrastructure, is more expensive and difficult to achieve than 'soft dig', along open land. The routing of pipework is a balance between cost and effectiveness.

Figure 19 and Figure 20 depicts the land within the study area by dig type, and local constraints, and are good indicators of the likely cost of dig. A more detailed evaluation of pipe routing options is considered for each cluster taken forward for detailed modelling.

A comprehensive analysis of constraints will need to take place for any clusters then taken to detailed feasibility.

Figure 14: Land by dig type

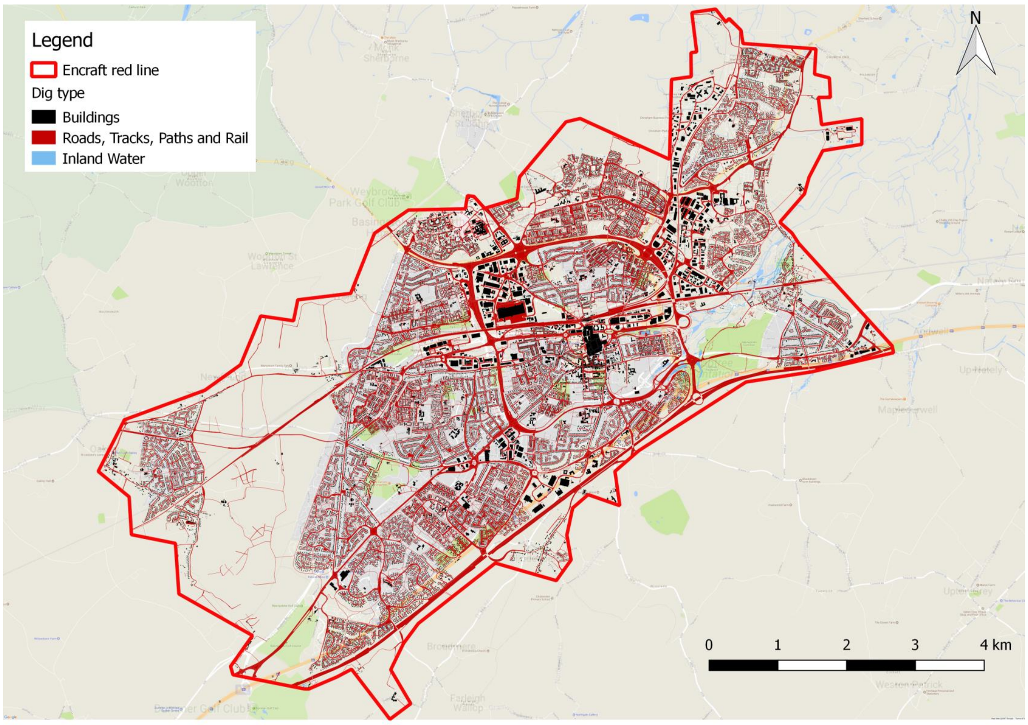


Figure 15: Local constraints

4.1 Energy system constraints

District heat networks can be particularly attractive propositions in off-gas areas, where residents and or businesses are reliant on costly heating options. Figure 21 show that there are few off-gas areas; those that exist are sporadically spread across the study boundary. The largest of these regions are located in largely uninhabited areas and do not intersect any regions of interest, whilst the others cover high-rise developments where electricity is the prevalent heating fuel.

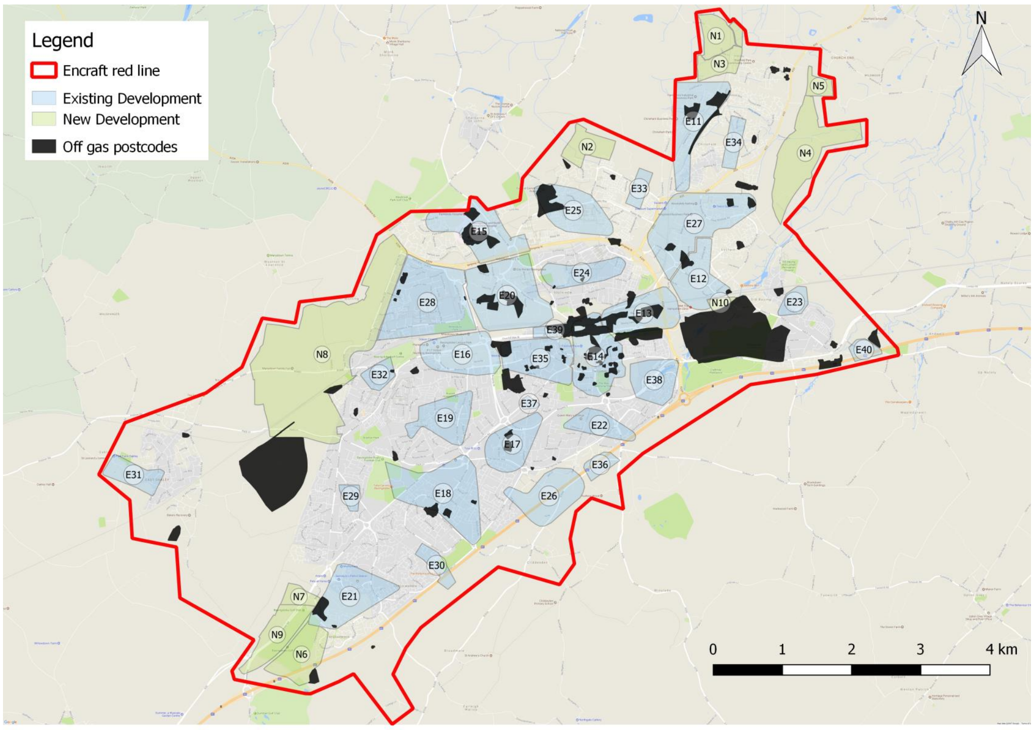


Figure 16: Off gas postcodes within study boundary

5. Preliminary cluster analysis results

The heat loads referenced in the table below were calculated prior to the majority of stakeholder engagement activities and the sourcing of building Display Energy Certificates, and so may be different to those referenced in the table of connected loads. The table below depicts the cluster analysis undertaken for existing buildings across the study area:

Cluster ID	Cluster Name	Cluster map area (m2)	Energy density per map square meter for top loads (MWh/m2/yr)	No. industrial addresses	Total No. addresses	Average building energy density (top loads) per GIFA kWh/m^2	No. municipal buildings	Anchor Load (Y:1; N:0)	Load Diversity of top loads (Distinct BLPU classes)	Local Priority Area (Y:1; N:0)	% addresses off gas	Major Constraint (Y:1; N:0)	Linear heat density for cluster top loads (MWh/m)	Viable heat network (Y:1; N:0; M:Micro cluster)
E11	Chineham Business Park	678,458	2	26	280	302	-		1	-	3	-	1	1
E12	Mars Drinks UK	464,801	2	109	244	889	-	1	1	-	1	-	20	0
E13	Basing View	529,849	35	2	385	1,340	-		2	1	1	1	5	1
E14	Town Centre	672,563	12	8	2,340	456	6	3	6	1	4	1	1	1
E15	North Hampshire Hospital	666,451	17	20	1,101	690	5	6	7	-	22	-	2	1
E16	Leisure Park	564,608	4	36	159	400	2	4	4	1	1	1	1	1

Cluster ID	Cluster Name	Cluster map area (m2)	Energy density per map square meter for top loads (MWh/m2/yr)	No. industrial addresses	Total No. addresses	Average building energy density (top loads) per GIFA kWh/m^2	No. municipal buildings	Anchor Load (Y:1; N:0)	Load Diversity of top loads (Distinct BLPU classes)	Local Priority Area (Y:1; N:0)	% addresses off gas	Major Constraint (Y:1; N:0)	Linear heat density for cluster top loads (MWh/m)	Viable heat network (Y:1; N:0; M:Micro cluster)
E17	Cranbourne Business and Enterprise College	431,502	2	57	366	197	2	1	2	-	1	1	1	1
E18	Brighton Hill Community College	944,001	1	4	1,238	203	5	1	3	-	0	1	0	1
E19	Hampshire County School	435,059	4	-	831	235	7		2	-	-	-	1	1
E20	Houndsmill Estate	984,868	0	96	262	98	-		1	-	3	-	3	1
E21	Sainsburys Supermarket	655,978	0	1	570	327	-		1	-	0	-	13	0
E22	Queens Mary College	262,363	6	-	179	407	1	2	3	-	-	-	1	1
E23	St Mary's CofE Junior School	129,549	2	-	88	157	-		1	-	-	-	2	M
E24	The Vyne School	342,261	6	1	413	199	7	1	3	-	0	-	1	1

Cluster ID	Cluster Name	Cluster map area (m2)	Energy density per map square meter for top loads (MWh/m2/yr)	No. industrial addresses	Total No. addresses	Average building energy density (top loads) per GIFA kWh/m^2	No. municipal buildings	Anchor Load (Y:1; N:0)	Load Diversity of top loads (Distinct BLPU classes)	Local Priority Area (Y:1; N:0)	% addresses off gas	Major Constraint (Y:1; N:0)	Linear heat density for cluster top loads (MWh/m)	Viable heat network (Y:1; N:0; M:Micro cluster)
E25	Alexanders Care and Support Agency	551,181	3	-	1,030	251	6		2	-	0	-	1	1
E26	Viables Industrial Estate	543,725	7	19	216	502	1		3	-	1	-	1	1
E27	Kingsland Business Park	995,436	2	108	685	518	4	1	3	-	1	1	2	1
E28	Fort Hill Community School	1,140,269	1	2	2,247	255	7	1	2	-	0	-	1	1
E29	Kempshott Schools	85,010	4	1	111	171	-		1	-	-	-	4	M
E30	Hatch Warren School	142,193	2	-	255	167	-		1	-	-	-	4	M
E31	Peter Houseman Recreation Ground	259,422	1	4	138	151	-		1	-	1	-	4	M
E32	The Academy Basingstoke	141,270	2	32	264	132	-		1	-	1	1	3	0

Cluster ID	Cluster Name	Cluster map area (m2)	Energy density per map square meter for top loads (MWh/m2/yr)	No. industrial addresses	Total No. addresses	Average building energy density (top loads) per GIFA kWh/m^2	No. municipal buildings	Anchor Load (Y:1; N:0)	Load Diversity of top loads (Distinct BLPU classes)	Local Priority Area (Y:1; N:0)	% addresses off gas	Major Constraint (Y:1; N:0)	Linear heat density for cluster top loads (MWh/m)	Viable heat network (Y:1; N:0; M:Micro cluster)
E33	Marnel Community Schools	118,723	3	-	152	116	2		2	-	-	-	1	1
E34	Chineham Medical Practice	155,624	1	-	221	110	-		1	-	-	-	2	M
E35	College of Technology	549,921	1	19	1,637	222	2		2	-	0	-	1	1
E36	Martins VW	114,083	11	1	144	409	-		2	-	-	-	3	1
E37	King's Furlong School	35,915	6	-	37	106	-		1	-	-	-	1	M
E38	Costello School	367,927	5	-	38	501	3	1	2	-	-	1	2	1
E39	Railway high-rise housing	101,631	22	-	831	182	-		1	-	1	-	2	1
E40	Martins VW	98,483	-	9	111	-	-		-	-	-	1	-	0

Cluster analysis for future residential site allocations:

Cluster ID	Cluster Area (m2)	Residential cluster heat load (MWh/yr)	Commercial cluster heat load (MWh/yr)	Total cluster energy load (MWh/yr)	Residential cluster energy density per map square meter (MWh/m2/yr)	Total cluster energy density per map square meter (MWh/m2/yr)	No. residential addresses	No. commercial addresses	Total No. addresses	Avg. energy density per address (MWh/address/yr)	Average building energy density per GIFA (kWh/m2)	No. municipal buildings	Anchor Load (Y:1; N:0)	Load Diversity (No distinct primary BLPU classes)	No. addresses off-gas	Waste heat available (Y:1; N;)
N 1	266,142	2,512	-	2,512	9	9	390	-	390	6	69	-	-	1	-	-
N 2	253,355	2,898	-	2,898	11	11	450	-	450	6	69	-	-	1	-	-
N 3	194,765	2,705	-	2,705	14	14	420	-	420	6	69	-	-	1	1	-
N 4	830,848	2,892	133	3,025	3	4	450	1	451	7	70	1	1	2	1	1
N 5	102,264	1,063	-	1,063	10	10	165	-	165	6	69	-	-	1	-	-
N 6	450,650	6,441	-	6,441	14	14	1,000	-	1,000	6	69	-	-	1	1	-
N 7	117,799	1,997	-	1,997	17	17	310	-	310	6	69	-	-	1	-	-
N 8	2,901,43	21,901	266	22,167	8	8	3,400	2	3,402	7	69	2	2	2	2	-

	8															
N 9	408,808	4,831	-	4,831	12	12	750	-	750	6	69	-	-	1	-	-
N 1 0	44,766	644	-	644	14	14	100	-	100	6	69	-	-	1	-	-

6. Energy supply technology options

There are a number of heating technologies that work well with heat networks. They are examined below. This appendix provides supplementary information to that referenced in the main report: *Heat supply opportunities and low carbon sources, and Energy supply options appraisal.*

Community Gas Boilers
The use of centralised gas-fired boilers supplying community heating can be ruled out almost immediately as a substitute for locally sited gas boilers. Although often technically viable, the marginal increase in efficiency offered by modern gas boilers is normally negated by network heat losses and energy centre running costs.

Combined heat and power (CHP)
Combined heat and power (CHP) integrates the production of usable heat and power (electricity), in one single, highly efficient process. CHP generates electricity whilst also capturing usable heat that is produced in this process.

Currently the main source of fuel for CHP is gas from the gas network. Where gas from anaerobic digesters is available, CHP can be a good match. CHP can also be run from gasified biomass, although this is a very immature technology currently.

CHP is particularly suited for heat networks as the electricity generated can be sold at a good profit, and can cross subsidise the heat tariff to provide heat at a competitive rate.

In order to sell the electricity a private wire network connection may need to be installed. On a private wire network, the electricity generator connects directly to the consumer over privately owned distribution assets, thus bypassing the public network. Top-up and backup power is normally provided by the public network at a single connection point.

In the UK, the value of CHP electricity depends very much on the trading arrangement. Direct sales for surplus electricity exported to the National Grid yields rather low value for the electricity produced; whereas utilising all electricity generated on the site that by selling it through a private wire network at a local level can fetch a price comparable to retail tariffs. Obviously the private wire network requires investment and entails other costs (e.g. operation and maintenance).

CHP can provide opportunities to provide grid capacity control, depending on scale and location. This is beyond the scope of this report.

Gas CHP produced electricity is regarded as low carbon because it is currently considerably less carbon intensive than grid electricity. This is due to the grid incurring losses through transmission and distribution, alongside the fact that carbon intensive sources such as coal are currently used in the production of grid electricity. This will not always be the case. Over the next ten years or so it is predicted that the carbon intensity of the grid will decrease dramatically as coal fired power stations are decommissioned, and more renewables and nuclear are commissioned [Figure 17]. This may mean that there will be times when gas CHP electricity is not considered low carbon. For example in the summer when solar, wind and nuclear are the primary generators. There will still be a role for gas CHP but it may not be straightforward. If hydrogen is introduced to the gas network, this will provide more complexity to the picture.

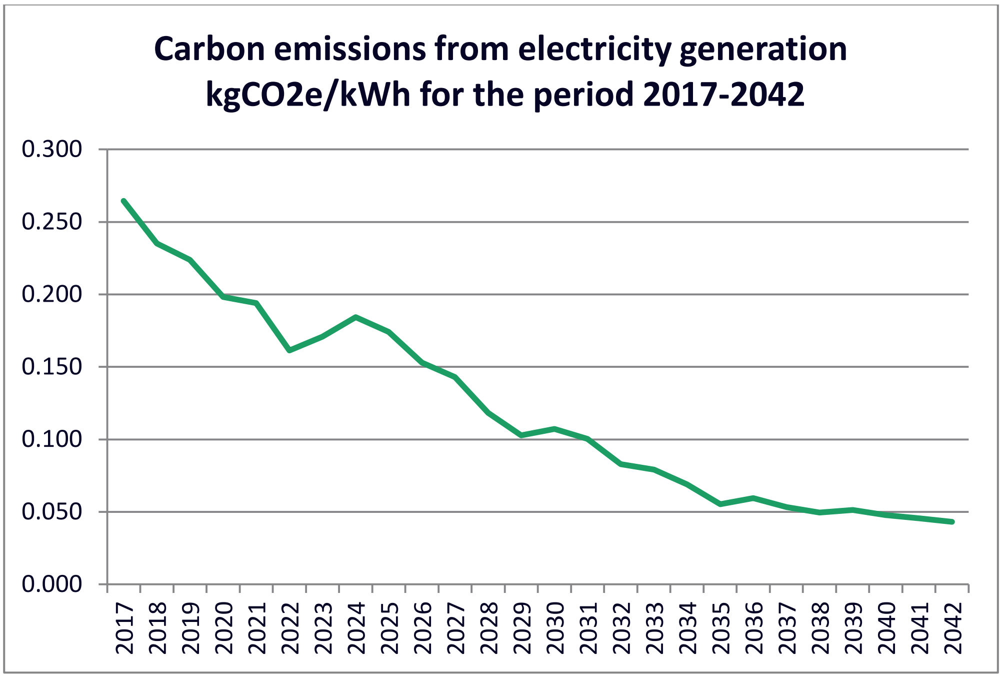


Figure 17: Carbon emissions from electricity generation up to 2042. (BEIS - Grid average - Generation based

Biomass boilers

Biomass can provide a very low carbon energy source, in the right situation. Commercial Scale biomass boilers can be fuelled using wood pellets or chips. Wood chip tends to be cheaper, but require better quality boilers to run efficiently and cleanly.

There are a number of concerns regarding using biomass in a built up area.

- Biomass requires use of a large space, and due to wood storage requirements this often conflicts with the value of land within urban areas. A 1MW biomass plant working 24/7 would require 500m^3 of storage to store 14 days-worth of wood chip at peak load. This is equivalent to 3 x 40ft shipping containers, in addition to space required for plant.
- Biomass plants do have issues with air quality under Clean Air Act 1993 and this often acts as an obstacle to their implementation as heat networks work best in dense urban areas, where air quality can already be an issue.
- If steam and high pressures are used, then public safety concerns can be an issue.
- Delivery transport can also cause pollution issues due to increased traffic for fuel delivery.

- Biomass boilers are more expensive, and can be more costly to maintain than an equivalent gas boiler or CHP unit. They also need more downtime.
- Where biomass is considered financially viable this is often due to the renewable heat incentive (RHI), which is a government scheme that pays per unit of low carbon heat generated. The security of this as an income is currently under consultation and can't currently be guaranteed.

BioGasification is a process that converts organic carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called syngas (from synthesis gas) or producer gas and is itself a fuel. The power derived from gasification and combustion of the resultant gas is considered to be a source of renewable energy if the gasified compounds were obtained from biomass.

In small business and building applications, where the wood source is sustainable, 250-1000 kWe and new zero carbon biomass gasification plants have been installed in Europe that produce tar free syngas from wood and burn it in reciprocating engines connected to a generator with heat recovery. This type of plant is often referred to as a wood biomass CHP unit but is a plant with seven different processes: biomass processing, fuel delivery, gasification, gas cleaning, waste disposal, electricity generation and heat recovery.

This technology is still very immature in the UK but may provide a potential roadmap from gas-based CHP in the future to using lower carbon energy sources.

Heat Pumps
DECC published a report in February 2016 which recognises the value of using heat pumps in District Heating to lower carbon emissions in place of central gas boilers or gas based CHP. The full report 'Heat Pumps in District Heating' runs to 135 pages. The following is an extract of some of the key findings:

- Alongside a decarbonising grid, integrating heat pumps into district heating offers large CO_2 emissions reduction potential.
- The analysis showed that incorporating heat pumps into district heating schemes has the potential, in the context of a rapidly decarbonising electricity grid, to offer large CO_2 savings relative to district heating based on either gas-CHP (for large schemes) or gas boilers (for small schemes). Assuming the current trajectory towards low carbon electricity generation, we found CO_2 savings versus gas burning schemes in the range 48-84%.

CO_2 savings are greater where the following scheme characteristics are combined:

- Heat pumps provide a larger fraction of the heating
- Heat pumps operate with a lower source-sink temperature difference, leading to increased efficiency
- Network thermal losses are lower, especially for lower temperature distribution networks with building integrated heat pumps

The expense of adding in heat pumps where existing plant rooms have plant and gas connections already available may make heat pumps an expensive alternative to using gas boilers and gas CHP units. This will lead to the heat price being higher than for a CHP/boiler approach due to not being able to recover the costs of installation. Where a low carbon electricity source is used then heat pumps can offer a large carbon saving over conventional heat sources.

Heat pumps alone may not be able to provide peak loads, and so use of thermal store and top up boilers may be required.

Heat pumps can be installed with heat sinks in boreholes, shallow 'slinky', or in a water body.

Ground Source Heat Pumps

Ground source heat pumps use the ambient temperature of the ground as a heat sink/ source. There two types; borehole and surface.

Boreholes can be expensive to install but provide the most reliable and effective heat sources. They are less prone to seasonal variation than other heat sinks.

Surface heat sinks require coils of pipe to be installed in shallow trenches. They need a large area to be effective.

Water source heat pumps

Water source heat pumps can be either open or closed systems. Where a large body of water is available, closed loop systems can be a cheaper alternative to shallow ground source sinks as the coils are literally dropped in open water(such as a canal). Open systems, where the water is extracted directly from the water source to be run through a heat exchanger, can be very effective and cheap, but can need to be designed and maintained very well.

7. Stakeholder workshop attendees list

Basingstoke project prioritisation workshop 15/09/17

Attendees	Organisation
Jim Lott	Encraft
James Wayman	Encraft
Martin Kerslake	External consultant working on behalf of Encraft
Sarah Muskett	Basingstoke and Deane Borough Council
Lucy Martins	Basingstoke and Deane Borough Council
Mike Bovis	Basingstoke and Deane Borough Council
Kerry De Rosa	Basingstoke and Deane Borough Council
Edward Rehill	Basingstoke and Deane Borough Council
Matt Melville	Basingstoke and Deane Borough Council
Peter Gunner	Basingstoke and Deane Borough Council
Carlos Mascarenhas	Veolia
Andy Macqueen	Veolia
Gillian Brown	North Hampshire Hospital
Andy Drover	North Hampshire Hospital
Paul Bond	North Hampshire Hospital
Michael Aslin	Anvil Arts

8. Modelling Assumptions

The modelling assumptions provided below have been taken from credible sources and tailored for the project.

Model assumptions

Default model assumptions	
Model start year	2020
Model life (default)	25
Discount rate (default)	3.5%
RHI lifetime (years)	20
Inflation	3.0%

Whole life costing

Capital and operating costs of heat raising plant

Technology	CAPEX	OPEX (£/kWth/yr)	Replacement period (yrs)	Fraction of CAPEX to replace (%)
Gas CHP	£800/kWe	£20/kWth	20	80%
Counterfactual and top-up gas boilers	£70/kWth	£6/kWth	12	90%
Biomass heat (1000kW)	£300/kWth	£18/kWth	20	80%
Water Source Heat Pump (including power supply)	£2,230/kWth	£9/kWth	15	80%

CAPEX assumptions are generally based on experience and discussions with equipment manufacturers, suppliers and pipework contractors over a number of other projects. These have also been confirmed or supplemented by a number of real quotations across a range of other projects.

Real CHP engine efficiency data has been used to model the schemes. We have calculated the heating energy which we believe could be supplied by CHP, and anticipate that exact sizing will be carried out during a full feasibility study.

CHP CAPEX has been taken as £800/kWe and typically sized for 40% of the peak heat load. Where gas CHP is proposed a top-up gas boiler has been modelled to provide 80% of the remaining heat load; the rest being met through thermal storage.

Manufacturers indicate that typical maintenance contracts for CHP are 15 years based on running 8,000 hrs/yr. and this equates to ~120,000 hours total engine life. However, most machines will run closer to 6,000hours/yr. and the anticipated life is therefore around 20 years. In practice some engines in this size range are still running well over 120,000 hrs.

Biomass CAPEX varies with the size of plant. In general, the larger the machine, the lower the £/kWe but a 1,000kW plant has been taken as £300/kW fully installed and commissioned (excluding boiler house costs).

Heat pump CAPEX varies with the size of machine and overall size of each project. In general, the larger the machine the lower the £/kWe. Heat pump coefficient of performance (COP) has been assumed to be 3.0.

Other network capital and operational costs

Pipework capex has been split into 'spine' pipework and smaller secondary connection pipework. Spine pipework has been mapped and measured. This is assumed to be buried pre-insulated pipework between £700/m in soft dig where there are no obstacles and £1,300/m in hard dig.

At this master planning stage, the length of secondary connection pipework from the spine to each building has been estimated. Secondary pipework is assumed to be buried pre-insulated plastic (PEX) at £500-1000/m per metre depending upon size and dig conditions. PEX is cheaper, easier to install and can be connected to steel pipework. Where pipes can be routed in areas of soft dig, such as football field, green walkways and tow paths, pipe costs can be significantly minimised.

Additional costs have been included where significant barriers need to be crossed e.g. railway lines and major roads.

Heat network maintenance costs have been applied at a rate of £5/meter.

CAPEX costs		
Pipework - spine - hard dig	1,300	£/m
Pipework - secondary - hard dig	1,000	£/m
Pipework - spine - soft dig	700	£/m
Pipework - secondary - soft dig	500	£/m
Pipework - road crossing	2,600	£/m
Pipework - rail crossing/water crossing	3,900	£/m
Energy centre build costs	1000	£/m2

CAPEX costs		
Plant room pumps, controls	0.008	£/kWth
Thermal storage	1,000	£/m3
Heat interface unit (residential)	1,000	£/connection
Heat interface unit (commercial)	10,000	£/connection
Metering connection (residential)	600	£/connection
Metering connection (commercial)	3,000	£/connection
Private Wire (where wire can be placed in pipe trench)	100	£/m
Private Wire (where wire cannot be placed in pipe trench)	200	£/m

Thermal storage has been sized assuming the requirement for 0.014m3/MWh as per referenced by DECC in the report: *Assessment of the costs, performance, and characteristics of UK Heat Networks.*

Heat meter maintenance is assumed to be a flat rate of £3/MWh thermal.

Business rates have been applied at a rate of £6/MWh thermal, alongside annual staffing costs for metering, billing and revenue collection at a rate of £11/MWh; both in accordance with the DECC report: *Assessment of the costs, performance, and characteristics of UK Heat Networks.*

Once total project CAPEX has been estimated we have included a further 2% for commissioning, 5% for design fees, 5% for project management fees and a 10% contingency. Although this adds 22% to project capex we believe this is realistic and prudent.

District Heating

We have assumed a ΔT of 30°C DH system flow-return temperature differential with losses given below (flow-return temperature of 70-40°C).

	% of heat output
Distribution pumping energy	2
Losses (as % of final energy)	10

Carbon factors

Carbon factors have been taken from DEFRAs greenhouse gas reporting factors.

Carbon conversion factors (Gross CV basis)		
Gas	0.00018	t CO2e/kWh
Biomass	0.00001	t CO2e/kWh
Electricity	See forecasted factors below	-
District heat	0.00020	t CO2e/kWh

Forecasted electricity carbon conversion factors:

Year	Grid average			
	Consumption-based			Generation-based
	Domestic	Commercial/ Public sector	Industrial	
2017	0.290	0.285	0.280	0.265
2018	0.258	0.253	0.248	0.235
2019	0.245	0.241	0.236	0.224
2020	0.217	0.213	0.209	0.198
2021	0.213	0.209	0.205	0.194
2022	0.177	0.174	0.170	0.161
2023	0.187	0.184	0.181	0.171
2024	0.202	0.198	0.195	0.184
2025	0.191	0.188	0.184	0.174
2026	0.168	0.165	0.162	0.153
2027	0.157	0.154	0.151	0.143
2028	0.130	0.127	0.125	0.118
2029	0.113	0.111	0.109	0.103
2030	0.117	0.115	0.113	0.107
2031	0.110	0.108	0.106	0.100
2032	0.091	0.089	0.088	0.083
2033	0.087	0.085	0.084	0.079
2034	0.076	0.074	0.073	0.069
2035	0.061	0.060	0.058	0.055
2036	0.065	0.064	0.063	0.060
2037	0.059	0.057	0.056	0.053

Year	Grid average			
	Consumption-based			Generation-based
	Domestic	Commercial/ Public sector	Industrial	
2038	0.054	0.053	0.052	0.049
2039	0.056	0.055	0.054	0.051
2040	0.052	0.051	0.050	0.048
2041	0.050	0.049	0.048	0.045
2042	0.047	0.047	0.046	0.043
2043	0.045	0.044	0.043	0.041
2044	0.042	0.042	0.041	0.039
2045	0.040	0.039	0.039	0.036
2046	0.038	0.037	0.036	0.034
2047	0.035	0.034	0.034	0.032
2048	0.033	0.032	0.031	0.030
2049	0.030	0.030	0.029	0.027
2050	0.028	0.027	0.027	0.025
2051	0.028	0.027	0.027	0.025
2052	0.028	0.027	0.027	0.025
2053	0.028	0.027	0.027	0.025
2054	0.028	0.027	0.027	0.025
2055	0.028	0.027	0.027	0.025
2056	0.028	0.027	0.027	0.025
2057	0.028	0.027	0.027	0.025
2058	0.028	0.027	0.027	0.025
2059	0.028	0.027	0.027	0.025
2060	0.028	0.027	0.027	0.025
2061	0.028	0.027	0.027	0.025
2062	0.028	0.027	0.027	0.025
2063	0.028	0.027	0.027	0.025
2064	0.028	0.027	0.027	0.025
2065	0.028	0.027	0.027	0.025

Energy Prices

Heat Supply - We have assumed a heat sales price of 4.66p/kWh from the CHP plant for both residential and commercial customers. Any more than 4.6p/kWh is likely to discourage customers connecting, any less reduces the revenue and return on investment even further. This is based on information from the Department of Energy and Climate Change (2015).

A gas price of 2.03p/kWh has been used, assuming an 80% boiler efficiency.

Private Wire Electricity Supply - Electricity sales have been assumed to be 8.00p/kWh for commercial customers. We have assumed private wire sales on a residential network would not be practical. This price is based on standard private wire prices provided by other schemes in operation.

Energy prices		
Heat retail price	0.4660	£/kWh
Gas purchase price	0.0203	£/kWh
Biomass feedstock purchase price (Source: Basingstoke Biomass Energy Cooperative)	0.031	£/kWh
Electricity purchase price	0.0999	£/kWh
Export electricity price	0.0491	£/kWh
Electricity sales price	0.0800	£/kWh

Renewable Heat Incentive

We have assumed that RHI will be available for the biomass proportion of heat supplied at the current non-domestic RHI rate. The first tier of RHI can be applied up to the first 1314hours of plant operation, after which tier 2 comes into force.

RHI prices (Ofgem)		
RHI (biomass <200kWth) - Tier 1	0.0271	£/kWhth
RHI (biomass <200kWth) - Tier 2	0.0071	£/kWhth
RHI (WSHP) - Tier 1	0.0909	£/kWhth
RHI (WSHP) - Tier 2	0.0271	£/kWhth

CCL

CCL has been applied to gas boiler input fuel providing heat for commercial heat loads; sourced from HM Revenue and Customs.

CCL prices		
CCL rate (gas)	0.00198	£/kWh
CCL rate (Electricity)	0.00568	£/kWh

9. Connected Loads

The table of connected loads provides an overview of all of the addresses considered for connection to a network during the modelling works; their heating and electricity demand, and whether these demands were based on real meter data, Display Energy Certificates, or industry energy benchmarks.

Cluster	Phase	Building	Heating data source	(Non-electric) Heating demand (kWh)	Electricity data source	Electricity demand (kWh)
Cluster E13	1	Village Hotel (with swimming pool)	Benchmark	2,898	Benchmark	1,124
Cluster E13	1	BELVEDERE HOUSE	Benchmark	1,519	Benchmark	5,328
Cluster E13	1	NORTHERN CROSS	Benchmark	1,515	Benchmark	2,241
Cluster E13	1	Business Environment Offices & Adjacent Complex	Benchmark	1,277	Benchmark	1,889
Cluster E13	1	NETWORK HOUSE	Benchmark	738	Benchmark	1,092
Cluster E13	1	MOUNTBATTEN HOUSE	Benchmark	-	Benchmark	6,950
Cluster E13	2	ENI ENGINEERING E & P HOUSE	Benchmark	1,280	Benchmark	1,893
Cluster E13	2	MATRIX HOUSE	Benchmark	1,254	Benchmark	1,856
Cluster E13	2	SOUTHERN CROSS	Benchmark	1,000	Benchmark	1,480
Cluster E13	2	UNUM HOUSE	Benchmark	383	Benchmark	567
Cluster E13	2	QUANTUM HOUSE	Benchmark	412	Benchmark	609
Cluster	3	WAITROSE	Benchmark	1,228	Benchmark	1,758

E13						
Cluster E13	3	JOHN LEWIS	Benchmark	1,011	Benchmark	1,447
Cluster E13	3	Basingstoke Campus	Benchmark	-	Benchmark	3,777
Cluster E14	1	Indigo Business Centres	Benchmark	50	Benchmark	75
Cluster E14	1	Civic Offices	Meter data	873	Meter data	1,239
Cluster E14	1	Costello School	Meter data	719	Meter data	505
Cluster E14	1	Magistrates Court	Meter data	162	Meter data	220
Cluster E14	2	Fairfields Primary School	Meter data	137	Meter data	914
Cluster E14	2	Lady Susan Court	N/A	-	Benchmark	604
Cluster E14	2	Premier Inn	Benchmark	693	Benchmark	286
Cluster E14	3	Debenhams PLC	Benchmark	-	Benchmark	3,655
Cluster E14	3	M&S	Benchmark	-	Benchmark	2,284
Cluster E14	3	Next (BHS)	Benchmark	-	Benchmark	1,083
Cluster E14	3	The Anvil Trust	Meter data	542	Meter data	529
Cluster E14	3	Haymarket Theatre	Meter data	174	Meter data	134
Cluster E14	3	Festival Place Communal Heating	Meter data	206	Meter data	3,727
Cluster E14	3	Barclays	Benchmark	1,776	Benchmark	2,628
Cluster	3	Scott House	Benchmark	1,334	Benchmark	987

E14						
Cluster E14	3	Basingstoke Sports Centre	Benchmark	1,032	Benchmark	511
Cluster E14	3	AXA (Phoenix Life)	Benchmark	852	Benchmark	1,124
Cluster E15	1	Hospital (Ward Block, Sherborne, Firs, Acute Assessment Unit, ARK, Lasham Building)	Meter data	23,206	Meter data	10,319
Cluster E15	1	Candover Clinic	Meter data	217	Meter data	642
Cluster E15	2	St Michaels Hospice	Benchmark	-	Benchmark	77
Cluster E15	2	Castle Hill Primary	Benchmark	147	Benchmark	30
Cluster E15	2	Viridian Residential	Meter data	1,344	Meter data	394
Cluster E15	2	Homefield House	Meter data	480	Benchmark	53
Cluster E15	3	Ambulance	Meter data	56	Benchmark	40
Cluster E15	2	Headway Place	Meter data	108	Benchmark	19
Cluster E15	2	Fairway House	Meter data	460	DEC	79
Cluster E15	2	Firvale	Meter data	24	Meter data	77
Cluster E15	1	Parklands Hospital	Meter data	1,558	Meter data	855
Cluster E15	2	NHS Property Services	DEC	0	DEC	51
Cluster E15	2	Rooksdown Community Centre	Benchmark	67	Benchmark	14

Cluster E15	3	Apollo Hotel	Benchmark	779	Benchmark	322
Cluster E15	3	Eli Lilly	Benchmark	1,878	Benchmark	2,478
Cluster E15	3	Just Learning Nursery	Meter data	120	Meter data	32
Cluster E16	1	Basingstoke Aquadrome	DEC	7,924	DEC	1,269
Cluster E16	1	Ice Rink	Benchmark	672	Benchmark	333
Cluster E16	1	Wessex Bowl	Benchmark	359	Benchmark	178
Cluster E16	1	Odeon Cinema	Benchmark	1,921	Benchmark	676
Cluster E16	1	Gala Clubs (Bingo)	Benchmark	-	Benchmark	1,537
Cluster E16	1	Premier Inn Hotel	Benchmark	691	Benchmark	286
Cluster E16	2	iFly Indoor Skydiving	Benchmark	-	Benchmark	256
Cluster E16	2	Loddon Vale Indoor Bowling Club	Benchmark	367	Benchmark	182
Cluster E16	2	Milestones Museum	Benchmark	649	Benchmark	444
Cluster E16	2	Parcelforce Worldwide	Benchmark	1,080	Benchmark	599
Cluster E16	2	BIOMERIEUX UK LTD	Benchmark	543	Benchmark	301
Cluster E16	2	Johnsons Apparel Master	DEC	616	DEC	25
Cluster E16	2	Basingstoke Fire Station	Benchmark	403	Benchmark	135
Cluster E16	2	Lidl Supermarket	Benchmark	3104	Benchmark	379

10. Miscellaneous full size maps

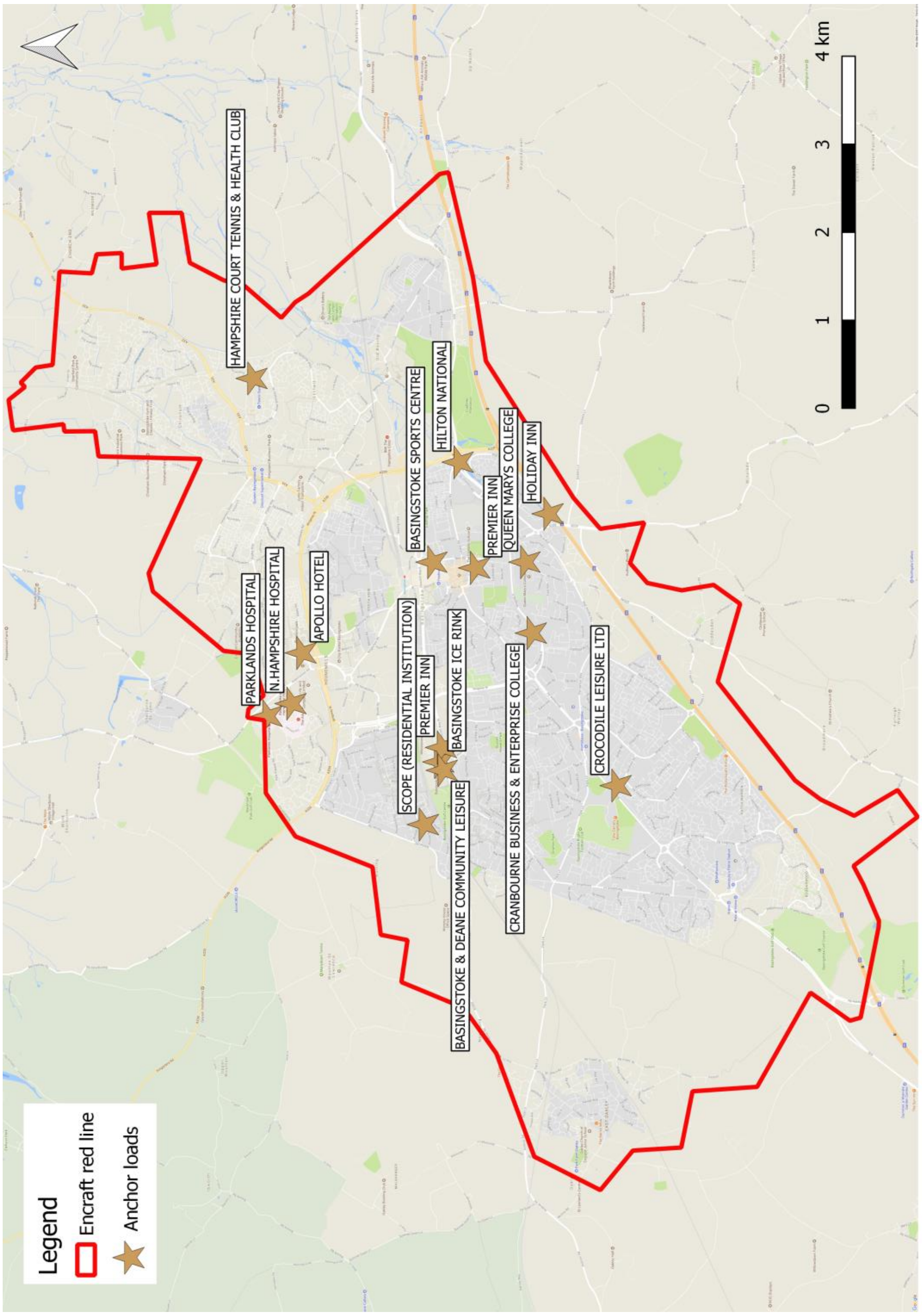


Figure 18: Significant loads across study area

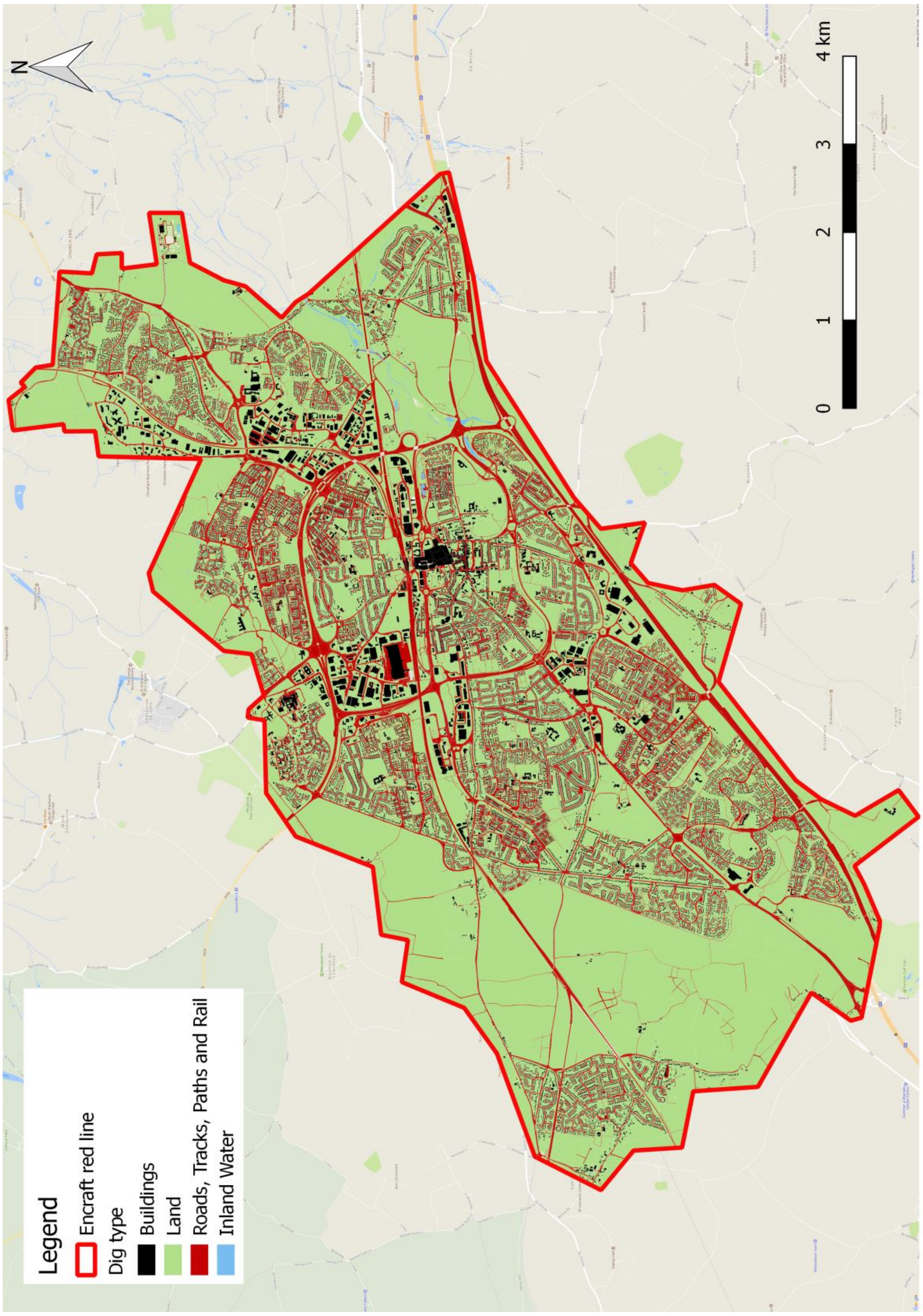


Figure 19: Land by dig type

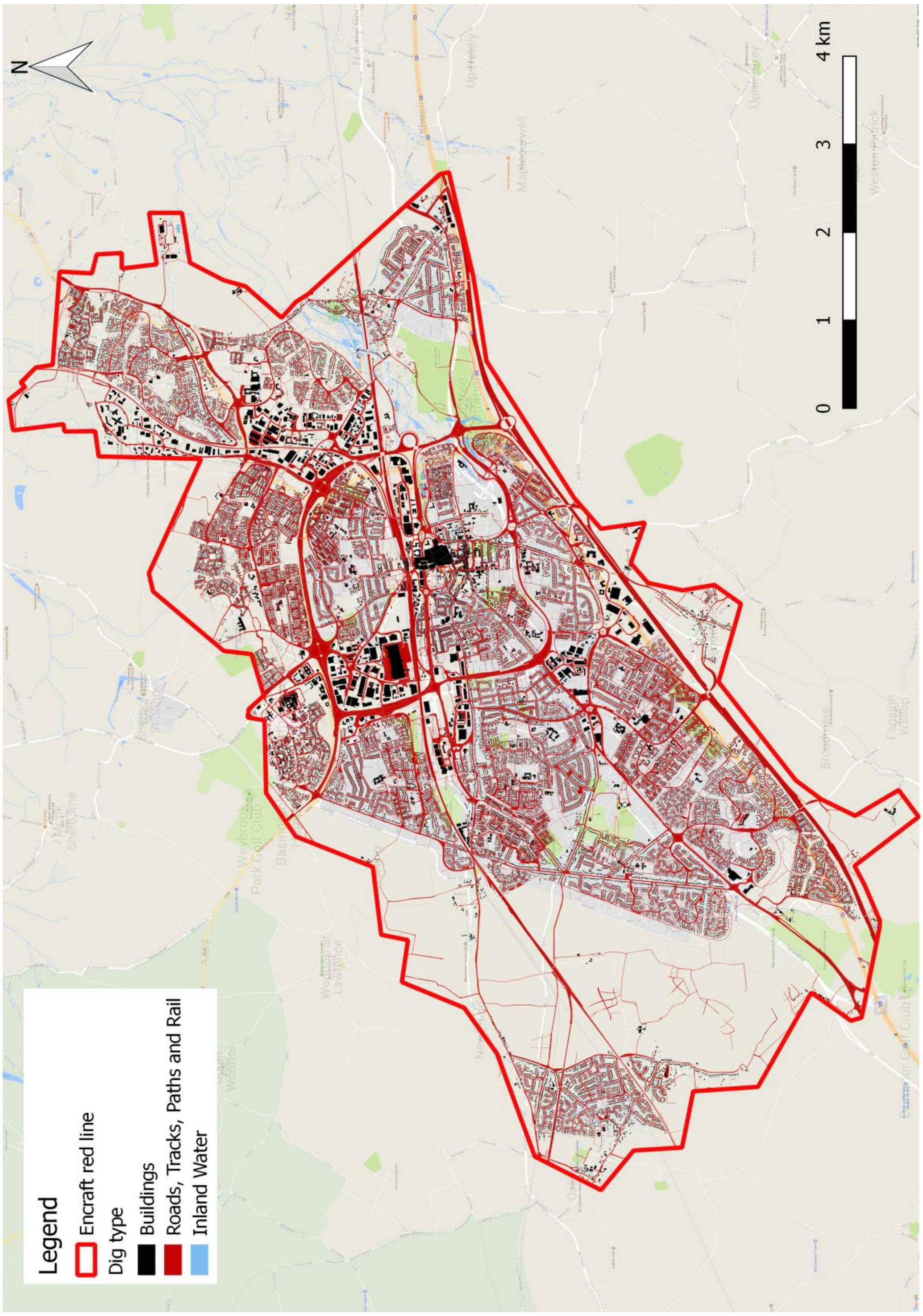


Figure 20: Local constraints

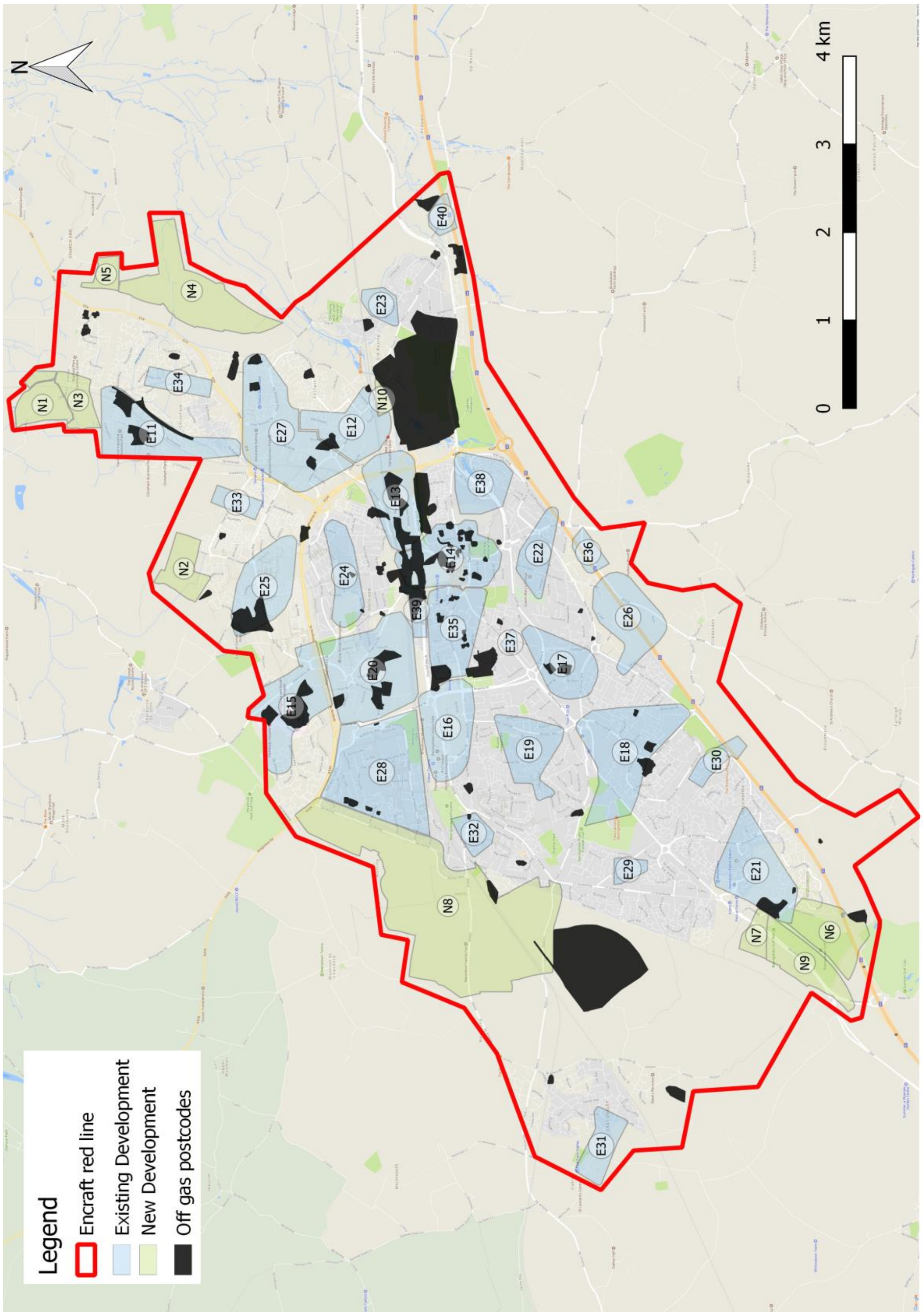


Figure 21: Off gas postcodes within study boundary

Figure 22: Basing View cluster map showing dig type

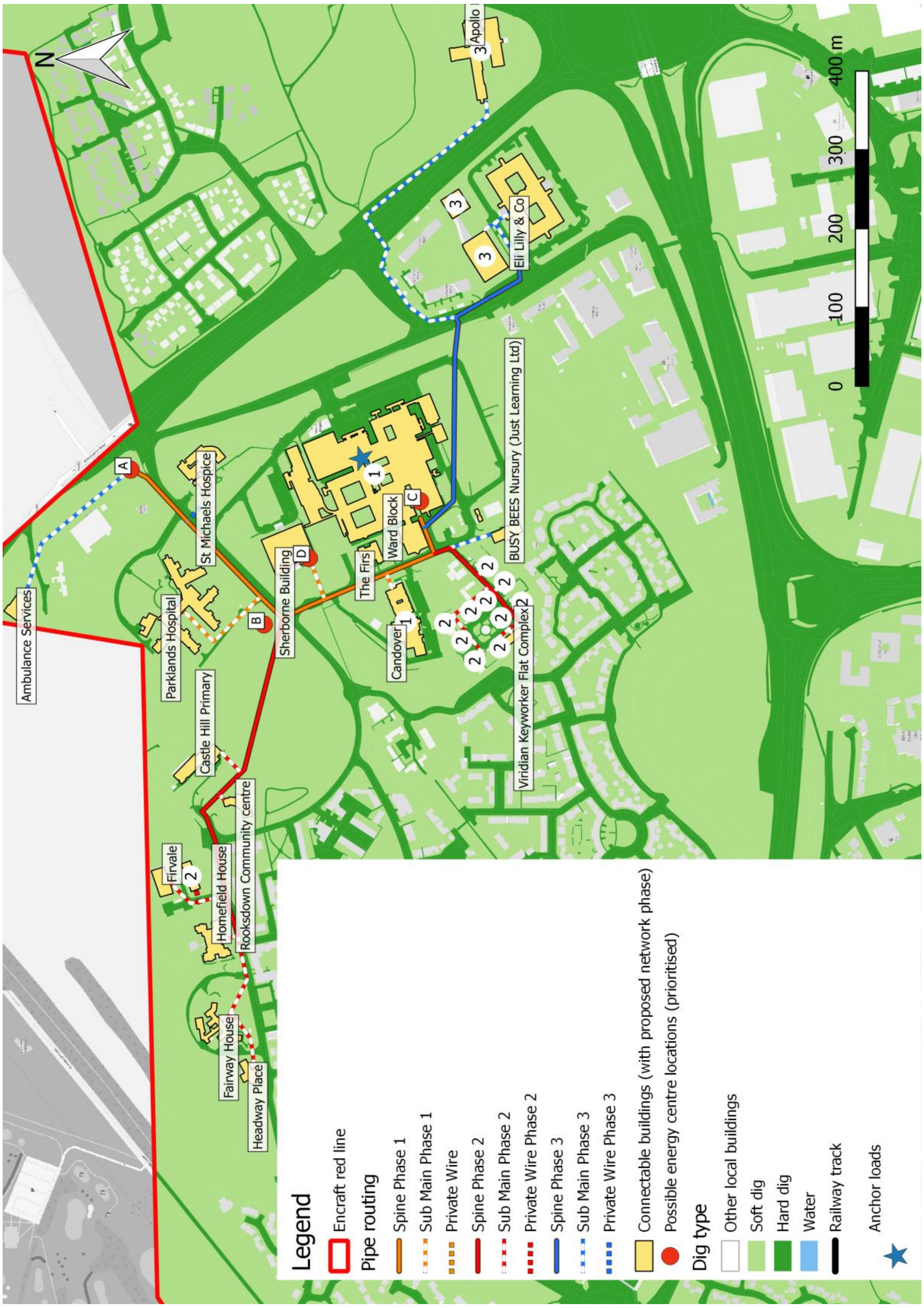


Figure 23: Hospital cluster map showing dig type

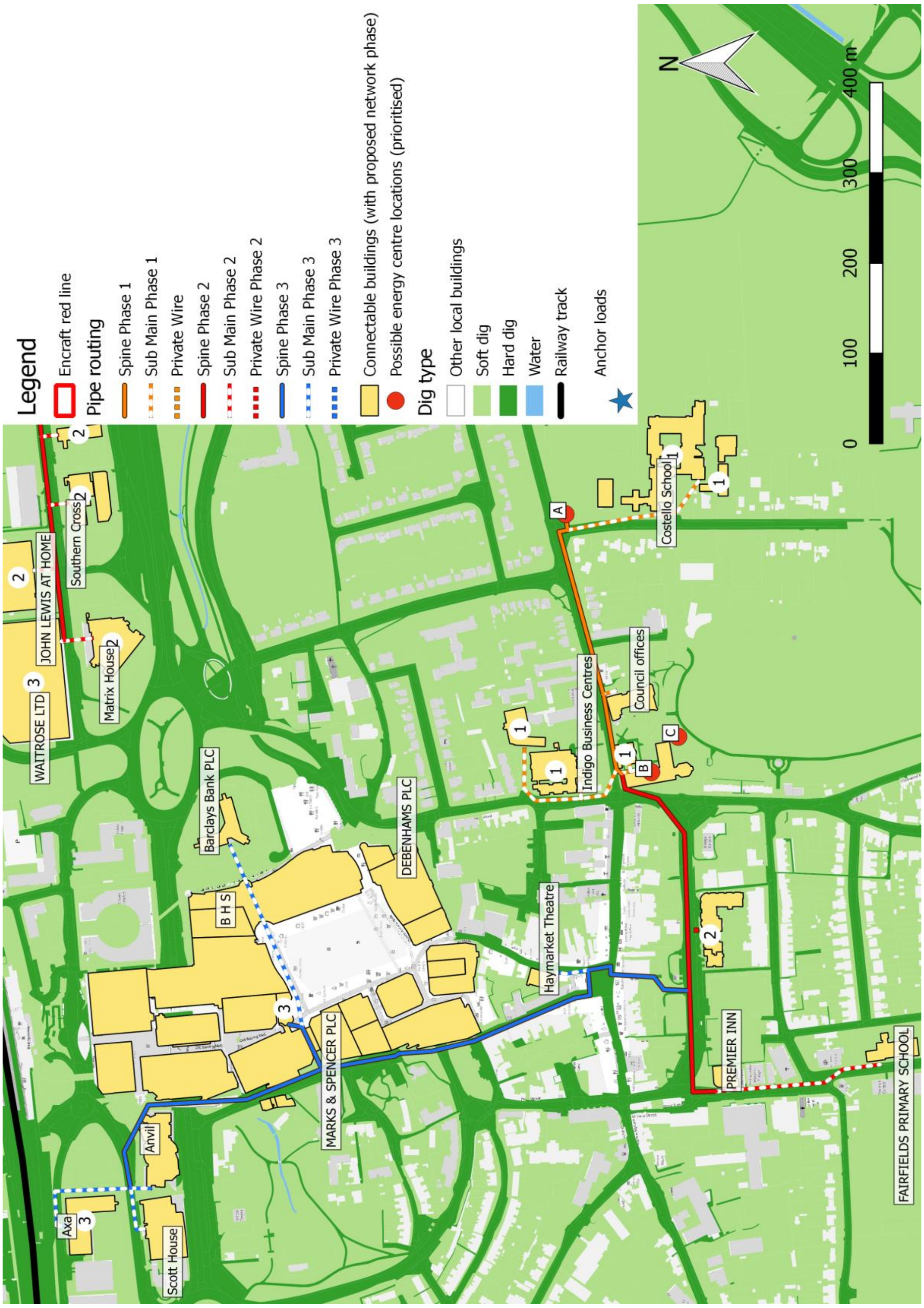


Figure 24: Town Centre map showing dig type

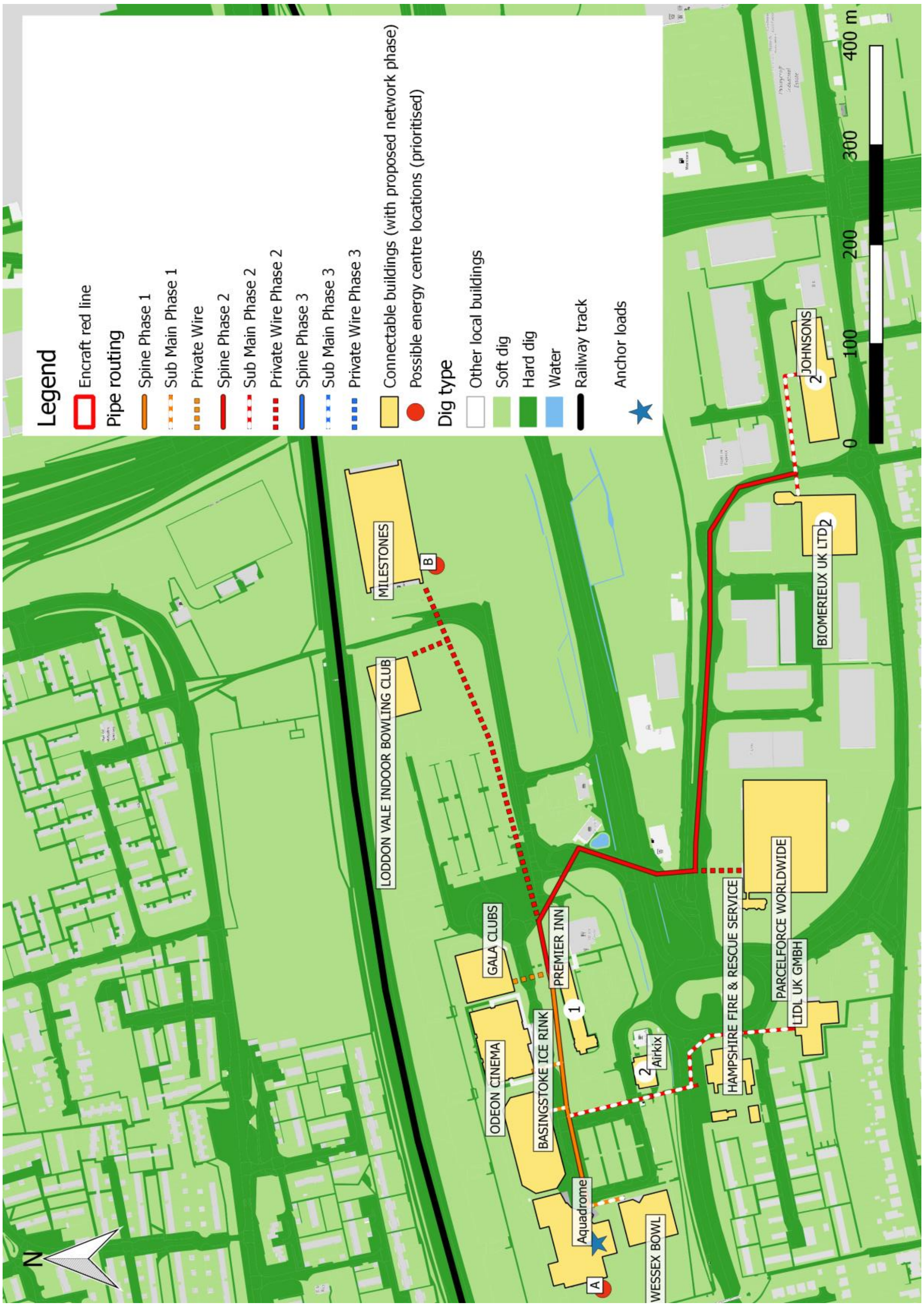


Figure 25: Leisure cluster map showing dig type

11. Modelling details

The appendix provides full details of the technical and financial characteristics for each phase of each cluster.

Thermal storage has been included in the modelling but not at a detailed half-hourly level. This would be part of a future more detailed techno-economic feasibility study.

11.1.1 Basing View

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and in an investment that will future proof the network for later development phases.

Table 5 shows the annual heat demand, peak heat consumption and, CHP and auxiliary heat raising plant capacity for each of the three phases, which may be met by one or more installations, and thermal storage requirements.

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and in an investment that will future proof the network for later development phases.

Table 5: Operational characteristics for the Basing View clusters

Cluster	Total annual heat demand (MWh)	Total peak heat consumption (kW)	Total modelled CHP size (kWth)	Auxiliary heat raising plant size (kWth)	Total thermal store size (m^3)
Phase 1	7,948	1,921	770	1,689	111
Phase 2	12,276	3,063	1,230	2,691	172
Phase 3	14,514	3,604	1,440	3,173	203

Indicative pipe and private wire lengths have been modelled to reach the boundary of the key buildings within the cluster only, and in most cases no account has been made for the need for any additional internal pipework.

Table 6: Summary of pipe distances and plant specifications for each part of the heat network (Basing View cluster)

Assumptions and calculation methodologies for items including thermal storage and CHP sizing are evidenced in the appendices.

Technical specifications	Phase 1	Phase 2	Phase 3

CHP Size (kWth)	770	1,230	1,440
Auxiliary (top-up gas boiler) (kWth)	1,689	2,691	3,173
Thermal storage (m^3)	111	172	203
Buildings on network (residential)	-	-	-
% of retrofit residential properties in cluster	-	-	-
Buildings on network (commercial)	6	11	15
Pipework - spine - hard dig (m)	483	766	766
Pipework - secondary - hard dig (m)	78	270	274
Pipework - spine - soft dig (m)	-	-	-
Pipework - secondary - soft dig (m)	-	-	-
Pipework (road crossing) (m)	-	-	-
Pipework (rail crossing) (m)	-	-	5
Pipework (water crossing) (m)	-	-	-
Building connection pipework (m)	-	-	-
Private wire length (where wire cannot be placed in pipe trench) (m)	-	-	412
Private wire length (where wire can be placed in pipe trench) (m)	561	1,036	1,040

Table 7: Summary of capital costs for each part of the heat network (Basing View cluster)

Capital cost (£)	Phase 1	Phase 2	Phase 3
Plant (Primary heating raising plant)	503,768	804,720	942,112
Plant (Auxiliary)	118,233	188,354	222,138

Plant room building works	65,000	80,000	80,000
Plant room pumps, controls	64,900	100,200	118,500
Pipework	705,900	1,265,800	1,289,300
Thermal Store	111,000	172,000	203,000
Heat Interface Unit (Building connection)	60,000	110,000	150,000
Private Wire	56,100	103,600	186,400
Metering	18,000	33,000	45,000
SUB TOTAL	**1,702,901**	**2,857,675**	**3,236,450**
Commissioning (2%)	34,100	57,200	64,700
Design (5%)	85,100	142,900	161,800
Project Management (5%)	85,100	142,900	161,800
Contingency (10%)	170,300	285,800	323,600
TOTAL	**2,077,501**	**3,486,475**	**3,948,350**

11.1.2 North Hampshire Hospital

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and in an investment that will future proof the network for later development phases.

Table 8 shows the annual heat demand, peak heat consumption and, CHP and auxiliary heat raising plant capacity for each of the three phases, which may be met by one or more installations, and thermal storage requirements.

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and in an investment that will future proof the network for later development phases.

Table 8: Operational characteristics for the Hospital cluster

Cluster	Total annual heat	Total peak	Total	Auxiliary heat	Total thermal

	demand (MWh)	heat consumption (kW)	modelled CHP size (kWth)	raising plant size (kWth)	store size (m^3)
Phase 1	24,981	5,418	2,170	4,764	350
Phase 2	27,610	5,964	2,390	5,244	387
Phase 3	30,442	6,588	2,640	5,792	426

Indicative pipe and private wire lengths have been modelled to reach the boundary of the key buildings within the cluster only, and in most cases no account has been made for the need for any additional internal pipework.

Table 9: Summary of pipe distances and plant specifications for each part of the heat network (Hospital cluster)

Assumptions and calculation methodologies for items including thermal storage are evidenced in the appendices.

Technical specifications	Phase 1	Phase 2	Phase 3
CHP Size (kWth)	2,170	2,390	2,640
Auxiliary (top-up gas boiler) (kWth)	4,764	5,244	5,792
Thermal storage (m^3)	350	387	426
Buildings on network (residential)	-	160	160
% of retrofit residential properties in cluster	-	-	-
Buildings on network (commercial)	5	13	17
Pipework - spine - hard dig (m)	48	363	766
Pipework - secondary - hard dig (m)	-	-	347
Pipework - spine - soft dig (m)	475	749	749
Pipework - secondary - soft dig (m)	202	769	1,196
Pipework (road crossing) (m)	25	35	95
Pipework (rail crossing) (m)	-	-	-

Technical specifications	Phase 1	Phase 2	Phase 3
Pipework (water crossing) (m)	-	-	-
Building connection pipework (m)	-	-	-
Private wire length (where wire cannot be placed in pipe trench) (m)	-	-	30
Private wire length (where wire can be placed in pipe trench) (m)	750	1,916	3,153

Table 10: Summary of capital costs for each part of the heat network (Hospital cluster)

Capital cost (£)	Phase 1	Phase 2	Phase 3
Plant (Primary heating raising plant)	1,419,710	1,563,644	1,727,205
Plant (Auxiliary)	333,512	367,079	405,452
Plant room building works	100,000	100,000	100,000
Plant room pumps, controls	203,900	225,400	248,500
Pipework	560,900	1,471,700	2,712,100
Thermal Store	350,000	387,000	426,000
Heat Interface Unit (Building connection)	50,000	290,000	330,000
Private Wire	75,000	191,600	321,300
Metering	15,000	135,000	147,000
SUB TOTAL	**3,108,022**	**4,731,423**	**6,417,557**
Commissioning (2%)	62,200	94,600	128,400
Design (5%)	155,400	236,600	320,900
Project Management (5%)	155,400	236,600	320,900
Contingency (10%)	310,800	473,100	641,800
TOTAL	**3,791,822**	**5,772,323**	**7,829,557**

11.1.3 Town Centre

Table 11 shows the annual heat demand, peak heat consumption and, CHP and auxiliary heat raising plant capacity for each of the three phases, which may be met by one or more installations, and thermal storage requirements.

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and in an investment that will future proof the network for later development phases.

Table 11: Operational characteristics for the Town Centre

Cluster	Total annual heat demand (MWh)	Total peak heat consumption (kW)	Total modelled CHP size (kWth)	Auxiliary heat raising plant size (kWth)	Total thermal store size (m^3)
Phase 1	1,303	390	160	339	18
Phase 2	2,634	675	270	594	37
Phase 3	8,550	2046	820	1,799	120

Indicative pipe and private wire lengths have been modelled to reach the boundary of the key buildings within the cluster only, and in most cases no account has been made for the need for any additional internal pipework.

Thermal storage has been included to help address the fluctuating energy demands in the buildings being supplied.

Table 12: Summary of pipe distances and plant specifications for each part of the heat network (Town Centre cluster)

Technical specifications	Phase 1	Phase 2	Phase 3
CHP Size (kWth)	160	270	820
Auxiliary (top-up gas boiler) (kWth)	339	594	1,799
Thermal storage (m^3)	18	37	120
Buildings on network (residential)	-	-	-
% of retrofit residential properties in cluster	-	-	-
Buildings on network (commercial)	6	8	14
Pipework - spine - hard dig (m)	306	722	1,555
Pipework - secondary - hard dig (m)	579	766	1,015
Pipework - spine - soft dig (m)	-	-	-

Technical specifications	Phase 1	Phase 2	Phase 3
Pipework - secondary - soft dig (m)	-	-	217
Pipework (road crossing) (m)	15	25	30
Pipework (rail crossing) (m)	-	-	-
Pipework (water crossing) (m)	-	-	-
Building connection pipework (m)	-	-	-
Private wire length (where wire cannot be placed in pipe trench) (m)	-	-	-
Private wire length (where wire can be placed in pipe trench) (m)	900	1,513	3,117

Table 13: Summary of capital costs for each part of the heat network (Town Centre)

Capital cost	Phase 1	Phase 2	Phase 3
Plant (Primary heating raising plant)	91,429	169,652	536,480
Plant (Auxiliary)	23,765	41,596	125,910
Plant room building works	25,000	30,000	65,000
Plant room pumps, controls	10,600	21,500	69,800
Pipework	1,015,800	1,769,600	3,273,700
Thermal Store	18,000	37,000	120,000
Heat Interface Unit (Building connection)	60,000	80,000	140,000
Private Wire	90,000	151,300	311,700
Metering	18,000	24,000	42,000

Capital cost	Phase 1	Phase 2	Phase 3
SUB TOTAL	**1,352,593**	**2,324,648**	**4,684,590**
Commissioning (2%)	27,100	46,500	93,700
Design (5%)	67,600	116,200	234,200
Project Management (5%)	67,600	116,200	234,200
Contingency (10%)	135,300	232,500	468,500
TOTAL	**1,650,193**	**2,836,048**	**5,715,190**

11.1.4 Leisure Park

Given the expected regeneration at the leisure park, only two phases have been modelled, to provide an indication as to whether an opportunity exists and therefore whether further modelling of the future leisure park may be warranted

The capacity ***of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and is an investment that will future proof the network for later development phases.***

Table 14 shows the annual heat demand, peak heat consumption and CHP capacity, which may be met by one or more installations, and thermal storage requirements.

The capacity of the thermal storage provision is scaled to allow for high levels of confidence and resilience within the each network particularly in the earlier development phases and is an investment that will future proof the network for later development phases.

Table 14: Operational characteristics for the Leisure Park cluster

Cluster	Total annual heat demand (MWh)	Total peak heat consumption (kW)	Total modelled CHP size (kWth)	Auxiliary heat raising plant size (kWth)	Total thermal store size (m^3)
Phase 1	11,567	2,441	980	2,144	162
Phase 2	15,225	3,778	1,130	3,705	213

Indicative pipe and private wire lengths have been modelled to reach the boundary of the key buildings within the cluster only, and in most cases no account has been made for the need for any additional internal pipework.

Table 15: Summary of pipe distances and plant specifications for each part of the heat network

Assumptions and calculation methodologies for items including thermal storage are evidenced in the appendices.

Technical specifications	Phase 1	Phase 2
CHP Size (kWth)	980	1,130
Auxiliary (top-up gas boiler) (kWth)	2,144	3,705
Thermal storage (m^3)	162	213
Buildings on network (residential)	-	-
% of retrofit residential properties in cluster	-	-
Buildings on network (commercial)	5	9
Pipework - spine - hard dig (m)	-	-
Pipework - secondary - hard dig (m)	146	279
Pipework - spine - soft dig (m)	292	952
Pipework - secondary - soft dig (m)	220	220
Pipework (road crossing) (m)	35	50
Pipework (rail crossing) (m)	-	-
Pipework (water crossing) (m)	-	-
Building connection pipework (m)	-	-
Private wire length (where wire cannot be placed in pipe trench) (m)	46	447

Technical specifications	Phase 1	Phase 2
Private wire length (where wire can be placed in pipe trench) (m)	693	1,501

Table 16: Summary of capital costs for each part of the heat network

Capital cost	Phase 1	Phase 2
Plant (Primary heating raising plant)	641,159	739,296
Plant (Auxiliary)	150,098	259,383
Plant room building works	65,000	80,000
Plant room pumps, controls	94,400	124,300
Pipework	551,400	1,185,400
Thermal Store	162,000	213,000
Heat Interface Unit (Building connection)	50,000	90,000
Private Wire	78,500	239,500
Metering	15,000	27,000
SUB TOTAL	**1,807,557**	**2,957,879**
Commissioning (2%)	36,200	59,200
Design (5%)	90,400	147,900
Project Management (5%)	90,400	147,900
Contingency (10%)	180,800	295,800
TOTAL	**2,205,357**	**3,608,679**

12. Supplementary modelling outputs

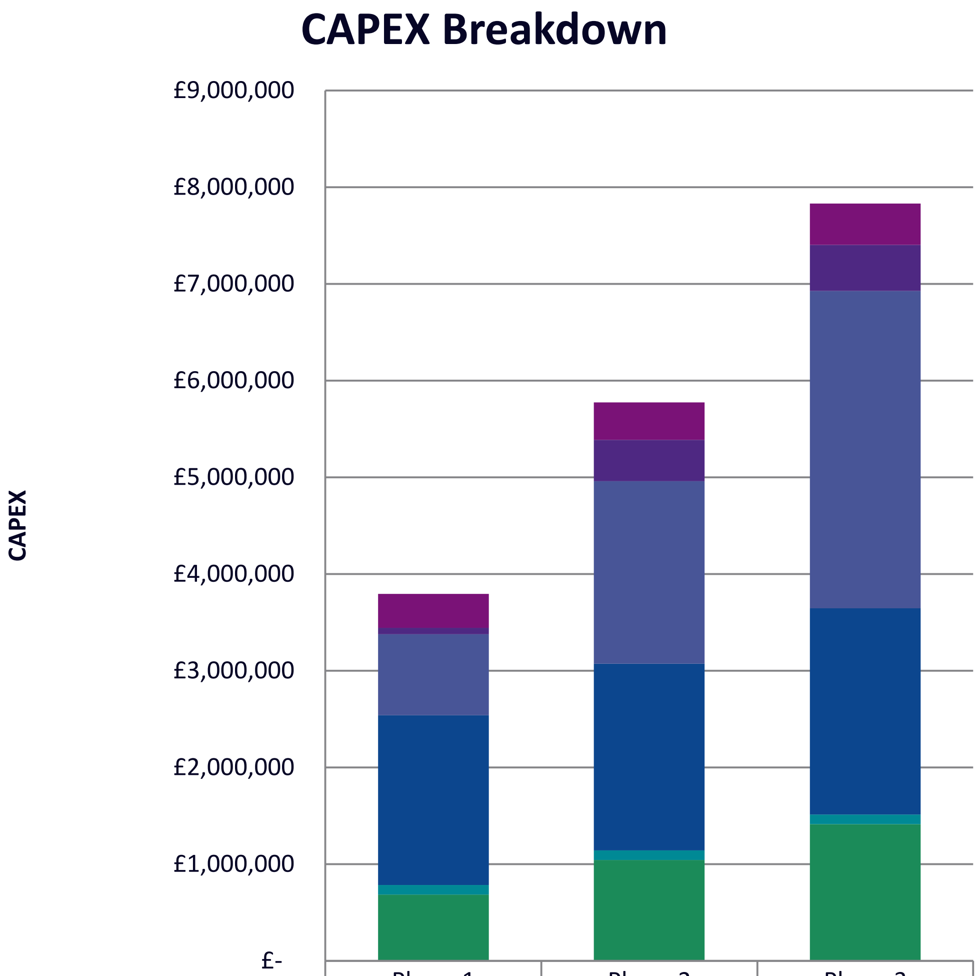
12.1 Capital and operational cost breakdown

A detailed breakdown of modelling assumptions including RPI and discount rates are available in appendix 8. Assumptions have been taken from credible sources and tailored for the project.

12.1.1 Basing View

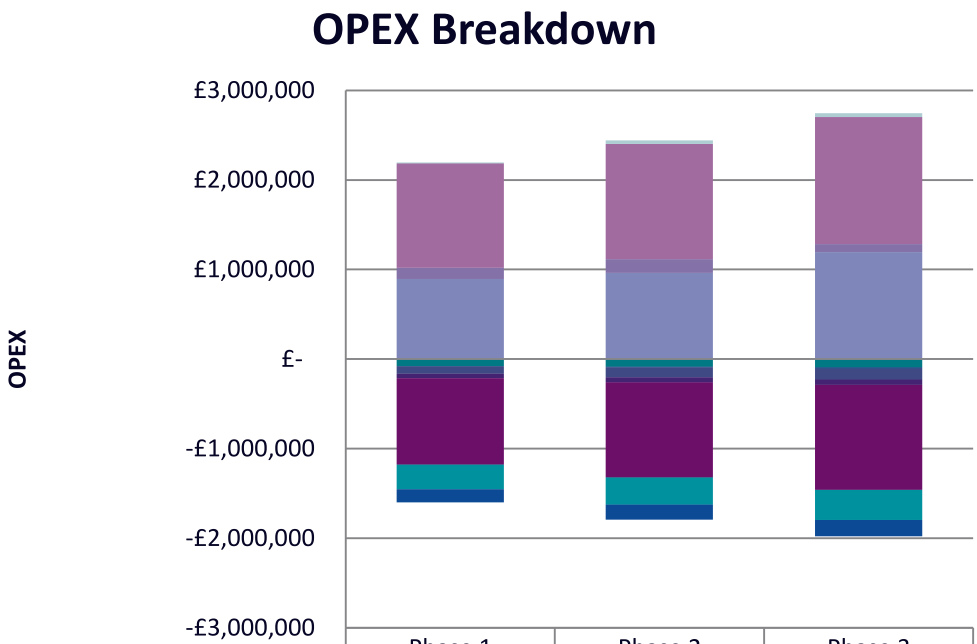
Figure 26 shows the capital costs (CAPEX) for the modelled clusters within Basing View, and the makeup of this expenditure; with CHP plant supplying heat to all customers, and private wire electricity to the commercial premises only.

Figure 26 shows phase 3 requires the highest capex as it has the longest pipework and the greatest CHP and auxiliary plant capacity. The extra pipework involved in connecting all of the loads leads to a capital expenditure for this scheme of circa £4m at phase 3.



	Phase 1	Phase 2	Phase 3
Thermal storage	£350,000	£387,000	£426,000
HIU and heat meter	£65,000	£425,000	£477,000
Ancilliary plant, pipework and private wire	£839,800	£1,888,700	£3,281,900
Heat raising plant	£1,753,222	£1,930,723	£2,132,657
Energy centre building	£100,000	£100,000	£100,000
Commissioning, design, project management and contingency	£683,800	£1,040,900	£1,412,000

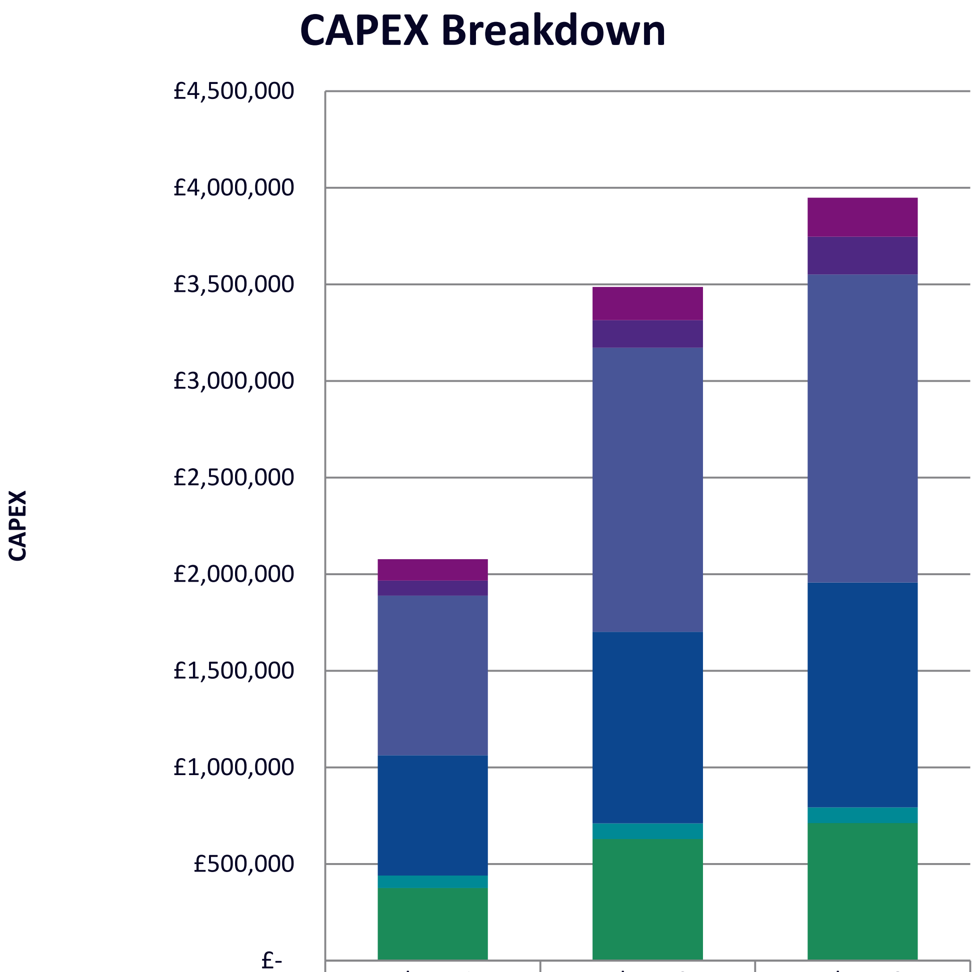
Figure 26: CAPEX breakdown for the Basing View cluster



	Phase 1	Phase 2	Phase 3
Standing charges	£10,000	£37,840	£45,840
RHI	£-	£-	£-
Heat sales	£1,164,100	£1,286,600	£1,418,600
Electricity export	£125,799	£155,428	£89,372
Private wire sales	£895,024	£961,709	£1,192,968
Business rates	-£149,884	-£165,662	-£182,654
ESCO management costs	-£274,788	-£303,713	-£334,866
Climate Change Levy (CCL)	£-	£-	£-
Gas costs	-£961,800	-£1,062,800	-£1,171,600
Electricity costs	-£49,910	-£55,165	-£60,819
HIU and heat meter maintenance	-£85,434	-£111,175	-£121,204
Heat network maintenance	-£3,800	-£9,600	-£15,800
Heat raising plant maintenance	-£73,893	-£81,362	-£89,870
Energy centre building maintenance	-£2,000	-£2,000	-£2,000

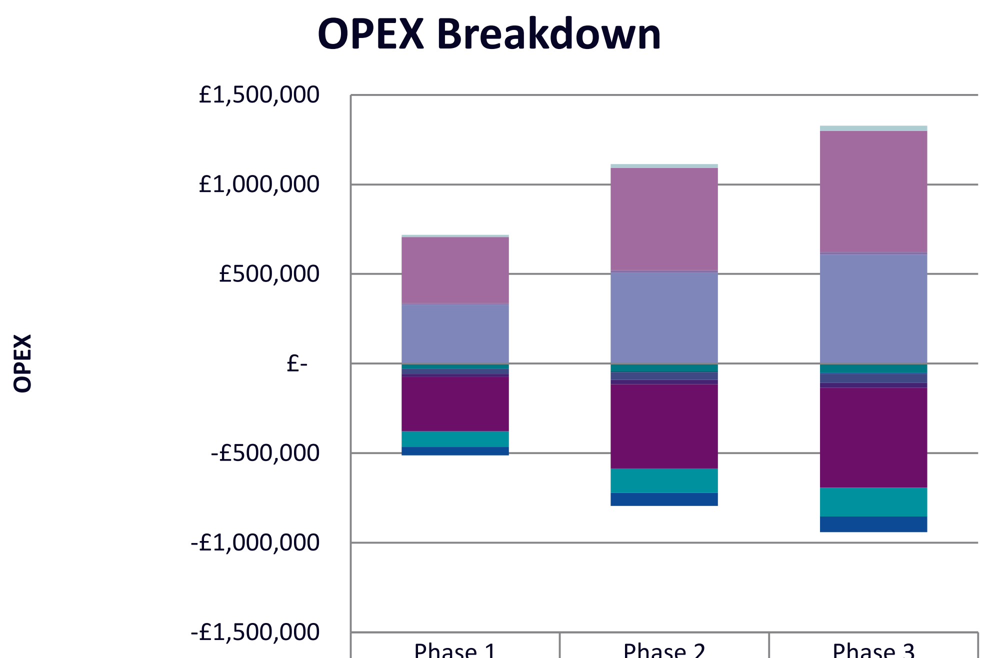
Figure 27: OPEX breakdown for the Basing View cluster

12.1.2 Town Centre



	Phase 1	Phase 2	Phase 3
Thermal storage	£111,000	£172,000	£203,000
HIU and heat meter	£78,000	£143,000	£195,000
Ancilliary plant, pipework and private wire	£826,900	£1,469,600	£1,594,200
Heat raising plant	£622,001	£993,075	£1,164,250
Energy centre building	£65,000	£80,000	£80,000
Commissioning, design, project management and contingency	£374,600	£628,800	£711,900

Figure 28: CAPEX breakdown for the Town Centre cluster

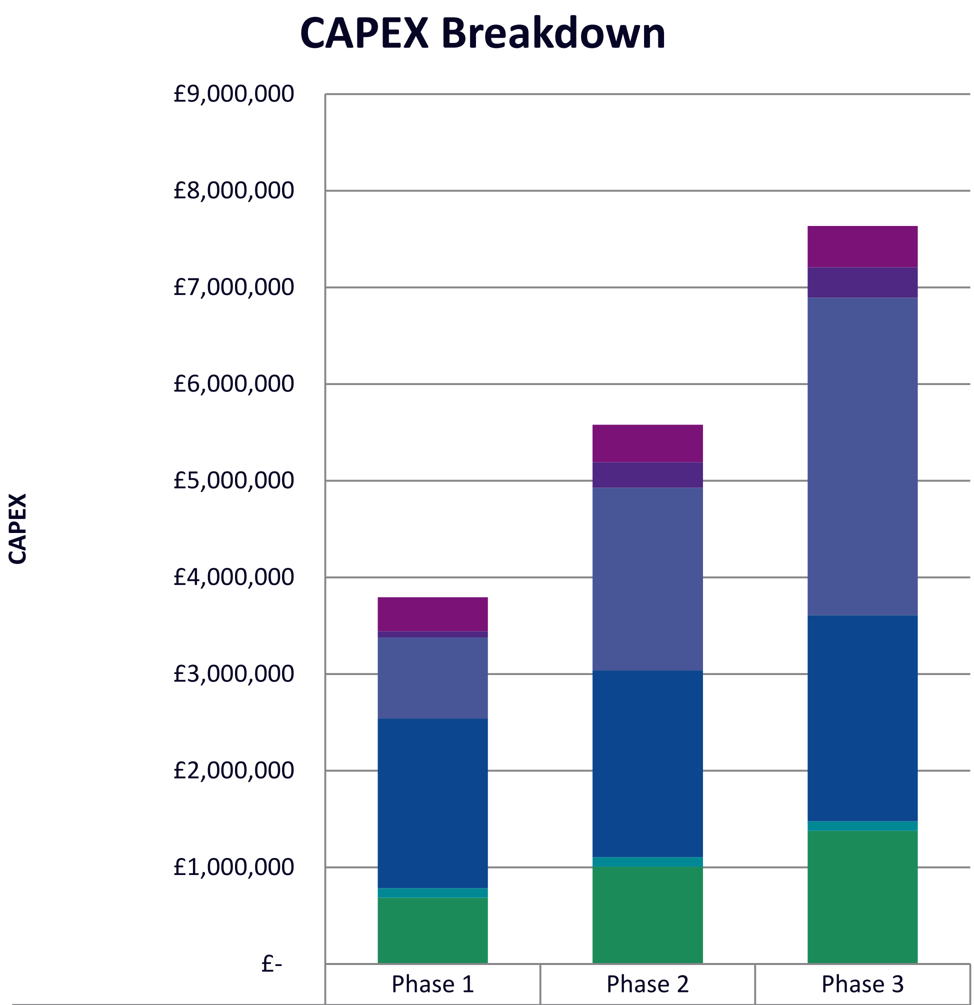


	Phase 1	Phase 2	Phase 3
Standing charges	£12,000	£22,000	£30,000
RHI	£-	£-	£-
Heat sales	£370,400	£572,100	£676,400
Electricity export	£7,804	£12,055	£14,254
Private wire sales	£328,547	£507,932	£607,941
Business rates	-£47,685	-£73,657	-£87,089
ESCO management costs	-£87,423	-£135,038	-£159,663
Climate Change Levy (CCL)	£-	£-	£-
Gas costs	-£304,200	-£469,800	-£557,700
Electricity costs	-£15,884	-£24,525	-£29,001
HIU and heat meter maintenance	-£27,622	-£42,839	-£50,850
Heat network maintenance	-£2,800	-£5,200	-£5,200
Heat raising plant maintenance	-£26,210	-£41,821	-£49,110
Energy centre building maintenance	-£1,300	-£1,600	-£1,600

Figure 29: OPEX breakdown for the Town Centre cluster

12.1.3 North Hampshire Hospital

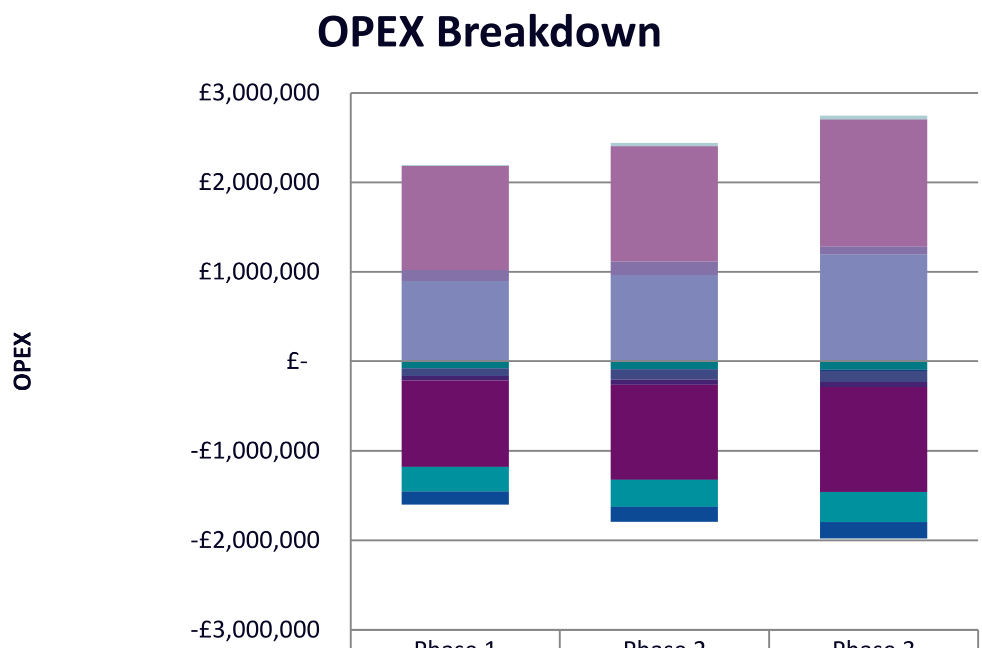
Figure 30 shows the capital costs (CAPEX) for the modelled clusters within the Hospital cluster, and the makeup of this expenditure; with CHP plant supplying heat to all customers, and private wire electricity to the commercial premises only.



	Phase 1	Phase 2	Phase 3
Thermal storage	£350,000	£387,000	£426,000
HIU and heat meter	£65,000	£265,000	£317,000
Ancilliary plant, pipework and private wire	£839,800	£1,888,700	£3,281,900
Heat raising plant	£1,753,222	£1,930,723	£2,132,657
Energy centre building	£100,000	£100,000	£100,000
Commissioning, design, project management and contingency	£683,800	£1,005,700	£1,376,800

Figure 30: CAPEX breakdown for the Hospital cluster

Figure 31 shows the breakdown of operating revenue and expenditure for the Hospital cluster. The extension of the network from phase 1 to 3 requires significant capital but the returns are minimal.

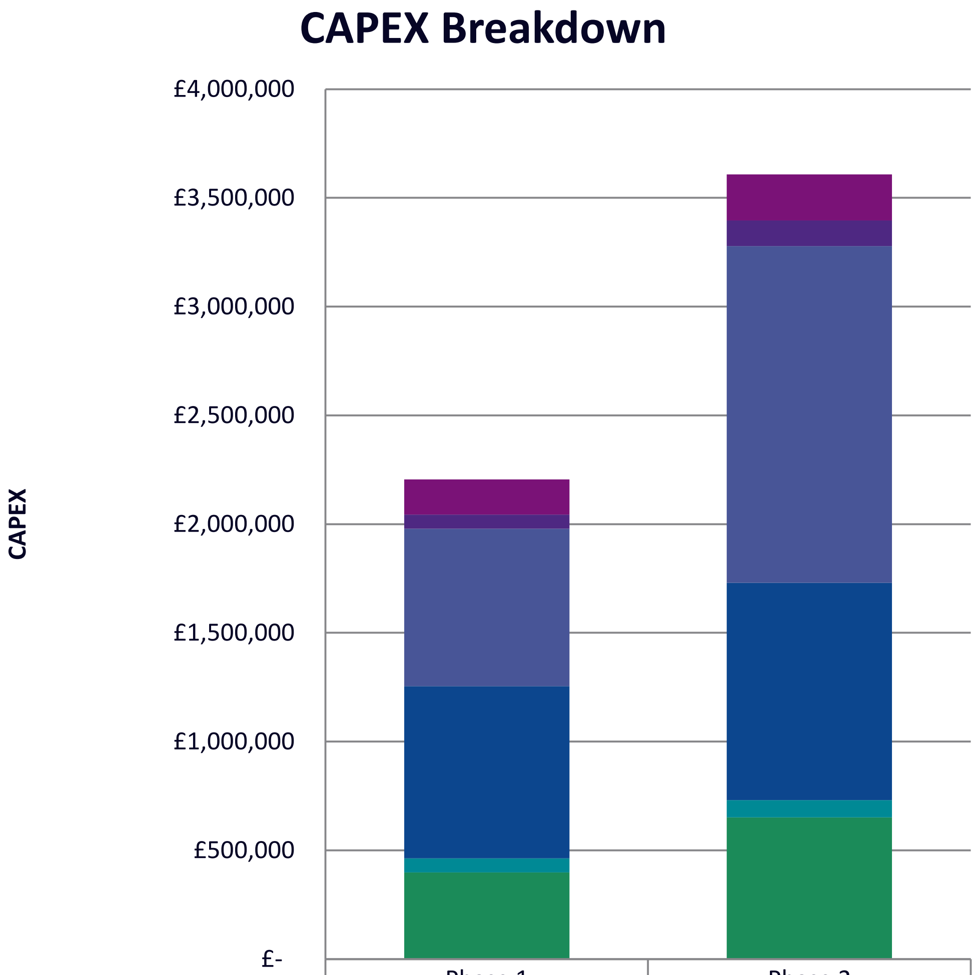


	Phase 1	Phase 2	Phase 3
Standing charges	£10,000	£37,840	£45,840
RHI	£-	£-	£-
Heat sales	£1,164,100	£1,286,600	£1,418,600
Electricity export	£125,799	£155,428	£89,372
Private wire sales	£895,024	£961,709	£1,192,968
Business rates	-£149,884	-£165,662	-£182,654
ESCO management costs	-£274,788	-£303,713	-£334,866
Climate Change Levy (CCL)	£-	£-	£-
Gas costs	-£961,800	-£1,062,800	-£1,171,600
Electricity costs	-£49,910	-£55,165	-£60,819
HIU and heat meter maintenance	-£85,434	-£111,175	-£121,204
Heat network maintenance	-£3,800	-£9,600	-£15,800
Heat raising plant maintenance	-£73,893	-£81,362	-£89,870
Energy centre building maintenance	-£2,000	-£2,000	-£2,000

Figure 31: OPEX breakdown for the Hospital cluster

12.1.4 Leisure Park cluster (existing)

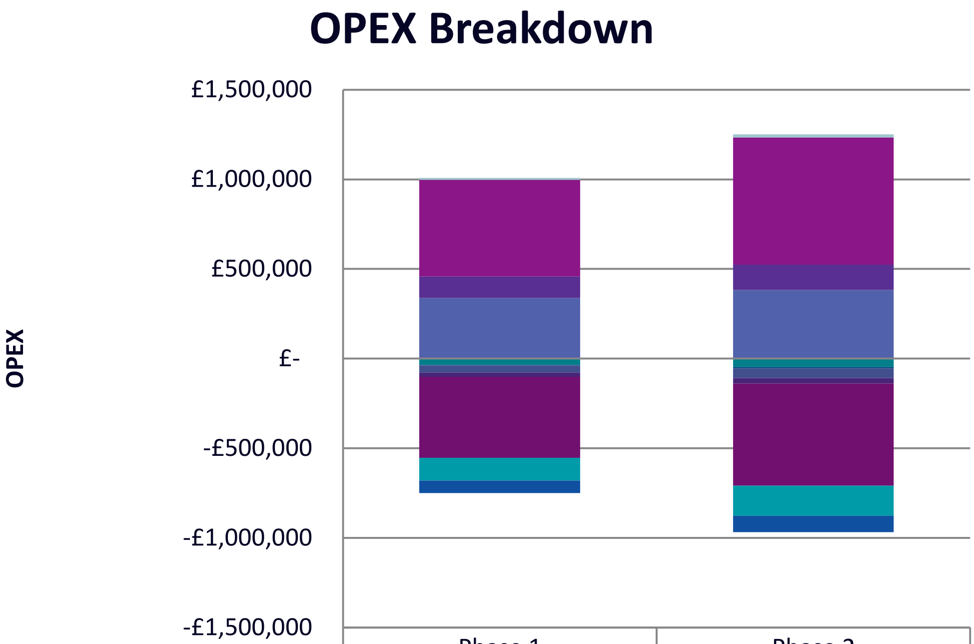
Figure 32 shows the capital costs (CAPEX) for the modelled clusters within the Hospital cluster, and the makeup of this expenditure; with CHP plant supplying heat to all customers, and private wire electricity to the commercial premises only.



	Phase 1	Phase 2
Thermal storage	£162,000	£213,000
HIU and heat meter	£65,000	£117,000
Ancilliary plant, pipework and private wire	£724,300	£1,549,200
Heat raising plant	£791,257	£998,679
Energy centre building	£65,000	£80,000
Commissioning, design, project management and contingency	£397,800	£650,800

Figure 32: CAPEX breakdown for the Leisure Park cluster

Figure 33 shows the breakdown of operating revenue and expenditure for the Hospital cluster. As with the hospital cluster, the extension of the network from phase 1 to 2 requires significant capital but the returns are minimal.



	Phase 1	Phase 2
Standing charges	£10,000	£18,000
RHI	£-	£-
Heat sales	£539,000	£709,500
Electricity export	£120,677	£140,154
Private wire sales	£337,721	£383,632
Business rates	-£69,404	-£91,353
ESCO management costs	-£127,240	-£167,480
Climate Change Levy (CCL)	£-	£-
Gas costs	-£452,300	-£570,000
Electricity costs	-£23,107	-£30,420
HIU and heat meter maintenance	-£39,829	-£52,666
Heat network maintenance	-£3,500	-£7,500
Heat raising plant maintenance	-£33,323	-£46,315
Energy centre building maintenance	-£1,300	-£1,600

Figure 33: OPEX breakdown for the Leisure Park cluster

13. Energy Service Company's (ESCOs)

13.1 Heat Network Governance Structures

Background
In March 2012 the UK Government published its Heat Strategyi highlighting the importance of the contribution of heat networks in reducing carbon emissions in the UK. The investment in local utility infrastructure and energy generation has a role to play in attracting direct inwards investment into the local economy and is an opportunity to enhance the local environment and sense of 'place'. The importance of the heat network is identified within the local policies and plans for Basingstoke, both in the retro-fit of existing buildings and in the regeneration areas of the District.

What is an Energy Service Company
The Energy Service Company (ESCO) is special purpose vehicle (SPV) that is a legally constituted corporate entity with all the requirements and obligations, ability to make capital investments and create revenues associated with a limited company (e.g. limited by equity, guarantee, not-for-profit, CIC). The ESCO is a special purpose vehicle (SPV) in the energy sector and typically falls into two main categories:

- ESCO: Energy Performance Contract where investment in efficiency measures is repaid through recovering a share of the energy-related savings; and
- ESCO: Energy Service Contracts where the investment in energy generation and supply is repaid through operational sales.

In this case the ESCO is defined as a SPV to design, fund, deliver and operate the delivery of utility services initially in the form of heat and power that will require the creation and management of long-term capital assets and the operation of those the assets over time.. As a legal entity the ESCO is a is a structure that ring-fences risk, supports investment from multiple sources, has a Board that delivers the vision through a business plan and reports in the normal way. It is envisioned that the heat network

Basingstoke ESCO – creation and operational
The purpose of this review is to identify the options to design, build, finance and operate local district heat networks in Basingstoke and the structures that will take the risks and rewards of the long-term operations.
The building of the network and energy centres is a construction activity that includes complex wayleaves for infrastructure, optimising and future-proofing. The activity is well understood and subject to consents can be completed in a few years. As a construction project the capital structures are well understood and there are specialist investors in the market. The ESCO that builds the network for the commissioning body will be a well understood, ring-fenced investment opportunity where the construction SPV hands over to an operational ESCO.

The heat network operations are typically governed by contracts and are expected to include:

- heat sales contracts with end users:
- distribution contracts to transport the heat and
- heat procurement contracts with the heat generators such as the energy centre.

It is possible that the key individual operational activities are performed by a number of interrelated ESCOs with distinct risk profiles that will combine to provide contracted services to each other ultimately serving the end-user, the potential benefits of this approach are highlighted below.
The Legal Frameworks Report published by the Green Building Council in 2012 identifies the role of the 'Network Promoter' and three different ESCO scheme structures that are seen as relevant and adaptable to whatever commercial and financial framework is chosen for a particular project.

The Network Promoter
The Network Promoter is a key player in every scheme (irrespective of size or complexity) and is the overseeing body which will often have instigated the scheme. The network promoter has an interest in ensuring that the scheme is procured and continues to operate, although that interest may be limited in time or its scope. The promoter may include the local authority, a development authority other key stakeholders. The ESCO is not usually also the promoter, because its function is essentially different from that of the network promoter and the ESCO will often be an external contractor which performs its role under contract from the promoter.

Scheme Types
There are three distinct types of scheme identified by the Green Building Council, there may be combinations and it should be noted that schemes may change over time, subject to the constitution of the ESCO:

Single Site and Ownership Scheme
These schemes are confined to a single site, the heat source being based in a building's plant room and typically serving residential units and perhaps also some small scale commercial premises, normally all on a site in the same ownership. Part of the network could be off site and the scheme could be a new development or a retro-fit.

Single Site Multiple Ownership Scheme
This is a collection of adjacent development sites that creates a single site, but where the individual sites are owned by different developers. The network connecting the different parts of the sites could be under the operation either of one entity or more than one entity operating or owning different parts of the network. If these schemes use CHP as the heat source there may be significant quantities of electricity to export – either to users on site (private wire) or to the national grid (PPA).

Multiple Site Schemes
This is a collection of remote sites where the heat pipe-work passes across land owned by others not related to the scheme. The network could be operated by a single operator or multiple operators as above. This type of scheme involves extensive heat pipe networks connected to a range of

different heat producers and maybe seen as a natural extension of the above 2 schemes. The capital costs of such schemes are substantial and may have payback periods exceeding 15 years. If however, heat networks fill the role as outlined in the Government's Heat Strategy, such networks will need to be constructed, to enable the volume of heat supply and heat demand implied by the strategy to be linked cost effectively. The challenge is financing and installing the main heat transmission network, but once installed these networks have the potential to be stable long term investments. The challenge is to grow the network to that scale in the first place.

Benefits of an operational ESCO governance structure

Key benefits of the ESCO:

- Long-term assets owned by a long-term structure
- Risk and reputation of all parties is ring-fenced and managed
- Investment and repayments are self-contained
- Control, benefits and liabilities are shared in accordance with Shareholder Agreement and defined strategy
- Multiple parties from the public and private sector can participate, and change in membership can be accommodated by the terms of the Shareholder Agreement.
- Can claim capital allowances and incentives, may make and appeal planning applications.

Benefits of multiple ESCOs in a single heat network

The ESCO structure also allows multiple ESCOs operating in the same heat network to interact with each other with the effect of reducing the investor risk, cost of capital and providing a level of market-led competition. Creating a single ESCO might have the effect of creating a local monopoly and require ongoing and strong oversight to ensure that the capital, contract prices and retail pricing are at a competitive rate and overseen to the benefit of all. A single ESCO will have multiple assets and aims, thus creating a complex risk environment for the potential investors and stakeholders to manage.

Multiple ESCOs will add structural complexity that requires careful management but allows:

- Differing risk profiles and time scales associated with each key activity and asset to be closely managed and aligned with the different risk appetites of potential investors and expertise of the ESCO staff.
- Introduce a level of competition, for example between Generating ESCOs and Retailing ESCOs whilst the PipeCo ESCO may operate with a wider socio-economic set of objectives over a long term – thus PipeCo can purchase heat from a number of heat generators and sell to a number of retail ESCOs competing for the same end-user contract
- Convert uncertainty into manageable risk, thus if a key risk is expanding the network of pipes into a development area with delayed returns it can be funded by public and infrastructure capital rather than energy asset funders

- Allow flexibility in the phased development of multiple networks with a structure that can support network expansion and consolidation at a later stage
- Governance can be aligned and balanced between the public and private sector objectives.

The Heat Trust Guidelines are optional but provide a useful baseline for the establishment of an equitable retail tariff structure.

An example of a heat network with multiple operational ESCOs might include:

Key Activity	Asset	Relationship	Asset life	Objective	
Operational Heat generation	New energy centre and connections	Contracted heat sales to HeatCO	Energy plant 20 – 30 years	Maximise revenues from heat sales	GenCO
Heat Distribution	Optimised pipe network, connections and controls	Contract with HeatCo to distribute heat from GenCo to end-users	Pipework, stores and controls - 70 years	Maximise revenues from heat distribution	PipeCo
Operational heat sales	Heat procurement, distribution and sales contracts	Contracted heat sales to end-users	Customer list, credit and contracts	Optimise revenues from contracted heat sales	HeatCO

Planning
There is no standardised planning policy across the UK for heat networks, it is local planning policies that promote the network and are critical to driving forward the scheme and future expansion.

In many cases, in single site schemes or large redevelopment projects, all the planning can be prepared in advance and all the legal relationships can be forethought and provided for. The benefits of decentralised energy occur if promoters, particularly local authorities, can promote and enable an existing network to take on additional load if and when it becomes available. The principle is perhaps that a network should therefore be expanded when enough new loads are available.
The decentralised energy scheme has to fit within the over-all planning and environmental policies and might include:

- Social housing Right to Buy and shared ownership.
- Use of fuels and run times;
- Route of the pipework, private wires and crossing points
- Location of energy centres, technology selection, thermal stores and connection nodes

- Requirement to connect to a network if commercially and socio-economically viable

The scheme may also benefit from planning support in the use of the Energy Masterplan driving the use of Community Infrastructure Levy and deployment of funds from developers under Allowable Solutions schemes.

Role of the ESCO
Projects need to be structured so that there are available funding options and contract structures that reflect the functional delivery requirements and entitlements of each party on the project; together with the distribution of risk in a way which makes that and the funding deliverable. This means the role and involvement of the ESCO can vary between projects and successful ESCO structures will be tailored and flexible enough to meet the local needs. The role of an ESCO will vary substantially according to all the considerations referred to above, there are core functions often falling within the scope of their activities as set out below:

Core obligations
From a legal standpoint, the delivery of a project will be embodied within a number of core Obligations as set out below:

- The party legally or contractually responsible for the delivery of the energy services
- Refurbishment /renewal of the plant and accumulation of the associated sinking fund.
- Maintenance of the financial viability of the scheme:
- Balancing price and cost
    - Managing the customer base by replacing departing customers and obtaining new customers
    - Managing the relationship with consumers on matters such as billing and consumer protection, in some instances accepting credit risk.
    - Managing the purchase of fuel, in some instances taking price risk.

In community regeneration schemes (most notably schemes not confined to a single site), there may also be an obligation to secure the extension or modification of the scheme to accept new consumers or sources of heat or power and to negotiate long-term utility wayleaves and access.
It should be noted however, that some or even most of these functions may be subcontracted to other parties; or the risk otherwise distributed to them, depending upon the technical, economic aspects, and funding structure of the scheme, as described above.

Operational Economics
Leaving aside the capital cost, the viability of a scheme is dependent upon its ability to generate revenue. Also, in common with most other utilities, such as electricity and gas, it is convenient to divide the revenue into two categories:

- The price paid for the product for which the consumer pays for each measured unit of heat consumed; and
- A contribution to the fixed costs of operating, maintaining and replacing the scheme. This, of course, is paid whether or not the consumer is drawing any supply of the product.

The viability of a scheme is affected by a number of constraints such as:

- Price increases - The ability to increase the price for heat and service charge is subject to constraints. One such constraint is the competitive forces of other forms of space and water heating such as conventional gas boilers. It is common for recent schemes to be subject to a condition that prices must remain in line with a defined and reasonable benchmark (including gas prices, RPI, the cost of maintenance and labour.
- Certainty of consumer base – Due to their small scale, the viability of decentralised energy schemes is much more susceptible to the ebb and flow of consumer demand from individual buildings or sites; or in the case of heat networks serving a range of buildings or sites not linked to development agreements, loss of sources of heat demand – for example through the re-development or change of use of commercial buildings. This is in contrast to national utility infrastructures which, inevitably, have a much wider customer base.
- Certainty of the heat and power generation, including the obligations to provide heat that maybe varied for certain classes of customers.

The scheme may commence operating and be financially supported before self-sufficiency. Then the agreements will need to deal with the arrangements for financial support in the interim and these will depend on the nature of that support.

Considerations for Basingstoke and Deane

The structure and governance and the importance of tailoring the ESCO for the local Basingstoke and Deane area has been commented on above. The ultimate structure will be a balance between the objectives of the stakeholders, and in particular in managing and delivering the commercial and the socio-economic aspirations of different stakeholders.

The use of the ESCO models allows flexibility in outcomes and the opportunity to align the differing asset classes with different lenders and thus manage strategic risk and mitigate uncertainty.

Potential for multiple ESCOs to manage:

- Energy Centre Development ESCO that designs, optimises, sources the capital, delivers and operates each energy centre and associated network connections and aligns with the aspirations and understanding of the investors in generation assets with life cycles of 20-30 years. [MK to add more]
- Network Development ESCO that designs, optimises, sources the capital, delivers and operates each phase of the pipework and aligns with the aspirations and time scales of infrastructure investors [MK to add more]
- Within each ESCO there will be investors that will be managing their risk, and the interest of the Council is seen as a key benefit in reducing delivery and long-term revenue risks
- The assets created by the two development ESCOs maybe procured and adopted by a specific operating ESCO that itself may be split into the heat and power generation and the network operator

- Charging the consumer through the operating ESCO will require the management of the end-user price often through equitable formulae, typically in commercial contracts or through the Heat Trust mechanisms
- Investment in network extensions and enhanced generation assets will be promoted by the operating ESCO in conjunction with the network promoter and the kety stakeholders – recognising that the associated capital servicing costs will reflect the reduce risk of investing in an existing organisation

14. Risk Register

Available as a separate appendix.

15. Communications Log

The following table provides a list of all of the attempts made to contact key project stakeholders, and a summary of the discussions (or intended discussions). This is in addition to stakeholder communication carried out directly by the Council, and stakeholders visited in person.

Date contacted	Business	Person contacted	Contact approach	Discussion points
24/07/2017	Council	Andy Dowling	Email	Stakeholder engagement list
24/07/2017	North Hampshire Hospital	Gillian Brown	Email	Introductory engagement
14/08/2017	Council	Mike Bovis	Email	Leisure park development
14/08/2017	Council	Edward Rehill	Email	Chineham EfW and surrounding development
14/08/2017	North Hampshire Hospital	Gillian Brown	Email	Meter data enquiry
16/08/2017	Council	Sarah Muskett / Lucy Martins	Email	Stakeholder engagement; Mall and Festival Place
16/08/2017	Council	Kate Dean	Email	Basing View Developer contact details
16/08/2017	Council	Peter Gunner	Email	Stakeholder contact - The Malls energy data and site visit organisation.
16/08/2017	Festival Place	Gary Cooper	Email	Stakeholder contact - Festival Place energy data and site visit organisation.
16/08/2017	North Hampshire Hospital	Gillian Brown	Email	Relationships with local stakeholders - the hospital.
17/08/2017	THE ANVIL TRUST LTD	Reception	Phone	Stakeholder contact - Directed to General Admin 01256 819797
17/08/2017	THE ANVIL TRUST LTD	Amanda Wise	Phone	Stakeholder contact - Voicemail left with technical services
17/08/2017	THE ANVIL TRUST LTD	Matthew Cleaver	Phone	Stakeholder contact - Phone/ email - requested meter data

17/08/2017	THE ANVIL TRUST LTD	Matthew Cleaver	Phone	Stakeholder contact - Positive conversation. Spoken to Matthew Cleaver. Request for data/site visit sent by email.
17/08/2017	APOLLO HOTEL	Reception	Phone	Stakeholder contact - To email - operations manager - bfaina@apollohotels.com
17/08/2017	APOLLO HOTEL	Bogdan Faina	Email	Introductory email
17/08/2017	Axa Wealth		Phone	Stakeholder contact - Company has been split and sold to phoenix life Birmingham.
17/08/2017	Biomerieux UK Ltd		Phone	Stakeholder contact - No Response by Phone
17/08/2017	APOLLO HOTEL	Bogdan Fiana	Phone	Stakeholder contact - Follow-up email sent
17/08/2017	THE ANVIL TRUST LTD		Phone	Stakeholder contact - No Response via phone
17/08/2017	CASTLE HILL PRIMARY SCHOOL, ROOKSDOWN CAMPUS	Reception	Phone	Stakeholder contact
17/08/2017	Clinical solutions international ltd		Phone	Stakeholder contact - No dial tone on number
17/08/2017	Eli Lilly		Phone	Stakeholder contact - Send letter to head office.
17/08/2017	ENI ENGINEERING E & P HOUSE		Phone	Stakeholder contact - No Response
17/08/2017	Everest Community Academy		Phone	Stakeholder contact - Not responsive - leisure centre is attached and shared - contact tomorrow.
17/08/2017	HAYMARKET THEATRE		Phone	Stakeholder contact - Run by same organisation as Anvil. Contact in progress.
17/08/2017	HOMEFIELD HOUSE NURSING HOME		Phone	Stakeholder contact - Contact head office.

17/08/2017	JOHNSONS APPAREL MASTER	Reception	Phone	Stakeholder contact - Contact head office.
17/08/2017	Lady Susan Court		Phone	Stakeholder contact - Call development management 01256479522.
17/08/2017	Milestone Transport Museum	Reception	Phone	Stakeholder contact - Email facilities mgr. Emma Barrett emma.barrett@hampshireculturaltrust.org.uk
17/08/2017	NETWORK RAIL LTD - BASINGSTOKE CAMPUS		Phone	Stakeholder contact - Call back
17/08/2017	Shoosmiths services ltd		Phone	Stakeholder contact - Fully serviced office - Call 01256 638013
17/08/2017	SOUTHERN ELECTRICITY PLC		Phone	Stakeholder contact - Customer account required for number
17/08/2017	St Michael's Hospice	Reception	Phone	Stakeholder contact - Email - Tracey Collins tracey.collins@stmichaelshospice.org.uk
17/08/2017	Thales missile electronics		Phone	Stakeholder contact - Basingstoke office shut down
17/08/2017	The Basingstoke Hotel		Phone	Stakeholder contact - Spoken to manager; and the manager will call James Wayman
18/08/2017	Everest Community Academy	Caretaker	Phone	Contacted caretaker. School is being taken over by a new trust. Asked to ring back on 4th September when the term starts.
18/08/2017	HOMEFIELD HOUSE NURSING HOME	Shaw Healthcare	Phone	Stakeholder contact - Phoned 0800 902 0092. Receptionist will pass message onto HQ and someone will return call. Also requested a letter be sent to Shaw Healthcare, 1 Links Court, Links Business Park, St Mellons, Cardiff; or try calling 0292 036 4411
18/08/2017	JOHNSONS APPAREL MASTER	Fulwood (Head Office)	Phone	Contacted head office. Asked to contact David Gray (Procurement Manager) or Andrew Barker (David's deputy). andrewbarker@jsg.com

18/08/2017	JOHNSONS APPAREL MASTER	Andrew Barker	Email	Emailed Andrew Barker. Returns to office next week.
18/08/2017	Milestone Transport Museum	Emma Barrett	Email	Stakeholder contact - Email sent.
18/08/2017	St Michael's Hospice	Tracey Collins	Email	Stakeholder contact - Email sent.
28/09/2017	Veolia	Andy Macqueen; Carols Mascarenhas	Phone	Conference call to discuss opportunity to connect to the Veolia Incinerator in Chineham

16. Code of Practice Compliance

✓	Indicates primary responsibility
P	Indicates partially met
	Not applicable to this stage

2.1 To achieve sufficient accuracy of peak heat demands and annual heat consumptions		
	2.1.1 Existing buildings - monthly heat demands	✓
	2.1.2 Estimate end use and losses	✓
	2.1.3 Space heating degree day analysis	✓
	2.1.4 Occupancy patterns	✓
	2.1.5 Peak demands	P
	2.1.6 Future heat demand	✓
2.2 To identify the most suitable low carbon heat sources and location of an energy centre		
	2.2.1 Available heat sources and technologies	✓
	2.2.2 Whole life costs and CO2 emissions	✓
	2.2.3 Environmental impact	✓
	2.2.4 Mixture of heat sources	✓
	2.2.5 Financial incentives	✓
	2.2.6 Operating model - heat source sizing	✓
	2.2.7 Operating model - demand profile	✓
	2.2.8 Suitable energy centre locations	✓
	2.2.9 Limit energy centre quantities	✓
	2.2.10 Future potential assessment	✓
2.3 To determine the location of top-up and standby boilers and use of existing boilers		
	2.3.1 Heat customer discussions	✓
	2.3.2 Centralised/distributed boilers	✓
	2.3.3 Hydraulic control	✓
	2.3.4 Space requirements	✓
2.4 To select suitable operating temperatures		
	2.4.1 Existing secondary system temperatures	
	2.4.2 Suitable heat source operating temperatures	
	2.4.3 Flow temperature reduction	
	2.4.4 Temperature differential	
	2.4.5 Higher flow temperature/thermal store	
	2.4.6 Hydraulic separation	
	2.4.7 Legionella	
	2.4.8 Maximum temperatures	✓

2.4.9 Space heating and Domestic Hot Water peak operating temperatures	
2.4.10 Rebalancing existing radiator circuits	
2.4.11 Heat exchanger approach temperatures	
2.4.12 Control systems in existing buildings	
2.5 To define heat network distribution routes pipe sizes and costs	
2.5.1 Minimise network length	✓
2.5.2 Service areas within networked buildings	
2.5.3 Major barriers	✓
2.5.4 Existing utilities review	
2.5.5 Pipe route constraints	✓
2.5.6 Third party wayleaves	
2.5.7 Highways Department discussions	
2.5.8 Pipe sizing calculations	
2.5.9 Pressure drop	
2.5.10 High velocity in steel pipes	
2.5.11 Insulation thickness	
2.6 To determine building connection costs including heat metering	
2.6.1 Direct/indirect connections	✓
2.6.2 Cost estimates	✓
2.6.3 Building connection capacity	✓
2.6.4 Costs for building level metering	✓
2.6.5 Costs for dwelling metering	✓
2.6.6 Retrofitting dwelling metering in existing buildings	✓
2.6.7 Metering and billing	✓
2.7 To minimise the negative impacts of phasing the development	
2.7.1 Phasing plan	✓
2.7.2 Pipe sizing provision for future expansion	✓
2.7.3 Low-carbon technology phasing	✓
2.7.4 Long term operational efficiency	✓
2.7.5 Energy centre location	✓
2.7.6 Cost penalty	
2.8 To assess operation and maintenance needs and costs	
2.8.1 Economic modelling of operational costs	✓
2.8.2 Maintenance costs	✓
2.8.3 Metering and billing costs	
2.8.4 Other costs	✓
2.8.5 Parasitic electricity consumption	✓
2.8.6 Long term repair and replacement strategy	✓
2.9 To conduct a consistent economic analysis and options appraisal	
2.9.1 Owner's/Developer's requirements	
2.9.2 Discounted cash flow model	✓
2.9.3 Period of analysis	✓

	2.9.4 Energy prices	✓
	2.9.5 Heat sales	✓
	2.9.6 Retrofit energy efficiency measures	
	2.9.7 Discount rate	✓
	2.9.8 IRR and NPV	✓
	2.9.9 Sensitivity analysis	✓
2.10 To analyse risks and carry out a sensitivity analysis		
	2.10.1 Risk register	✓
	2.10.2 Likelihood and severity of risks	✓
	2.10.3 Mitigation assignment	✓
	2.10.4 Major risk impact assessment	✓
2.11 To assess environmental impacts and benefits		
	2.11.1 CO2 emissions calculations	✓
	2.11.2 Heat losses and electricity use	✓
	2.11.3 NOx and particulate emissions	
	2.11.4 Environmental impact of biofuels	
	2.11.5 Acoustic survey	
	2.11.6 Visual impact	✓
	2.11.7 Pre-application discussions with local planning authority	
2.12 To develop preferred business structures contract strategy and procurement strategy		
	2.12.1 Construction, ownership and operation	✓
	2.12.2 Finance, risk, governance and exit strategy	✓
	2.12.3 Proposed contract structure	
	2.12.4 Fuel and electricity contracts	
	2.12.5 Procurement strategy	
	2.12.6 Termination provisions	
	2.12.7 Allocation of roles	

Reference: Code of Practice: CP1 heat networks code of practice for the UK

[i] http://www.ukgbc.org/resources/publication/uk-gbc-task-group-interim-report-sci-legal-frameworks

References

Legal Frameworks for Sustainable Energy Infrastructure report (Legal frameworks report) prepared by the UK Green Building Council in conjunction with Berkeley Group, E:ON and NHBC Foundation published in 2012 www.ukgbc.org [i]