THE FUTURE ROLE OF THE LONDON PLAN IN THE DELIVERY OF AREA-WIDE DISTRICT HEATING

BUROHAPPOLD ENGINEERING

Final Report – 29th June 2017

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00	Summary Report – DRAFT for GLA review	JG	26/05/17	DP, AY
01	Updates to carbon results	JG	01/06/17	DP
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date	**29/06/17**
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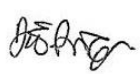
signature	
date	**29/06/17**

THE FUTURE ROLE OF THE LONDON PLAN IN THE DELIVERY OF AREA-WIDE DISTRICT HEATING

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BUROHAPPOLD ENGINEERING

EXECUTIVE SUMMARY

INTRODUCTION

- The roll out of heat networks to connect sources of low cost, low carbon and renewable heat to consumers is a core part of London's approach to decarbonising its building stock. The existing London Plan promotes heat networks as a key mechanism for the decarbonisation of new developments and requires boroughs to play their part in heat network planning and development.

- The Greater London Authority's (GLA) London Plan energy hierarchy, outlined in Policy 5.2 Minimising carbon dioxide emissions, requires new building development to follow the energy hierarchy when proposing site energy strategies to achieve carbon reductions:

  1. Be lean: use less energy
  2. Be clean: supply energy efficiently
  3. Be green: use renewable energy

- The GLA London Plan policy 5.5, Decentralised energy networks, is in place to achieve the Mayoral targets for decentralised heating and cooling networks. For District Heat Networks (DHN) to be expanded, schemes ranging from single blocks to area-wide developments should be designed to directly connect or safeguarded to connect to such networks. DHNs are seen as a way to increase renewable and low carbon technologies to decarbonise heating and cooing demands.

Sources:
1. The London plan the spatial development strategy for London, Consolidated with alterations since 2011, Greater London Authority, March 2016
2. Powering Ahead: Delivering Low Carbon Energy for London, October 2009 https://www.london.gov.uk/sites/default/files/mayor-publications-2009-docs-powering-ahead141009.pdf

STUDY OBJECTIVES

- The GLA requested consultancy advice to undertake a review of the existing London Plan policy within the context of changing carbon factors being considered at a national level. The aim was to understand the impact of retaining the existing policies on the deployment of site-wide heat networks in new developments and the ability for those developments to meet the mayors' zero carbon ambitions and onsite CO_2 reduction targets.

- The objectives of the study are to:
  - understand the implications of the proposed changes to the Standard Assessment Procedure (SAP) from the 2016 consultation by BEIS;
  - how the changes would impact the current London Plan energy hierarchy and the resulting deployment of communal heating systems in line with it;
  - test the ability for new typical residentially-led applications to meet carbon reduction targets; and
  - consider the subsequent cost of heat to consumers for each option.

- The study aims were to includes a quantitative and qualitative assessment of the objectives, as well as consider lessons learnt from other relevant policy and best practice from the UK and around the world. This study is to provide an evidence base for changes to the London Plan currently being written by the GLA.

- Two development scenarios were chosen for assessment through this study. Marginal development types (a small single block and a medium sized mixed use scheme) were chosen whilst larger area-wide development was excluded. These are denoted as scenario 1 and scenario 2 respectively. Six heat supply/servicing options were chosen to analyse a wide spectrum of technologies that cut across the Lean, Clean, Green energy hierarchy. These are outlined in the following graphs and in more detail in the main report.

CARBON INTENSITY OF HEAT ANALYSIS

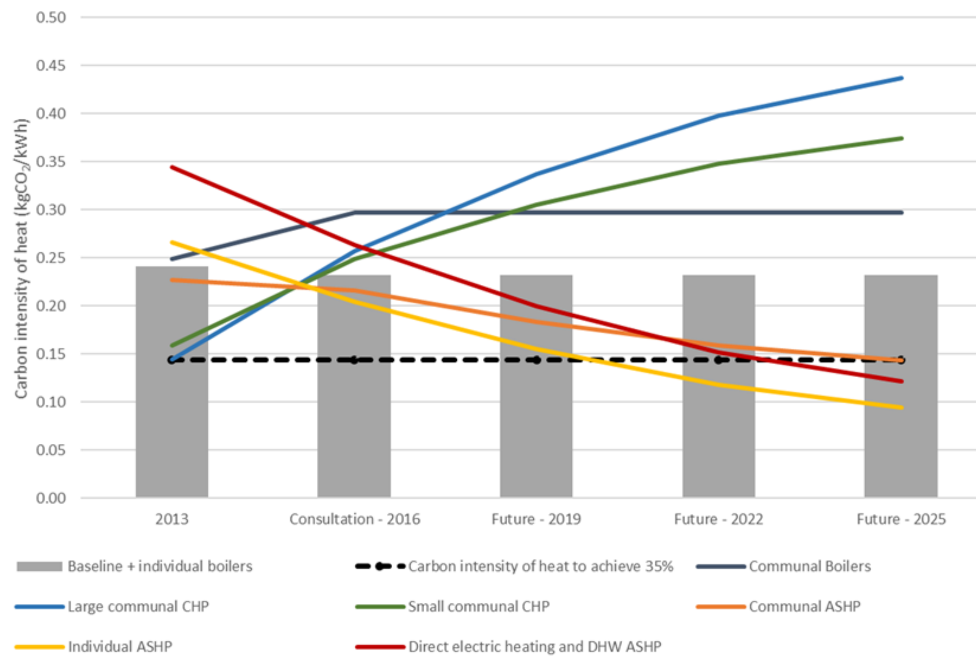
The carbon intensity of heat is the amount of Carbon Dioxide emitted in kilograms from producing a Kilowatt hour (kWh) of heat at point of use.

The graph shows the expected changes to the carbon intensity of heat by future set of BRE carbon factors by heat technology.

The analysis shows that from SAP 2019 onwards, gas engine CHP does not provide savings of delivered heat compared to communal boilers.

The carbon intensity of heat to achieve 35% has been assumed to be ~ 0.15kgCO_2/kWh. This is because this can be achieved by communal gas engine CHP engines in Part L 2013.

All electric options are expected to achieve this carbon intensity by 2025. Individual Air Source Heat Pumps (ASHPs) show the lowest carbon intensity due to no communal losses and can meet this carbon intensity by 2022.



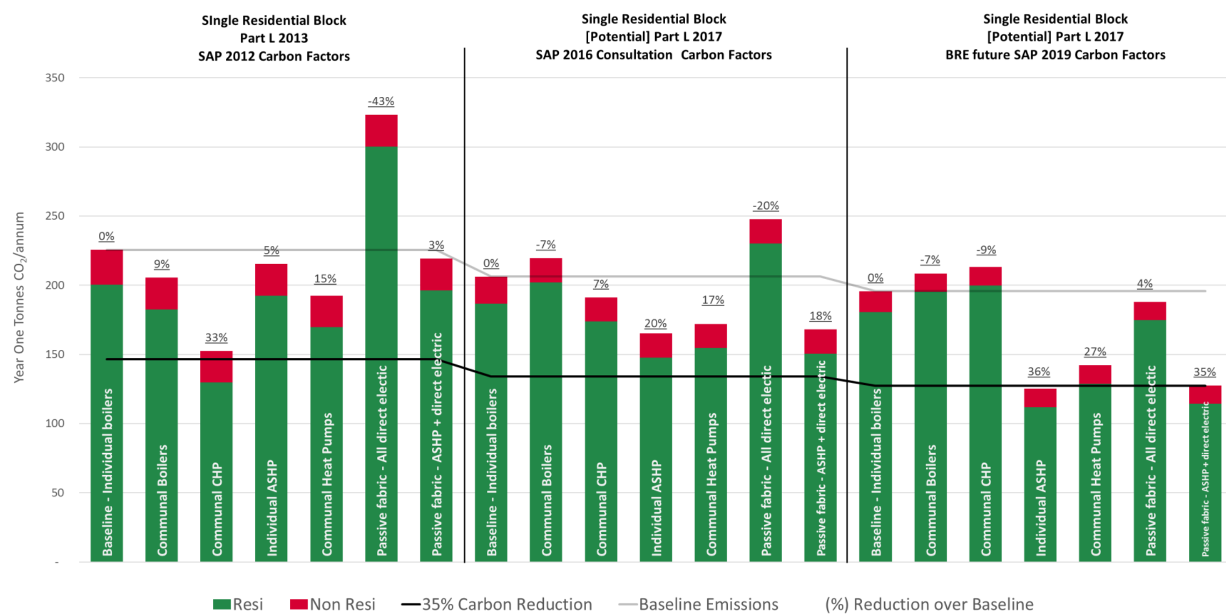
FUTURE CARBON REDUCTIONS:
SCENARIO 1 – SINGLE BLOCK

Analysis shows that gas engine CHP under current Building Regulations Part L 2013, is considered the heat supply technology that provides ~35% carbon reductions for single block and medium scale developments.

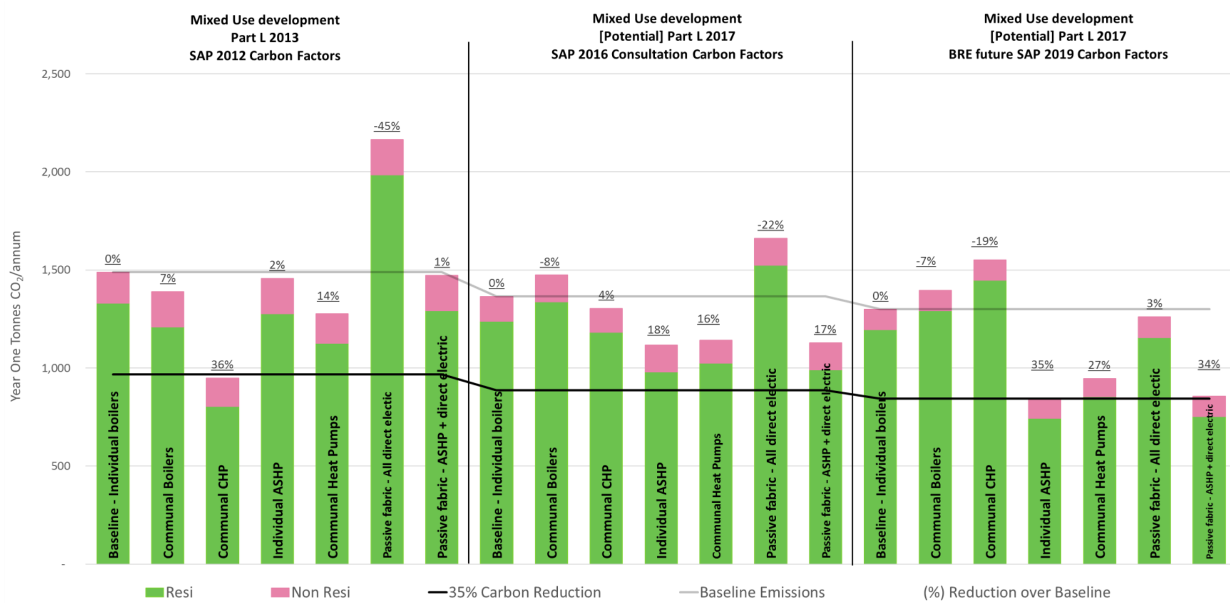
This study excluded large scale heat networks, which may also show the same results.

The analysis also shows that as SAP 2016 and beyond come into force there is likely to be a transition period in carbon reductions.

Using SAP 2016, no single option meets the 35% reduction target. Furthermore, gas engine CHP does not meet the baseline and does not provide carbon reductions at the time.



FUTURE CARBON REDUCTIONS:
SCENARIO 2 – MIXED USE



However, beyond 2019 electric heat technologies perform much better due to BRE projections of Grid decarbonisation.

Heat pumps utilised in individual dwellings or communal heating systems, show carbon savings in all years, over the baseline, increasing to between 27 – 36% using SAP 2019 carbon emission factors.

Systems that utilise passive building fabric will reduce heating demand and therefore provide carbon reductions. However heat pump technologies are required to provide significant carbon reduction beyond expected Building Regulations in force at the time.

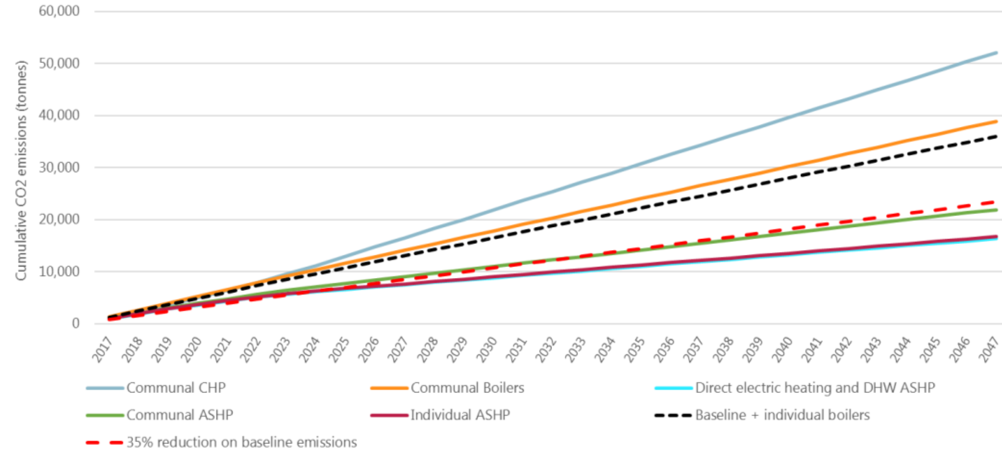
CUMULATIVE CARBON EMISSIONS

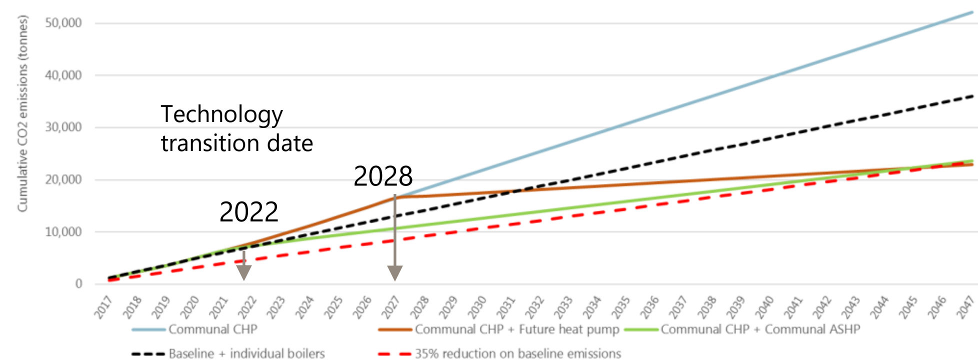
The cumulative carbon emission of each heat supply technology have also been considered.

Communal gas engine CHP significantly increases carbon emissions against communal boilers across a 30 year lifetime, whereas, despite electric systems having greater carbon emissions under Part L 2013, they are expected to provide greater than 35% reduction over the lifetime with BRE carbon factor projections.

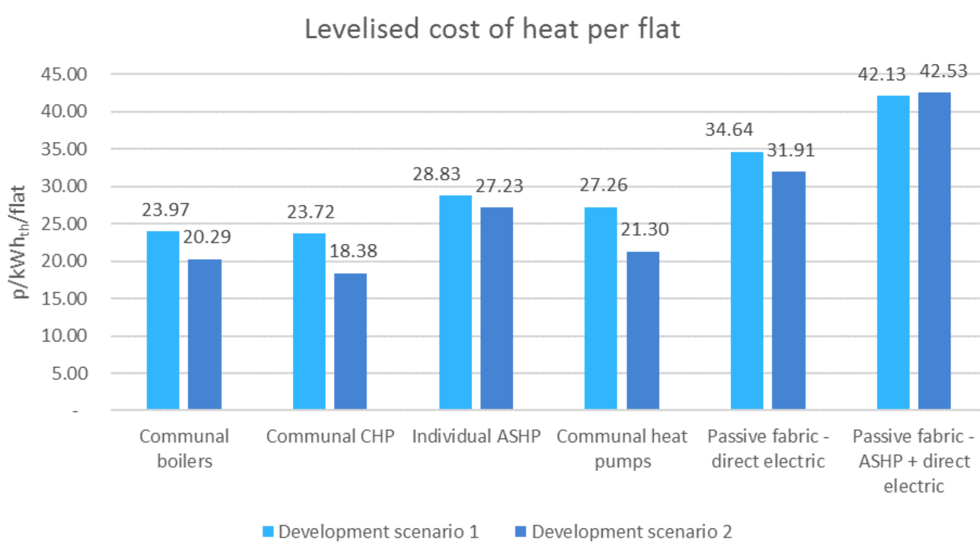
To reduce emissions in existing consented schemes that have gas engine CHP, at the time of plant replacement a lower carbon heat source should be used, such as:

- ASHPs by 2022 with a Seasonal Performance Factor (SPF) of 2.5
- Heat pumps from another environmental or waste heat source by 2028 with a SPF of 4.2





TECHNO-ECONOMIC ASSESSMENT:
LEVELISED COST OF HEAT



The levelised cost of heat is the cost of generating heat energy for a system or user. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime, which includes CAPEX, operational and maintenance costs, cost of fuel, cost of replacement. The graph shows the Levelised cost of heat for each supply option and each development scenario.

The analysis shows that communal heating is cheaper per kWh of heat in a larger developments (scenario 2) and individual heat pump options always show an increase in CAPEX compared to gas engine CHP and communal systems.

Gas engine CHP is the only option that shows a reduced levelised cost of heat reduction compared with gas boilers. However, communal heat pumps in scenario 2 have a similar cost to communal boilers. Direct electric systems show high levelised cost due to the high cost of electricity in comparison to gas.

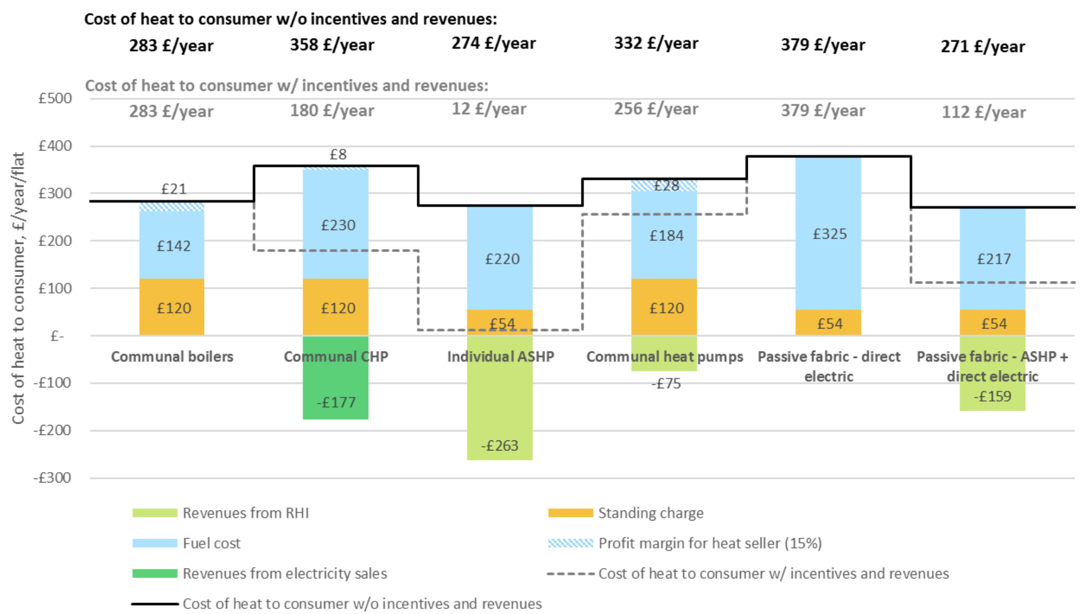
COST OF HEAT TO CONSUMERS

The graph shows the cost of heat to the consumer for each heat supply option for the small single block development. It shows the cost of heat with and without incentives or incoming revenue.

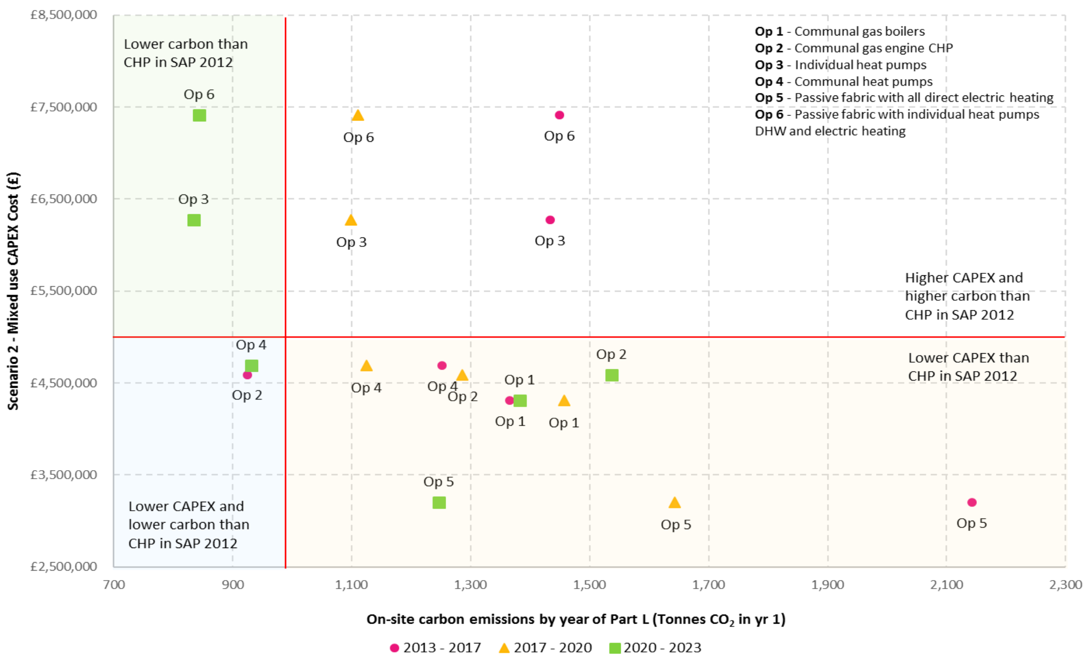
It shows that communal systems have comparable costs; gas engine CHP and heat pumps can be cheaper or equivalent to communal boilers if the revenues from incentives and electricity sales are passed on to the customer.

Individual ASHPs have nearly zero net fuel costs when Renewable Heat incentive (RHI) is available; however this only lasts for 7 years for residential dwellings under current government policy and without it, the costs are comparable to gas boilers.

Passive fabric with all direct electric systems have the greatest annual cost of heat to the consumer and are not eligible for any incentives.



INVESTMENT COST VS. CARBON



The graph shows the carbon emissions of each heat supply option under future expected iterations of Part L plotted against the capital cost to install them. It shows the results for the medium scale mixed used development. Regions have been created to show the comparison with gas engine CHP under SAP 2012, which has been shown to meet ~35% carbon reduction on site and to provide a benchmark of financial viability in many schemes across London.

Communal heat pumps shows equivalent carbon emissions to gas engine CHP, in 2013, with slightly increased CAPEX costs in 2019 onwards.

Individual heat pump options always show an increase in CAPEX but a reduction in carbon compared to gas engine CHP by 2019 onwards.

Passive Fabric with all direct electric heating show the lowest CAPEX of all the options, however show higher carbon emissions than all other options until 2019.

HOW TO FACILITATE HEAT NETWORKS AND LONG TERM CARBON REDUCTIONS GOING FORWARD

- The marginal development types chosen for the study, on a block/ single site level, are those that are key for connection to a localised DHN or area-wide DHN within a GLA opportunity area.
- For that reason it is important that these development types include communal heating and cooling systems for easy connection to DHNs that are available in the future, reducing the stumbling block for connection and mitigating replacement of individual dwelling plant.
- The follow will help facilitate DHNs and reduce carbon emissions going forward:
    - Demand reduction as a priority, reducing overall emissions, pipe sizing and therefore standing losses
    - Heat pump based district heat networks from a variety of heat sources
    - Reduction of flow and return temperature should be encouraged to reduce losses
    - Transition to lower carbon energy sources, such as environmental, waste heat and energy-from-waste will be key to arresting carbon emissions from gas engine CHP and natural gas. Accelerated replacement of gas engine CHP in existing or planned networks with communal heat pumps (as long as financially viable)
    - Allow for developments to install gas boiler only systems instead of gas engine CHP systems for extended periods of time, before DHN connection, to ensure developments are not locked into higher carbon scenarios with stranded assets.
- However, in locations where a DHN is not considered feasible, individual heat pump options will reduce overall cumulative carbon emissions in the long term. A technology-agnostic approach may be more appropriate to enable innovative and creative systems to achieve long term carbon goals. The cost implications and impacts on occupants energy bills should be strongly considered compared to a communal system even if a DHN is not imminently available.

REPORT CONTENTS

Section:

SECTION 1
INTRODUCTION

NATIONAL DRIVERS AND STRATEGY:
WHY IS DISTRICT HEATING IMPORTANT?

- The UK enacted the Climate Change Act 2008 which sets a legally binding target to achieve an 80% reduction in carbon emissions below a 1990 baseline.
- Heating and hot water for UK buildings make up around 40% of our energy consumption and 20% of our greenhouse gas emissions. It will be necessary to largely eliminate these emissions by around 2050 to meet the targets in the Climate Change Act and to maintain the UK contribution to international action under the Paris Agreement.
- Heat networks (district heating networks or DHN) can contribute to local authorities' targets and aspirations for carbon emissions reduction, fuel poverty, cost reduction, regeneration, local jobs and growth. In turn, local authorities have a vital role in developing heat networks; as sponsor, pivotal heat customer, heat source, planning authority and relationship brokers.
- Heat networks have standing losses from pipework, that transports hot water over long distances. Losses in the secondary side are more problematic than the primary side which can be as low as 6% of the energy supplied given the primary heat network has high utilisation. Primary side heat loss is defined as (annual heat generated - annual heat supplied)/annual heat generated x100%.

Sources:
1. Next steps for UK heat policy, Committee on Climate Change, October 2016
2. https://www.gov.uk/guidance/heat-networks-delivery-support

FUTURE HEAT SUPPLY CONSIDERATIONS:
2050 PATHWAYS

- In selecting an appropriate heating fuel supply source it is important to consider how CO_2 emissions associated with energy production will change over the next 25 years (indicative plant lifetime) to 40 years (indicative district heating network lifetime). A phased decarbonisation of the electricity grid is predicted to meet national CO_2 targets based on Government policy and technical feasibility. Currently, a reliance on fossil fuels means that natural gas is a significantly lower carbon fuel than electricity. Therefore, utilising gas engine CHP to offset electricity with associated high CO_2 emissions has given significant CO_2 savings in the past and is highlighted in national policy as a key technology as part of transition towards low and zero carbon heat.
- The UK Government Department of Energy & Climate Change (DECC) studies have shown that gas engine CHP remains a preferable low carbon technology up until the point that the grid decarbonises to the extent that the electricity offset by a gas engine CHP engine is of a higher CO_2 content than the electricity grid. When this happens, using heat pumps becomes a more attractive method of reducing emissions, notwithstanding concerns around the future financing of such schemes and the vulnerability of the renewable heat incentive (RHI). The RHI scheme is periodically reviewed for technologies and tariffs by Department for Business, Energy & Industrial Strategy (BEIS). The latest review took place in 2016 and reforms come into place in Spring 2017 and will apply until 1 April 2021.
- Heat pumps should, in theory, become competitive with gas engine CHP by 2020 in terms of CO_2 saving; this is dependent on a number of contributing factors which are surrounded by a considerable degree of uncertainty – the timely uptake of renewables in the UK electricity generation mix, the decommissioning of fossil fuel power stations and the uptake of "green gas" that would help decarbonise the gas grid.
- Gas engine CHP is a commonly used energy source to help achieve CO_2 emission reductions against today's building regulations, while heat pumps can be considered as a supply for future heat networks in line with the projected grid decarbonisation – heat networks can be designed to be compatible with both gas engine CHP and heat pumps to allow for flexibility of energy supply.

Sources:
1. Heat Networks: Code of Practice for the UK CP1 2015, CIBSE & ADE, 2015
2. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360323/20141001_Supporting_Tables_for_DECC-HMT_Supplementary_Appraisal_Guidance.xlsx
3. The Renewable Heat Incentive: A reformed and refocused scheme, GOV.UK https://www.gov.uk/government/consultations/the-renewable-heat-incentive-a-reformed-and-refocused-scheme

STUDY SCOPE: QUANTITATIVE ASSESSMENT

Quantitative assessment

Through energy, carbon and techno-economic analysis for typical agreed major planning applications examples, the study addresses the following scope:

A. proposed changes in the recent SAP consultation for the development of heat networks with gas engine CHP in London (specifically the changes to the carbon emissions factor and distribution loss factors). The impact should be expressed regarding both the cost viability of delivering heat networks and impact for the Mayor's existing CO_2 targets (Part L +35%)
B. comparison of heat pumps technologies and applications against typical individual building solutions for achieving equivalent CO_2 savings
C. the further impact of continued grid decarbonisation on trigger points for district heating technology choice
D. capital, operational and replacement costs for each system and the impacts on the heat price that customers are likely to pay

Qualitative assessment

Through qualitative assessment, narrative and research of the following elements are included within the scope:

A. results of the energy, carbon and techno-economic analysis to assess the impact on policy direction for the future London Plan, currently being written by the GLA.
B. a review of proposed changes in the recent SAP consultation for the development of gas engine CHP heat networks in London (specifically the changes to the carbon emissions factor and distribution loss factors).
C. lessons learnt from other relevant policy development, consented energy strategies in London and area wide heat network developments
D. impact of proposed SAP changes on the role of new build in connecting into existing heat networks and catalysing networks connecting the existing building stock

SECTION 2

SCENARIOS AND OPTIONS TESTED

DEVELOPMENT SCENARIOS AND SERVICING OPTIONS TESTED

- **Development scenarios:** Two development scenarios were chosen for assessment in this study. The aims were to assess development types that would be typical of the planning applications that the GLA would receive for approval and comment.
  - Three development scenarios were discussed; a small single block, medium sized mixed use scheme and an area wide network development. The marginal development types - a small single block and a medium sized mixed use scheme - were chosen, and the area wide development was excluded. These were chosen as they represented a block/ single site level which would be more open to variability in policy application and economic viability, whereas, it is expected that an area-wide development will more likely provide a feasible and viable DHN.
  - Energy benchmarks from previous typical BuroHappold projects have been generated for both the GLA Baseline and 'Lean' cases of the energy hierarchy. Benchmarks have been produced from typical demand figures, generated using BRE certified SAP 2012 and SBEM compliant software.
- **Servicing Options:** Six servicing options were chosen to analyse a wide spectrum of technologies that cut across the Lean, Clean, Green energy hierarchy. The options chosen also provides as cross section of the types of planning application servicing options that the GLA currrenlty receives for approval and comment.
  - BuroHappold is aware of work being undertaken to investigate the application and uptake of low carbon gas by decarbonising the gas grid. For this reason it has been excluded from this study.
  - Energy demand figures generated for each development scenario were then converted to fuel consumption figures based upon efficiencies of each heat supply technology option. Servicing option carbon emissions are generated based on annual fuel consumption in line with energy centre operational assumptions.

DEVELOPMENT SCENARIOS: DESCRIPTIONS

The table below outlines the two development scenarios chosen, the areas used for modelling and some key assumptions regarding the type of development. From this point on, development scenarios 1 and 2 will be stated.

Development Scenario	Key description	Key assumptions	NIA areas used
Development Scenario 1 – Small scale single block	Category 1A The Town and Country Planning (Mayor of London) Order 2008 Development which comprises or includes the provision of more than 150 houses, flats, or houses and flats. Single block with 2 cores 9 floors and 14 floors	• Smallest size of development typically referred to the Mayor/GLA • Not typical for gas engine CHP or only small scale offering • On-site management team to run heating services with manufacturer O&M packages • 14kWp of Solar PV	• Residential 11,750 sqm (170 units) • Retail 670 sqm Total – 12,420 sqm
Development Scenario 2 – Medium sized mixed use development	Medium sized mixed-use development ~ 1000 dwellings with ground floor non-residential uses 7 Blocks of 16 floors each	• Several blocks with a commercial offering a ground floor • Phased over a 3-5 year period • Site wide heat network and single energy centre • Typically medium sized gas engine CHP engine • Could be ESCO run • 63kWp of Solar PV	• Residential 78,400 sqm (995 units) • Retail 1,867 sqm • Offices 1,341 sqm • Restaurant 648 sqm • Community 489 sqm Total – 82,745 sqm

SERVICING OPTIONS: DESCRIPTIONS

Servicing option	1. Communal Boilers	2. Communal gas engine CHP and boilers	3. Individual heat pumps	4. Communal heat pumps	5. Passive fabric with all direct electric	6. Passive fabric with ASHP and direct electric
Key assumptions	**Communal** boiler on DHN of 91% efficiency	**Communal** boiler 30% of demand gas engine CHP sized for 70% of on site wide DHN	**Individual** ASHP for 100% of heat demand	**Communal** ASHPs for 70% of demand Gas boilers for 30% on site wide DHN	Passive fabric **Individual** Immersion heater in calorifier and Electric Space heating	Passive fabric **Individual** ASHP for DHW Electric Space heating
Dwelling Servicing	• All dwellings connect to communal network for Space Heating (SH) and Domestic Hot Water (DHW) • Solar PV	• All dwellings connect to communal network for Space Heating (SH) and Domestic Hot Water (DHW) • Solar PV	• All dwellings have individual system providing all Space Heating (SH) and Domestic Hot Water (DHW) with thermal store • Solar PV	• All dwellings connect to communal network for Space Heating (SH) and Domestic Hot Water (DHW) • Solar PV	• Triple glazing • ASHP for 100% DHW with thermal store • Space heating by panel heaters • Solar PV	• Triple glazing • ASHP for 100% DHW with thermal store • Space heating by panel heaters • Solar PV
Commercial Servicing	• Air-Source Heat Pumps VRF system for combined heating and cooling • Electric point of use Domestic Hot Water (DHW)	• Air-Source Heat Pumps VRF system for combined heating and cooling • DHN connection for DHW	• Air-Source Heat Pumps VRF system for combined heating and cooling • Electric point of use DHW	• Air-Source Heat Pumps VRF system for combined heating and cooling • DHN connection for DHW	• Air-Source Heat Pumps VRF system for combined heating and cooling • Electric point of use DHW	• Air-Source Heat Pumps VRF system for combined heating and cooling • Electric point of use DHW

SECTION 3

SAP CONSULTATION AND POTENTIAL PART L CHANGES

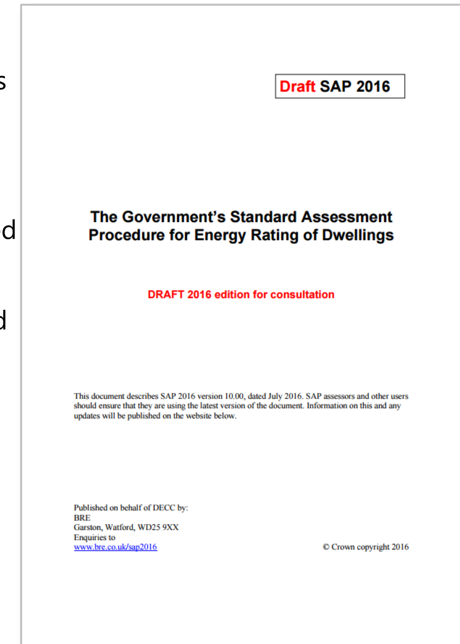
WHAT IS THE STANDARD ASSESSMENT PROCEDURE (SAP)

- The Standard Assessment Procedure (SAP) is adopted by Government as the UK methodology for calculating the energy performance of dwellings. The methodology is compliant with the recast Energy Performance of Buildings Directive (2010/31/EU). The calculation should be carried out using a computer program that implements the worksheet and is approved for SAP calculations. BRE approves SAP software used within schemes recognised by government.
- The GLA has chosen to use SAP as the method for developers to calculate the expected energy demands and carbon emissions in planning applications. This is because it aligns with the current Building Regulations requirements, is nationally prescribed and has scientific rigor.
- SAP compliant software produces a Dwelling CO_2 Emission Rate (DER) based on the architecture and systems for a dwelling. This metric is used for the purposes of compliance with building regulations, Approved Document Part L. The DER is equal to the annual CO_2 emissions per unit floor area for space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies, expressed in kg/m^2/year.
- The Standard Assessment Procedure (SAP) is adopted by Government as the UK methodology for calculating the energy performance of dwellings, of which Building Regulations Part L enforces the results and sets criterion targets. The SAP methodology and Part L are therefore separate and can be updated independently of each other. Building Regulations Part L has historically been updated every few years by Department for Communities and Local Government (DCLG), with versions released in 1995, 2002, 2006, 2010 and 2013. An update was due in 2016 however this was cancelled by DCLG. SAP methodology updates preceded these Part L updates, the first version of which was published in 1995, h further updates in 1998, 2001, 2005, 2009 and 2012.
- The Greater London Authority (GLA) requires SAP calculations for all residential planning applications and the GLA's current London Plan policy 5.2 requires 35% improvement on-site on a fixed Baseline Target Emission Rate (TER) using individual gas boilers of 89.5% efficiency. The remaining CO_2 emissions are to be offset to comply with Zero Carbon Homes policy.

Sources:
1. DRAFT SAP 2016 edition for consultation https://www.bre.co.uk/filelibrary/SAP/2016/SAP-2016-10.00--July-2016--CONSULTATION-VERSION-14-07-2016.pdf

SAP 2016 CONSULTATION CARBON FACTOR CHANGES

- The Building Research Establishment (BRE) have looked to update the procedure used for the calculation used for SAP which is based on the BRE Domestic Energy Model.
- The Department for Business, Energy & Industrial Strategy (BEIS) (formally DECC) proposed amendments to the latest version of SAP (referred to as SAP 2016 Consultation from this point on) which closed on 27th January 2017. The consultation proposed changes to the SAP approach which, if enacted, would form part of Building Regulations Approved Document Part L 2017 amendment or new version to respond to the SAP change. For the purpose of simplicity within this report, this change has been referred to as Part L 2017.
- The consultation responses are being reviewed at the time of writing and an official response is expected later this year. If changes are adopted it is expected that they may come into force in late 2017 or early 2018 but no official comment has been provided by BEIS, DCLG or BRE.
- The two most significant proposed changes to impact district and communal heating within the SAP consultation are:
  - fuel prices, CO_2 emissions and primary energy factors have been updated
  - the default distribution loss factors (DLF) associated with communal heating networks have been revised
- See appendix for further details on the DLFs and carbon factor changes proposed.


Draft SAP 2016

The Government's Standard Assessment Procedure for Energy Rating of Dwellings

DRAFT 2016 edition for consultation

This document describes SAP 2016 version 10.00, dated July 2016. SAP assessors and other users should ensure that they are using the latest version of the document. Information on this and any updates will be published on the website below.

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Enquiries to
www.bre.co.uk/sap2016

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Sources:
1. DRAFT SAP 2016 edition for consultation https://www.bre.co.uk/filelibrary/SAP/2016/SAP-2016-10.00--July-2016--CONSULTATION-VERSION-14-07-2016.pdf
2. Public consultation on proposals to amend the Standard Assessment Procedure (SAP) https://www.gov.uk/government/consultations/public-consultation-on-proposals-to-amend-the-standard-assessment-procedure-sap

EMISSIONS FACTORS – PROPOSED CHANGES

- The scope of this study is to analyse carbon emissions in line with the SAP 2016 consultation. The BRE produced a Consultation Paper: CONSP:07 with the SAP 2016 consultation release that described the development of CO_2 and primary energy factors for SAP 2016.
- The paper outlined how the projected system average electricity emission factors for current and future periods (coinciding with anticipated revisions of Part L of the Building Regulations). This provided an indication of the likely trajectory, but the emission factor for future years may be different. These are outlined below and have been used for future SAP years within this study
- The Marginal grid emission factors, as outlined by the LLDC consultation response, were not used and the following justification was provided by the BRE:
  - *"System average values reflect the primary energy and emissions associated with grid supply electricity in the UK and are appropriate for measuring and reporting energy and carbon impacts. In contrast marginal emission factors are appropriate for measuring the effect of changes in demand compared to a normal or baseline situation."*
- As the BRE have used the system average carbon emissions figures, this study will also follow this approach. These align with the Updated energy and emissions projections 2014: projections of greenhouse gas emissions and energy demand 2014 to 2030, October 2014, DECC.

Part L version/ years	2013 -2016	2017 - 2018	2019 -2021	2022 – 2024	2025 -2027
Information Source	SAP 2012	BRE SAP 2016 Consultation	Projected	Projected	Projected
Unit	$kgCO_2/kWh$				
Natural Gas	0.216	0.208			
Grid Electricity	0.519	0.398	0.302	0.229	0.183

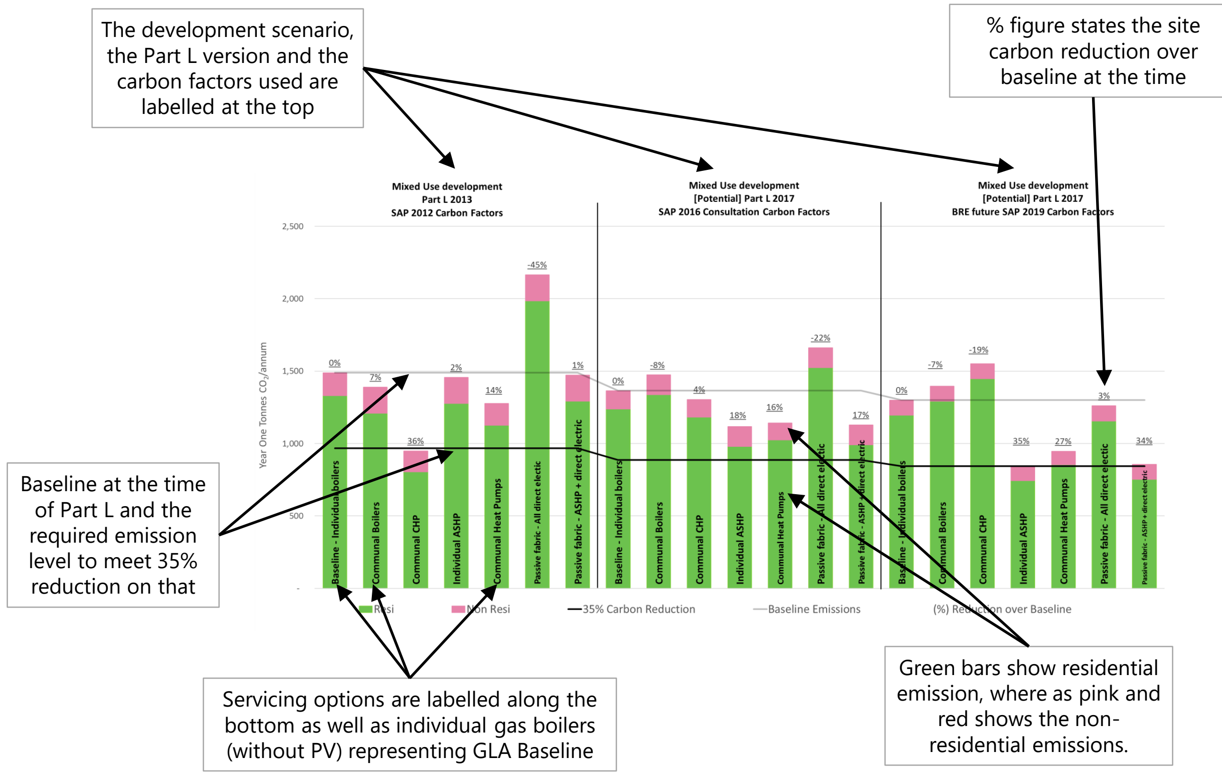
Sources:
1. DRAFT SAP 2016 edition for consultation https://www.bre.co.uk/filelibrary/SAP/2016/SAP-2016-10.00--July-2016--CONSULTATION-VERSION-14-07-2016.pdf
2. Consultation Paper: CONSP:07 - CO_2 AND PRIMARY ENERGY FACTORS FOR SAP 2016 – version 1.0 http://www.bre.co.uk/sap2016/page.jsp?id=3619

SECTION 5

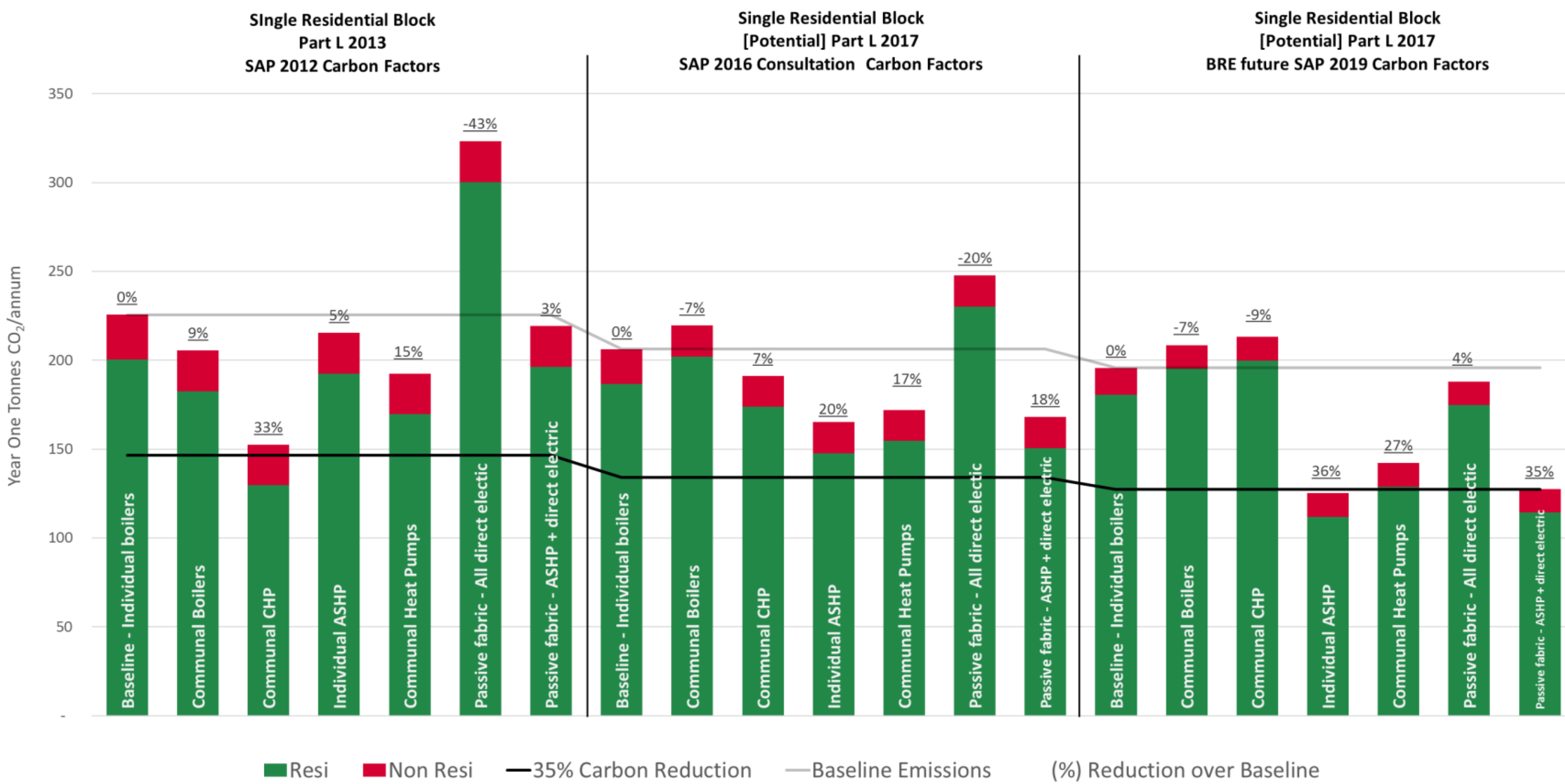
IMPACTS OF SAP CONSULTATION ON DEVELOPMENT SCENARIO CARBON EMISSIONS

CARBON EMISSIONS ANALYSIS

- The quantitative assessment has sought to analyse the impacts of the SAP 2016 consultation and the future 2019 carbon factors on both development scenarios for all six servicing options.
- Graphs have been produced to show the total carbon emissions from residential and non-residential elements, as well as total reductions, as explained through the annotations.



TECHNICAL RESULTS:
CARBON REDUCTIONS IN SCENARIO 1 – SINGLE BLOCK



TECHNICAL RESULTS:
CARBON REDUCTIONS IN SCENARIO 1 – SINGLE BLOCK

Communal gas engine CHP

- Communal gas engine CHP is the only option achieving 35% reduction with 2013 Part L Regulations
- However, only small carbon savings are observed using SAP 2016 Consultation
- And it is potentially not meeting Part L Regulations in 2019

Communal heat pumps

- Communal heat pumps show some reductions with current Regulations but not as significant as gas engine CHP
- With SAP 2016 Consultation, they perform better than gas engine CHP due to reduced network losses (~20% rather than 30%)
- They are potentially meeting future Regulations but not achieving the 35% target

Individual electric systems

- Individual electric systems are not recommended under current Regulations
- With SAP 2016 Consultation, however, the use of individual heat heat pumps represents the lowest carbon solution
- Individual heat pumps are the only systems achieving over 35% reductions with 2019 carbon factors

CARBON EMISSIONS ANALYSIS:
OVERALL CARBON REDUCTIONS IN SCENARIO 1 – SINGLE BLOCK

- Communal gas engine CHP shows the highest carbon savings under current Building Regulations Part L; however carbon emissions steadily increase with each update to the carbon emission factors and increased DLFs.
- Gas engine CHP does not show any carbon savings compared to individual gas boiler baseline from SAP 2019 onwards. This is because gas engine CHPs prioritise heat efficiencies for production of electricity. The lower the electricity carbon factor, the less effective a gas engine CHP is at reducing carbon emissions. Smaller gas engine CHPs generally have a higher heat efficiency compared to the larger engine in Scenario 2. Therefore under future regulations the electricity produced does not provide as significant carbon reductions compared to 2013 Part L Regulations.
- Under the 2016 SAP consultation, no servicing options in either development scenario meet the 35% reduction targets over the GLA baseline at the time. The best improvement is provided by Passive fabric with ASHP for space heating and immersion Heater for DHW, with 18% in SAP 2016.
- The communal boiler option will need to compensate for the lack of LZC technologies and communal pipework losses with additional fabric improvements in SAP 2016 and 2019, as no carbon reductions are shown over baseline in those years. These have not been modelled or costed within the analysis for the communal boilers going forward.
- Heat pump options, individual and communal show carbon savings in all years, over the baseline, increasing to between 35 & 36% in 2019.

CARBON EMISSIONS ANALYSIS:
OVERALL CARBON REDUCTIONS IN SCENARIO 2 – MIXED USE

CARBON EMISSIONS ANALYSIS:
CARBON REDUCTIONS IN SCENARIO 2 – MIXED USE

- The analysis shows the same trends and patterns of carbon reductions as per Development Scenario 1.
- The only marked difference is that the smaller gas engine CHP in Development Scenario 1 performs better than its larger equivalent in Development scenario 2; however it does not provide any carbon savings compared to individual gas boiler baseline. Larger gas engine CHPs prioritise electrical generation over heat production efficiency. Under future regulations, with a reduced electricity carbon factor, the electricity produced does not provide as significant carbon reductions compared to Part L 2013 Regulations.
- The passive fabric with all direct electric systems option only shows carbon savings in 2019, due to the reduced carbon factor for electricity. It shows a 3% reduction over baseline under SAP 2019. However the other all-electric systems options, which include heat pumps, out-perform it from between 34-35%, showing a significant improvement over baseline and the Passive fabric with all direct electric systems option.
- Communal heat pumps show a 27% carbon reduction for 2019, therefore not meeting the 35% reduction target. However, the overall carbon emissions are lower than those of the 35% reduction beyond the 2013 baseline.

THE FURTHER IMPACT OF CONTINUED GRID DECARBONISATION ON TRIGGER POINTS FOR COMMUNAL HEATING TECHNOLOGY CHOICE

- If the electricity grid is to decarbonise in line with the BRE projections (which align with BEIS projections) it is expected that there will be an increased number of heat pump technologies to provide the required carbon savings for high density developments in London. As SAP electricity emission factors reduce, higher seasonal performance factors will not be necessary to achieve the GLA's 35% on site carbon reductions.
- Following the carbon analysis, the SPFs of communal heat pumps were tested to understand the trigger points for varying technologies from differing energy sources. The below SPFs are indicative and not exhaustive of the heat pumps and heat sources that could provide the required values. The SPFs stated are heat pumps providing 70% of demand in combination with gas boilers for 30% of demand.

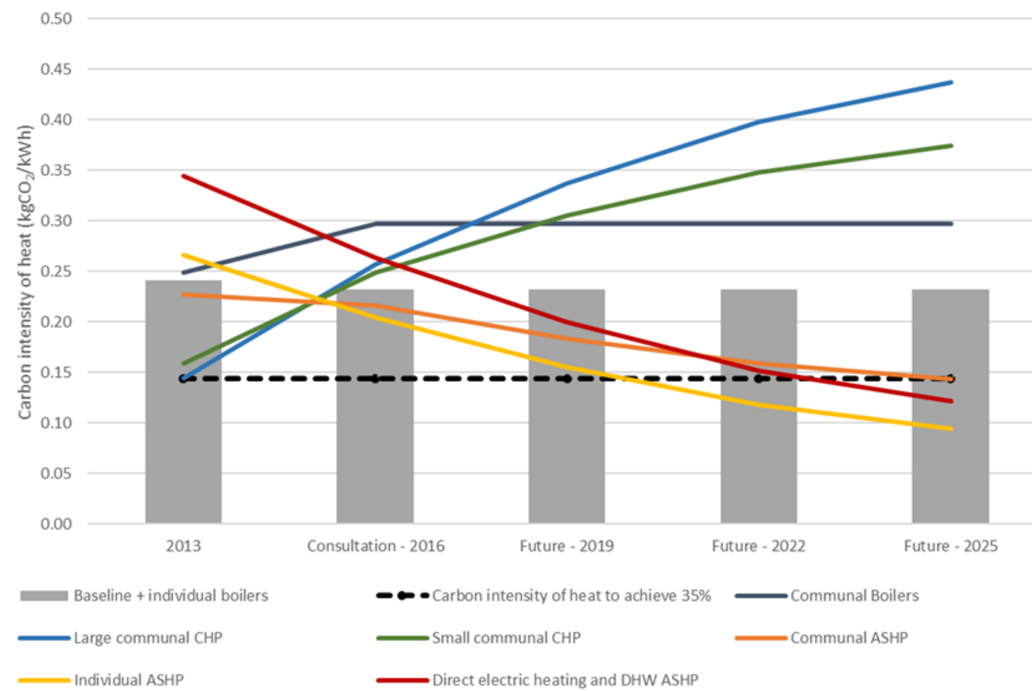
SAP version	SPF to meet 35% overall on site	Indicative communal heat pump technology and heat source to meet required SPF
2012	4.5 kWh/ kWh	• Waste Water Heat Pump (from municipal sewer waste water supply), • Open Loop Ground Source Heat pumps (for combined heating and cooling); or • High temperature CO_2 Heat Pump
2016	4.5 kWh/ kWh	
2019	3.5 kWh/ kWh	• Closed loop Ground Source Heat pump or Water Source Heat pump any of the above

APPLICATION OF HEAT PUMPS TECHNOLOGIES

- **Air Source Heat Pumps –** were chosen as the technology to test in more detail as they are considered the most common and can be applied to nearly any building typology or location. ASHPs are not limited by capacity their heat source, unlike other HP technologies. They also generally provide the lowest SPFs of all the HPs technologies, highest peak heat demands correlate with coldest external temperatures, therefore were considered as a typical backstop in the communal heat pump case. ASHPs also require access to external atmosphere; the easiest way is for the plant to be roof mounted. This has can have visual and acoustic considerations to factor into planning approval.
- **Ground or Water Source Heat Pumps –** can provide higher efficiencies and RHI payments compared to ASHPs, however they are limited by a local heat source capacity. Water Source Heat Pumps (WSHPs) require proximity to a consistent flowing water source as well as Environment Agency approval. Ground Source Heat Pumps (GSHPs) capacity is limited to depths of the boreholes drilled and site area, boreholes cannot be in too close proximity for efficient operation. Both these factors limit their applications for all developments in dense areas.
- **High temperature CO_2 Heat Pumps –** can produce high temperature LTHW (60-90 degrees C) without the need for harmful Green House Gas refrigerants. They require high pressures however can produce LTHW at high efficiency at third generation heat network temperatures (70-40 degree C). However, these are a relatively new technology to the market within the UK. However high temperature heat pumps consume more power which affects the COP. A lower temperature HP would be preferred where the heating system can be designed or adapted to lower supply temperatures

CARBON INTENSITY OF HEAT ANALYSIS

- The Carbon intensity of heat is the amount of Carbon Dioxide emitted in kilograms from producing a Kilowatt hour (kWh) of heat at point of use.
- The graph shows the expected changes to the carbon intensity of heat by future set of BRE carbon factors by heat technology.
- The analysis shows that from SAP 2019 onwards, gas engine CHP does not provide savings of delivered heat compared to communal boilers.
- The Carbon intensity of heat to achieve 35% has been assumed to be ~ 0.15 kg CO_2/kWh. This is because this can be achieved by communal gas engine CHP engines in Part L 2013.
- All electric options are expected to achieve options achieve the 0.15 kgCO_2/kWh by 2025. Individual Air Source Heat Pumps (ASHPs) show the lowest carbon intensity due to no communal losses and can meet this carbon intensity by 2022.

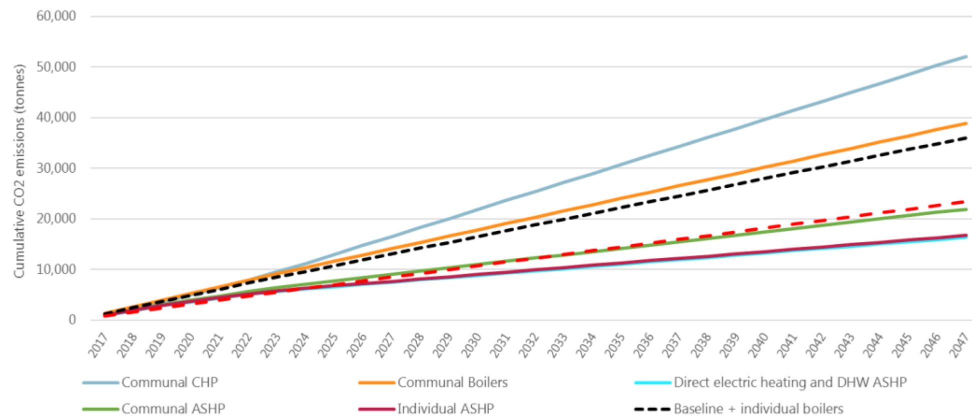


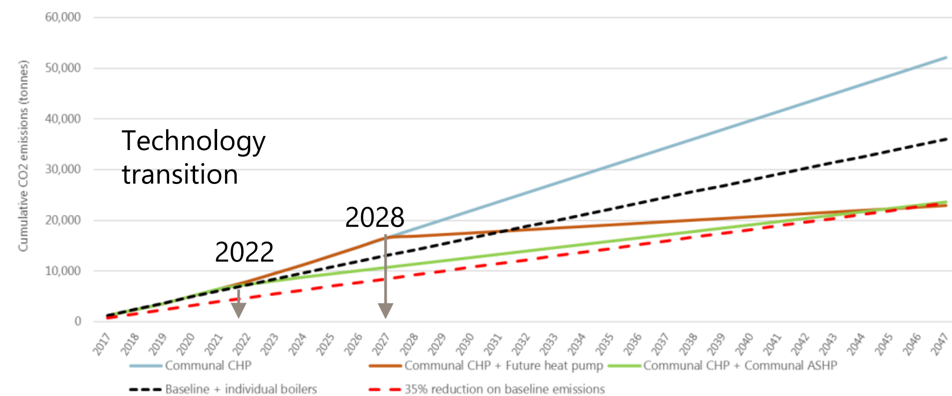
CUMULATIVE CARBON EMISSIONS

- Communal gas engine CHP provide significant carbon increase over communal boilers over a 30 year lifetime, in line with GLA Whole Life Costing guidelines.
- Even though electric systems have higher carbon emissions using Part L 2013, they are expected to provide >35% reduction over lifetime with BRE carbon factor projections.
- No long term difference in individual ASHPs and Passive servicing option as provide similar carbon savings from day one

How to arrest gas engine CHP emissions in existing consented schemes

- gas engine CHP emissions will need to be arrested to achieve long term carbon savings to 35% over the lifetime of the scheme.
- gas engine CHP should not be replaced with other gas engine CHP if long term carbon savings are to be achieved.
- Plant replacement with current ASHPs latest transition point 2022 to achieve 35% reduction – SPF 2.5 .
- Plant replacement with future heat pumps (any heat source) latest transition point 2028 to achieve 35% reduction – SPF 4.2.





THE IMPORTANCE OF TIMING TO SUPPORT MEETING UK CARBON BUDGETS

- Whilst the preceding evaluation of cumulative carbon emissions over a notional 30 year period is helpful to understand the long term performance of different technologies, its also important to remember that the timing of carbon emission reductions is a valid consideration.
- Progress reporting by the Committee on Climate Change identified a series of policy risks for delivery of the Fourth Carbon Budget, particularly relating to the buildings sector. Therefore, policy makers should consider giving greater weight to action that supports early and sustained contributions to meeting UK carbon budgets.

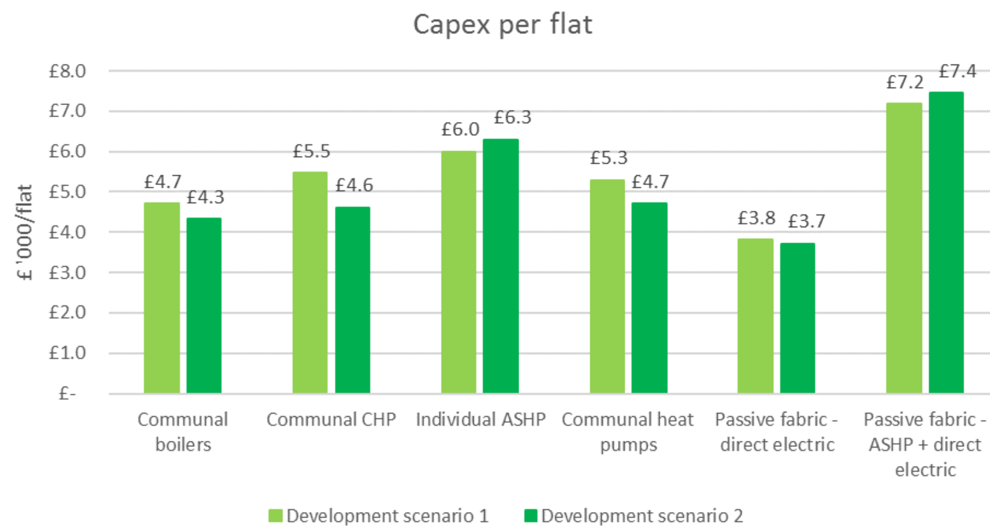
Sources:
1. https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/

SECTION 6

TECHNO-ECONOMIC ASSESSMENT

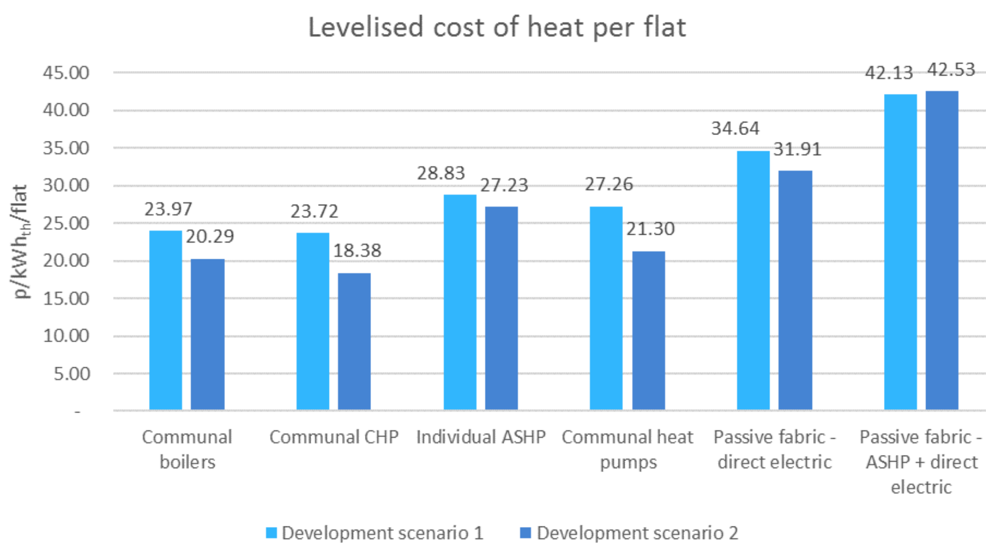
CAPEX COSTS PER FLAT

- Capital cost investment (CAPEX) has been calculated per development scenario and option. Appendix B outlines what has and hasn't been included in each option.
- The analysis shows that communal systems provide lower CAPEX per flat compared to individual systems due to economies of scale, apart from the direct electric, Option 5.
- Repeated fixed costs for individual plant increase overall CAPEX. These include: transformer uplift for additional electricity site capacity, the number of individual ASHP units and Passive fabric schemes.
- Communal systems also have a lower cost per flat in the larger development, scenario 2, as fixed infrastructure or communal cost are spreads between more dwellings.

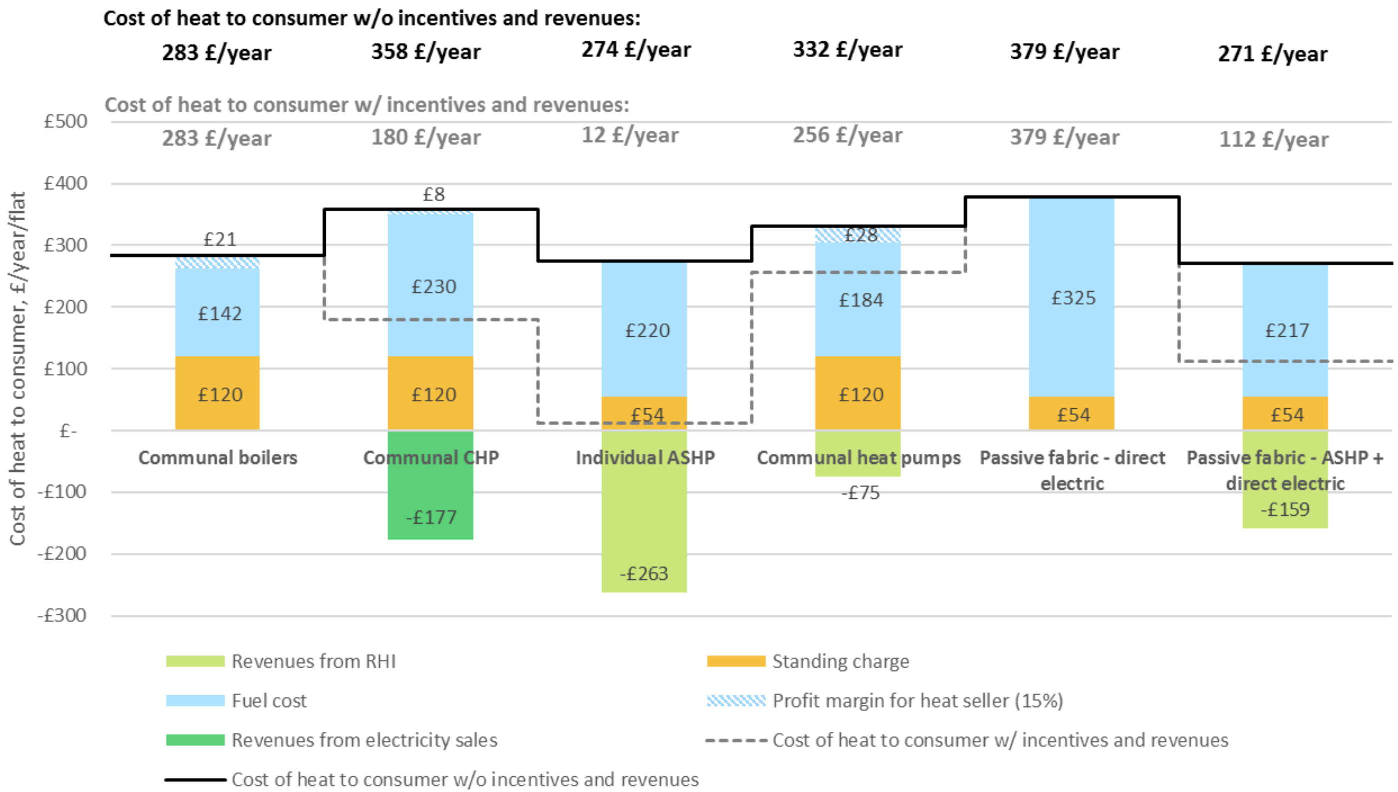


LEVELISED COST OF HEAT

- The levelised cost represents the cost incurred over the system's lifetime per unit of useful heat generated. This included CAPEX, OPEX, REPEX (replacement) and income or incentives.
- The analysis shows communal heating is significantly cheaper per kWh of heat in a larger development, as economy of scale reduces the system's costs.
- Gas engine CHP is the only option that shows a cost reduction on gas boilers, followed by communal heat pumps
- Direct electric systems show high levelised cost due to the high cost of electricity in comparison to gas
- Heat pumps show a lower cost on a communal scale due to commercial RHI for 20 years instead of 7 years for residential as well as increased efficiencies with peak gas boilers running on coldest days



TOTAL AVERAGED ANNUAL HEAT COSTS IN YEAR ONE TO OCCUPANT



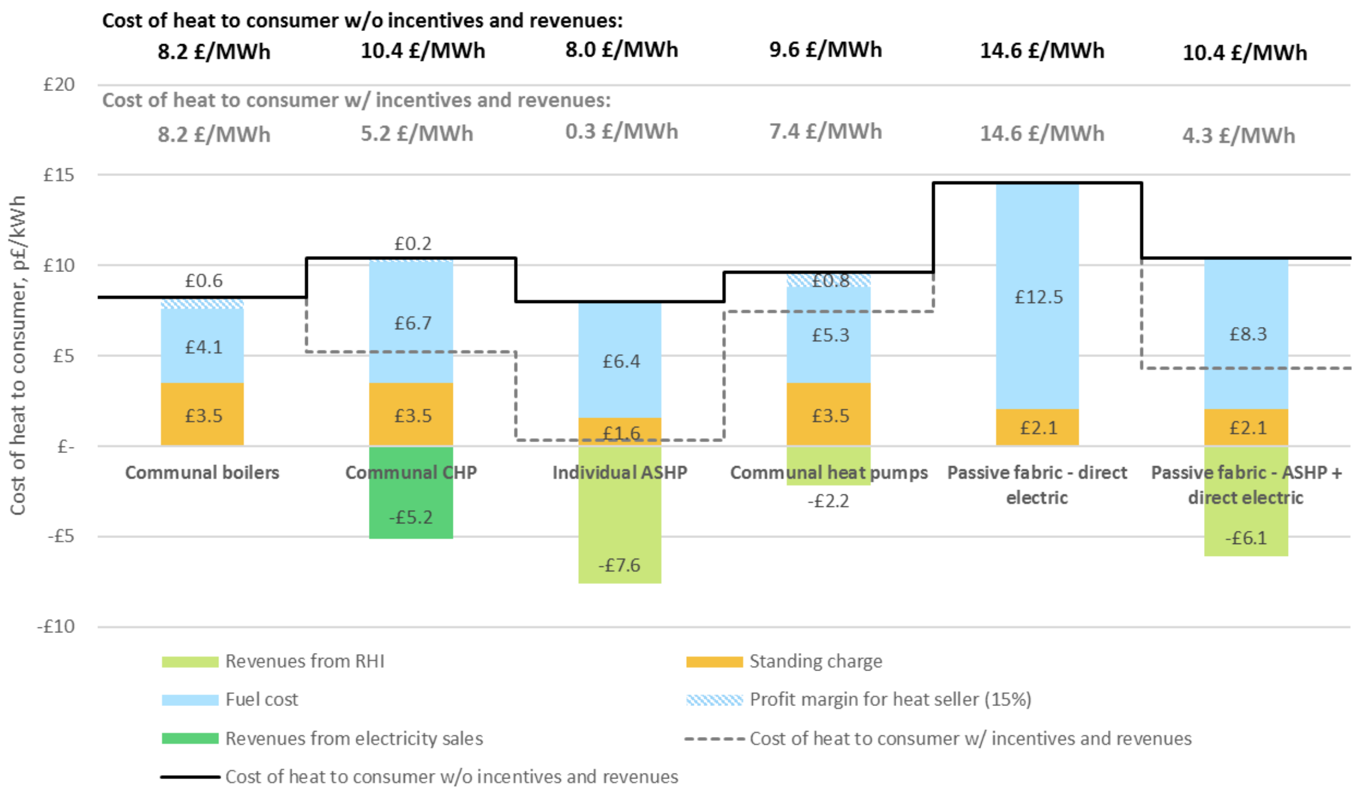
Sources:
1. Ofgem, Domestic RHI Tariffs and Payments
2. Ofgem, Non-domesric RHI Tariffs and Payments
3. Standing charges as per SAP Methodology 2012
4. Fuel costs as per DECC Energy & Emissions Projections – November 2015

TOTAL AVERAGED ANNUAL HEAT COSTS IN YEAR ONE TO OCCUPANT

- The analysis is shown for development scenario 1 only.
- The two scenarios are considered to have similar cost of heat to the consumer, as the results are shown on a per flat basis.
- The cost of heat to the consumer analysis is composed of the following elements:
  - a fixed standing charge on heat from community schemes and on the electricity bill;
  - fuel costs;
  - a 15% profit margin for the communal system's operator;
- Revenues from sales of electricity for gas engine CHP and Renewable Heat Incentive (RHI) for heat pumps; the Domestic RHI is applicable for individual heat pumps and is granted at 7.63p/kWh for 7 years, while the Non-Domestic RHI, applicable for communal heat pumps, is granted at 2.61p/kWh for 20 years.
- Direct electric systems have the highest cost, due to the lower relative efficiency and use of a high cost fuel, while individual ASHPs are relatively cheap, especially if the revenues from the RHI are passed on to the consumers.
- Communal systems have comparable costs; gas engine CHP and heat pumps can be cheaper or equivalent to communal boilers if the revenues from incentives and electricity sales are passed on to the customer.

Sources:
1. Ofgem, Domestic RHI Tariffs and Payments
2. Ofgem, Non-domesric RHI Tariffs and Payments
3. Standing charges as per SAP Methodology 2012
4. Fuel costs as per DECC Energy & Emissions Projections – November 2015

AVERAGED COST PER KILOWATT HOUR OF HEAT TO OCCUPANT



Sources:
1. Ofgem, Domestic RHI Tariffs and Payments
2. Ofgem, Non-domesric RHI Tariffs and Payments
3. Standing charges as per SAP Methodology 2012
4. Fuel costs as per DECC Energy & Emissions Projections – November 2015

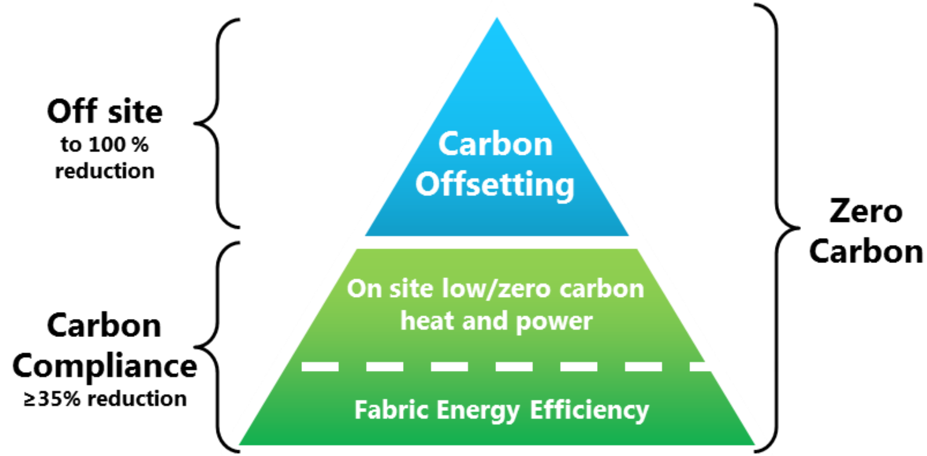
AVERAGED COST OF HEAT TO CONSUMERS

- Passive fabric with all direct electric systems shows the highest cost to the consumer per kWh as well as the highest overall cost of heat averaged over the year. This is due to the high electricity fuel cost. This is the option with lowest CAPEX but will increase occupant fuel bills be nearly double that of a communal boiler system.
- The total heat demand however is reduced compared to the communal boiler option, reducing the relative overall annual fuel bill down, however occupants would be at risk of even higher energy bills if demands increase over those assumed within the modelling.
- The cost of heat to the consumer for communal gas engine CHP and communal heat pumps, are in the region of 8-10p/kWh, although it could reach ~ 5p/kWh for gas engine CHP if revenues from electricity sales are passed onto the customer.
- Individual ASHPs, shows nearly zero net fuel costs when RHI is available, however this only lasts for 7 years for residential dwellings under current government policy and without it, increasing to comparison with gas boilers. The commercial RHI lasts for 20 years and is applicable in communal heating systems. Additionally the rates are lower then that for residential schemes.

Sources:
1. Ofgem, Domestic RHI Tariffs and Payments
2. Ofgem, Non-domesric RHI Tariffs and Payments
3. Standing charges as per SAP Methodology 2012
4. Fuel costs as per DECC Energy & Emissions Projections – November 2015

GLA'S ZERO CARBON HOMES AND CARBON OFFSET PRICE

- The existing GLA London Plan policy was prepared in expectation of the establishment of a national zero carbon homes and associated 'allowable solutions' framework, However the government decided to not continue with this policy. As a result carbon offset funds have been established by boroughs to collect carbon offset payments where a development is unable to viably or feasibly meet carbon dioxide emissions reduction targets on-site.
- If a planning application is submitted post 1st October 2016 GLA Zero Carbon Homes (ZCH) applied, in line with the GLA London Plan policy 5.2 Minimising Carbon Dioxide emissions.

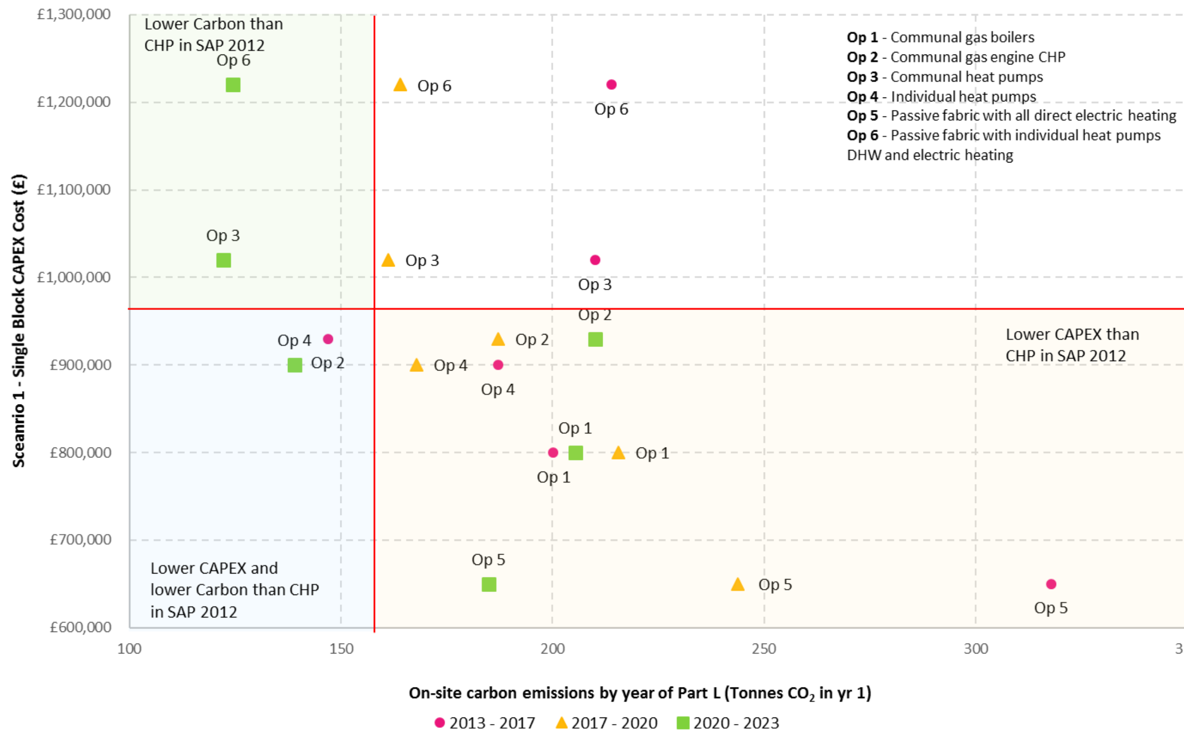


- Residential developments are expected to achieve at least 35% reduction in regulated carbon (beyond Part L 2013) on site. The remaining regulated CO_2 emissions, to 100%, are to be off-set through a cash-in-lieu payment. The current London Plan policy 5.2 also stipulates the from 2019 non-domestic buildings will also need to comply with assumed zero carbon.
- The price of carbon emissions is set by each London borough and prices vary across London. The GLA has set their own standard price of £60/tonne x 30yrs = £1800/tonne, as outlined in the GLA's Sustainable Design And Construction SPG.

Sources:
1. https://www.london.gov.uk/decisions/add397-review-carbon-offsetting-approaches-london
2. Sustainable Design And Construction, Supplementary Planning Guidance, GLA, April 2014

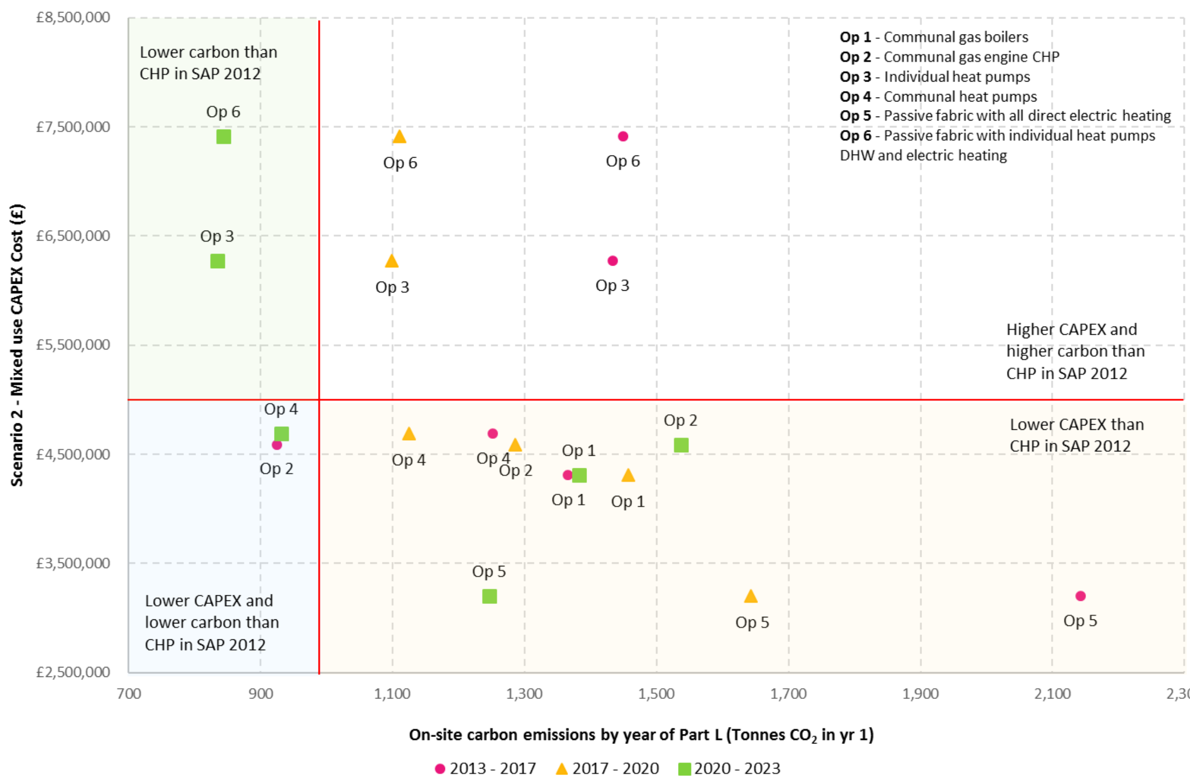
SCENARIO 1 SINGLE BLOCK:
MARGINAL ABETMENT COST COMPARISON

- The graph shows Capex against overall carbon emissions for each serving option in each Part L time period.
- Regions have been created to show the comparison to gas engine CHP under SAP 2012, which has been shown to meet ~35% carbon reduction on site as well as suggesting financial viability in many schemes across London.
- Individual heat pumps show reduced overall carbon emissions and communal Heat pumps also provides lower carbon emission as well as lower CAPEX.
- Passive Fabric with all direct electric heating also shows that it is close to the region of equivalent carbon savings as gas engine CHP (blue or green) with significantly reduced CAPEX.



SCENARIO 2 MIXED USE:
MARGINAL ABETMENT COST COMPARISON

- For development scenario 2, no options show a carbon reduction compared to gas engine CHP in SAP 2012 until 2019 onwards.
- Communal heat pumps shows equivalent carbon savings to gas engine CHP, in 2013, with slightly increased CAPEX costs in 2019.
- Individual heat pump options always show an increase in CAPEX but a reduction in carbon compared to gas engine CHP.
- Passive Fabric with all direct electric heating shows increased emissions relative to gas engine CHP, compared to the same option in Scenario 1 and therefore not equivalent to gas engine CHP. This is due to the increased non-residential to residential proportions within the scheme which do not connect to a LZC DHN in this option.



SECTION 7

INSIGHTS FROM ANALYSIS

CONNECTING DIFFERENT BUILDING TYPES TO NEW OR EXISTING HEAT NETWORKS

- The changes will impact both new developments connecting to new and existing DHNs.
  As outlined in the LLDC's SAP consultation response, new developments connecting to previously deigned DHNs will use differing factors to judge performance.
- The matrix shows options for both technical remediation and/ or derogations to planning and Building Regulations to still allow connection to DHNs and ensure stranded assets are not created from these changes.
- The GLA should consider how Policy is applied by planning officers in these cases.

HEAT NETWORK \ BUILDING	Existing	New
Existing	• Most likely won't be referred to planning • Review potential for future plants replacement – low carbon heat source	• It may not pass Part L / BREEAM • Use long term planning factors – future carbon factors as well as current, or cumulative carbon over lifetime • Explore derogation for Building Regulations compliance
New	• No Part L requirements • Plant to implement low carbon heat source once financially viable • Apportion carbon savings from new technologies to new developments?	• Use long term planning factors– future carbon factors as well as current, or cumulative carbon over lifetime • Built-in flexibility for servicing options • Straight to communal heat pumps or other equivalent LZC

HOW TO FACILITATE HEAT NETWORKS AND LONG TERM CARBON REDUCTIONS GOING FORWARD

- The marginal development types chosen for the study, on a block/ single site level, are those that are key for connection to a localised DHN or area-wide DHN within a GLA opportunity area.
- For that reason it is important that these development types include communal heating and cooling systems for easy connection to DHNs that are available in the future, reducing the stumbling block for connection and mitigating replacement of individual dwelling plant.
- The follow will help facilitate DHNs and reduce carbon emissions going forward:
  - Demand reduction as a priority, reducing overall emissions, pipe sizing and therefore standing losses
  - Heat pump based district heat networks from a variety of heat sources
  - Reduction of flow and return temperature should be encouraged to reduce losses
  - Transition to lower carbon energy sources, such as environmental, waste heat and energy-from-waste will be key to arresting carbon emissions from gas engine CHP and natural gas. Accelerated replacement of gas engine CHP in existing or planned networks with communal heat pumps (as long as financially viable)
  - Allow for developments to install gas boiler only systems instead of gas engine CHP systems for extended periods of time, before DHN connection, to ensure developments are not locked into higher carbon scenarios with stranded assets.
- However, in locations where a DHN is not considered feasible, individual heat pump options will reduce overall cumulative carbon emissions in the long term. A technology-agnostic approach may be more appropriate to enable innovative and creative systems to achieve long term carbon goals. The cost implications and impacts on occupants energy bills should be strongly considered compared to a communal system even if a DHN is not imminently available.

BUROHAPPOLD ENGINEERING

www.burohappold.com

APPENDIX A

ENERGY ANALYSIS INPUTS

SAP CARBON FACTORS

- From DRAFT 2016 edition for consultation
  https://www.bre.co.uk/filelibrary/SAP/2016/SAP-2016-10.00--July-2016--CONSULTATION-VERSION-14-07-2016.pdf
- From SAP Guidance 2009 and 2012 for past figures. Consultation Paper: CONSP: 07 for future figures
  https://www.bre.co.uk/filelibrary/SAP/2016/CONSP-07---CO_2-and-PE-factors---V1_0.pdf

Part L version	2013 -2016	2017 - 2018	2019 -2021	2022 – 2024	2025 -2027
Information Source	SAP 2012	BRE SAP 2016 Consultation	BRE anticipated	BRE anticipated	BRE anticipated
Unit	$kgCO_2/kWh$	$kgCO_2/kWh$	$kgCO_2/kWh$	$kgCO_2/kWh$	$kgCO_2/kWh$
Natural Gas	0.216	0.208			
Grid Electricity	0.519	0.398	0.302	0.229	0.183

BOILER AND GAS ENGINE CHP EFFICIENCIES

Engine / Boiler	Thermal Eff (%)	Electrical (%)	Thermal Capacity (kWp)	Electrical Capacity (kWp)	LHV Energy Input (kW)	HHV Energy Input (kW)	Heat fraction from gas engine CHP	Heat to Power
ENER-G 70	48.2%	31.0%	109	70	204	226	70%	1.56
ENER-G 425	37.8%	34.7%	468	430	1119	1238	70%	1.09
Communal Boiler	91.0%	0.0%	91	0	-	100	30%	n/a

COOLING AND HEAT PUMP EFFICIENCIES

System	DHW SPF ()	Space heating SPF ()	Cooling SEER ()	Cooling delivery efficiency (%)
Individual ASHPs System	1.71	2.49	4.5	0.8
Communal ASHP System	2.5		n/a	n/a
Direct electric heating	0.87	1.0	0.0	0.8
Chiller	n/a	n/a	5.0	0.8
notional cooled space (2013)	n/a	n/a	4.7	0.8
Notional mixed mode space (2013)	n/a	n/a	3.4	0.8

SOLAR PV ARRAY ASSUMPTIONS

Solar PV input	Variable
Solar PV roof utilisation	12%
Solar PV - % of ground floor area available	20%
Solar PV panel to roof ratio	60%
PV energy production (kWh/kWp)	850
area per collector (m2)	1.63
kWp/m2	0.154
kWh/m2	130.6
£ per kWp	£1,330
Lifetime (years)	30

Solar PV Emission Savings (kg CO_2/ annum)	PV Array Capacity (kWp)	2013	2016	2019
Scenario 1	14 kWp	-954	-731	-555
Scenario 2	63 kWp	- 4,265	-3721	-2482

APPENDIX B
ECONOMIC ANALYSIS INPUTS

WHAT IS INCLUDED IN CAPEX COSTING

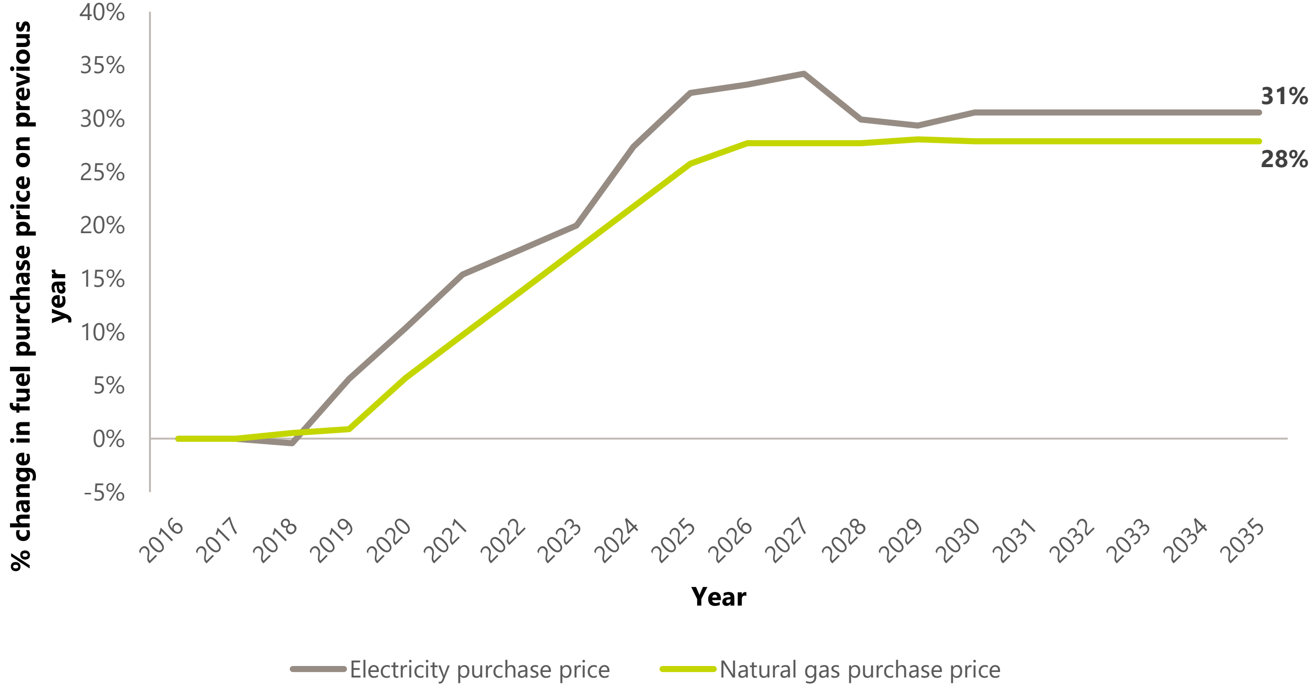
Location	Item	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electic	Passive fabric - ASHP + direct electric
Street	electrical infrastructure uplift	No	No	Yes	Yes	Yes	Yes
Building	Communal heating pipework	Yes	Yes	No	Yes	No	No
Building	electrical cabling uplift	No	No	Yes	No	Yes	Yes
Building	Gas connection	Yes	Yes	No	Yes	No	No
Building	district heating (between blocks)	Yes	Yes	No	Yes	No	No
Building	Solar PV	Yes	Yes	Yes	Yes	Yes	Yes
Plant room	Peak gas bolier size	Yes	Yes	No	Yes	No	No
Plant room	Thermal store size	Yes	Yes	No	Yes	No	No
Plant room	low carbon asset peak heat capacity	No	Yes	No	Yes	No	No
Plant room	Pumps	Yes	Yes	No	Yes	No	No
Plant room	Pressurisation unit	Yes	Yes	No	Yes	No	No
Plant room	expansion vessel	Yes	Yes	No	Yes	No	No
Plant room	Chemical dosing	Yes	Yes	No	Yes	No	No
Plant room	metering - Block - heat	Yes	Yes	No	Yes	No	No
Plant room	metering - In energy centre	Yes	Yes	No	Yes	No	No
Plant room	Grid in-feed	No	Yes	No	No	No	No
Plant room	SCR unit and Urea Tank	No	Yes	No	No	No	No
Plant room	electrical transformer uplift	No	No	No	No	No	Yes
Plant room	Gas metering	Yes	Yes	No	Yes	No	No
Plant room	Gas booster	Yes	Yes	No	Yes	No	No
Plant room	Energy centre fit out	Yes	Yes	No	Yes	No	No
Plant room	flues	Yes	Yes	No	Yes	No	No
Plant room or dwelling	low carbon asset installation costs	No	No	Yes	Yes	Yes	No
Dwelling	pipework in dwelling	Yes	Yes	Yes	Yes	No	No
Dwelling	HIUs numbers - similar for all	Yes	Yes	No	Yes	No	No
Dwelling	metering - HIU - heat	No	No	No	No	No	No
Dwelling	Individual SH and DHW heat pumps	No	No	Yes	No	No	No
Dwelling	Individual DHW only heat pumps	No	No	No	No	Yes	No
Dwelling	Individual DHW immersion heater	No	No	No	No	No	Yes
Dwelling	additional elec cabling in dwelling	No	No	Yes	No	Yes	Yes
Dwelling	Wall upgardes uplift	No	No	No	No	Yes	Yes
Dwelling	Triple glazing	No	No	No	No	Yes	Yes
Dwelling	heat emitter in flats - electric panel	No	No	No	No	Yes	Yes
Dwelling	heat emitter in flats - radiators wet	Yes	Yes	Yes	Yes	No	No

FINANCIAL INPUTS

- Financial inputs are generated from a series of sources. These include a mixture of Spon's Mechanical and Architect's and Builders' price books, Manufacture data and BuroHappold Project experience.

Development scenario	Cost	Unit	Heat supply option					
			Communal gas boilers	gas engine CHP + gas boilers	Individual heat pumps	Communal heat pumps	Passive + direct electric	Passive + direct electric + ASHP
Development scenario 1	Capex	£	800,000	930,000	1,020,000	900,000	650,000	1,220,000
	Opex	£/yr	40,000	46,500	51,000	45,000	32,500	61,000
	Repex	£/yr	26,667	31,000	34,000	30,000	21,667	40,667
Development scenario 2	Capex	£	4,310,000	4,590,000	6,270,000	4,690,000	3,700,000	7,410,000
	Opex	£/yr	215,500	229,500	313,500	234,500	185,000	370,500
	Repex	£/yr	143,667	153,000	209,000	156,333	123,333	247,000

FUTURE FUEL PRICES



COST TO OCCUPANT DATA

Development scenario		Metric	Unit	Communal boilers	Communal gas engine CHP	Individual ASHP	Communal heat pumps	Passive fabric - direct electric	Passive fabric - ASHP + direct electric
Development scenario 1	Total annual cost	Fuel cost	£/yr/flat	£ 142	£ 230	£ 220	£ 184	£ 325	£ 217
		Revenues from electricity sales	£/yr/flat	£ -	-£ 177	£-	£ -	£ -	£-
		Revenues from RHI	£/yr/flat	£ -	£ -	-£ 263	-£ 75	£ -	-£ 159
		Net fuel cost	£/yr/flat	£ 142	£ 53	£ 220	£ 184	£ 325	£ 217
		Profit margin for heat seller (15%)	£/yr/flat	£ 21	£8	£-	£ 28	£ -	£-
		Standing charge	£/yr/flat	£ 120	£ 120	£54	£ 120	£ 54	£54
		Cost of heat to consumer w/ incentives and revenues	£/yr/flat	£ 283	£ 180	£12	£ 256	£ 379	£ 112
		Cost of heat to consumer w/o incentives and revenues	£/yr/flat	£ 283	£ 358	£ 274	£ 332	£ 379	£ 271
	Cost per kWh	Heat demand	MWh/yr/flat	£ 3.4	£3.4	£ 3.4	£ 3.4	£ 2.6	£ 2.6
		Fuel cost	£/yr/flat	£ 4.1	£6.7	£ 6.4	£ 5.3	£ 12.5	£ 8.3
		Revenues from electricity sales	£/yr/flat	£ -	-£5.2	£-	£ -	£ -	£-
		Revenues from RHI	£/yr/flat	£ -	£ -	-£ 7.6	-£ 2.2	£ -	-£ 6.1
		Net fuel cost	£/yr/flat	£ 4.1	£1.5	£ 6.4	£ 5.3	£ 12.5	£ 8.3
		Profit margin for heat seller (15%)	£/yr/flat	£ 0.6	£0.2	£-	£ 0.8	£ -	£-
		Standing charge	£/yr/flat	£ 3.5	£3.5	£ 1.6	£ 3.5	£ 2.1	£ 2.1
		Cost of heat to consumer w/ incentives and revenues	£/yr/flat	£ 8.2	£5.2	£ 0.3	£ 7.4	£ 14.6	£ 4.3
		Cost of heat to consumer w/o incentives and revenues	£/yr/flat	£ 8.2	£ 10.4	£ 8.0	£ 9.6	£ 14.6	£10.4

SCENARIO 1:
OFFSET AND MARGINAL ABATEMENT COSTS

Servicing Option		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Scenario 1 - Single Block	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 800,000	£ 930,000	£ 1,020,000	£ 900,000	£ 650,000	£ 1,220,000
Carbon Offsetting Cost (£)	2013 - 2017	£ 340,424	£ 274,046	£ 387,583	£ 346,154	£ 581,627	£ 394,608
	2017 - 2020	£ 372,248	£ 344,161	£ 297,221	£ 309,380	£ 446,026	£ 302,609
	2020 - 2023	£ 375,329	£ 383,634	£ 225,539	£ 255,692	£ 338,451	£ 229,627

Scenario 1 - Single Block	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 800,000	£ 930,000	£ 1,020,000	£ 900,000	£ 650,000	£ 1,220,000
Yr 1 Carbon Emission (Tonnes CO_2)	2013 - 2017	205	152	215	192	323	219
	2017 - 2020	220	191	165	172	248	168
	2020 - 2023	209	213	125	142	188	128

Scenario 1 - Single Block	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 800,000	£ 930,000	£ 1,020,000	£ 900,000	£ 650,000	£ 1,220,000
Yr 1 on-site Carbon savings over baseline at the time (Tonnes CO_2)	2013 - 2017	20	73	10	33	- 98	6
	2017 - 2020	- 13	15	41	34	- 42	38
	2020 - 2023	- 13	- 17	70	54	8	68

Scenario 1 - Single Block	Year 1 Investment	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 800,000	£ 930,000	£ 1,020,000	£ 900,000	£ 650,000	£ 1,220,000
On-site CAPEX per Tonne of Carbon saved (£/Tonne CO_2)	2013 - 2017	£ 3,893	£ 6,108	£ 4,737	£ 4,680	£ 2,012	£ 5,565
	2017 - 2020	£ 3,644	£ 4,864	£ 6,177	£ 5,236	£ 2,623	£ 7,257
	2020 - 2023	£ 3,837	£ 4,364	£ 8,140	£ 6,336	£ 3,457	£ 9,563

Scenario 1 - Single Block	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 800,000	£ 930,000	£ 1,020,000	£ 900,000	£ 650,000	£ 1,220,000
Total Marginal Abatement Cost (£/Tonne CO_2)	2013 - 2017	£ 5,550	£ 7,908	£ 6,537	£ 6,480	£ 3,811	£ 7,365
	2017 - 2020	£ 5,339	£ 6,664	£ 7,977	£ 7,036	£ 4,423	£ 9,057
	2020 - 2023	£ 5,637	£ 6,164	£ 9,940	£ 8,136	£ 5,257	£ 11,363

SCENARIO 2:
OFFSET AND MARGINAL ABATEMENT COSTS

Servicing Option		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Scenario 2 - Mixed Use Development	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 4,310,000	£ 4,590,000	£ 6,270,000	£ 4,690,000	£ 3,200,000	£ 7,410,000
Carbon Offsetting Cost (£)	2013 - 2017	£ 2,316,875	£ 1,706,413	£ 2,622,677	£ 2,296,268	£ 3,898,076	£ 2,650,222
	2017 - 2020	£ 2,507,151	£ 2,348,024	£ 2,011,220	£ 2,056,615	£ 2,989,272	£ 2,032,344
	2020 - 2023	£ 2,513,396	£ 2,791,492	£ 1,526,164	£ 1,701,475	£ 2,268,304	£ 1,542,193

Scenario 2 - Mixed Use Development	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 4,310,000	£ 4,590,000	£ 6,270,000	£ 4,690,000	£ 3,200,000	£ 7,410,000
Yr 1 Carbon Emission (Tonnes CO_2)	2013 - 2017	1,390	948	1,457	1,276	2,166	1,472
	2017 - 2020	1,475	1,305	1,117	1,143	1,661	1,129
	2020 - 2023	1,396	1,551	848	945	1,260	857

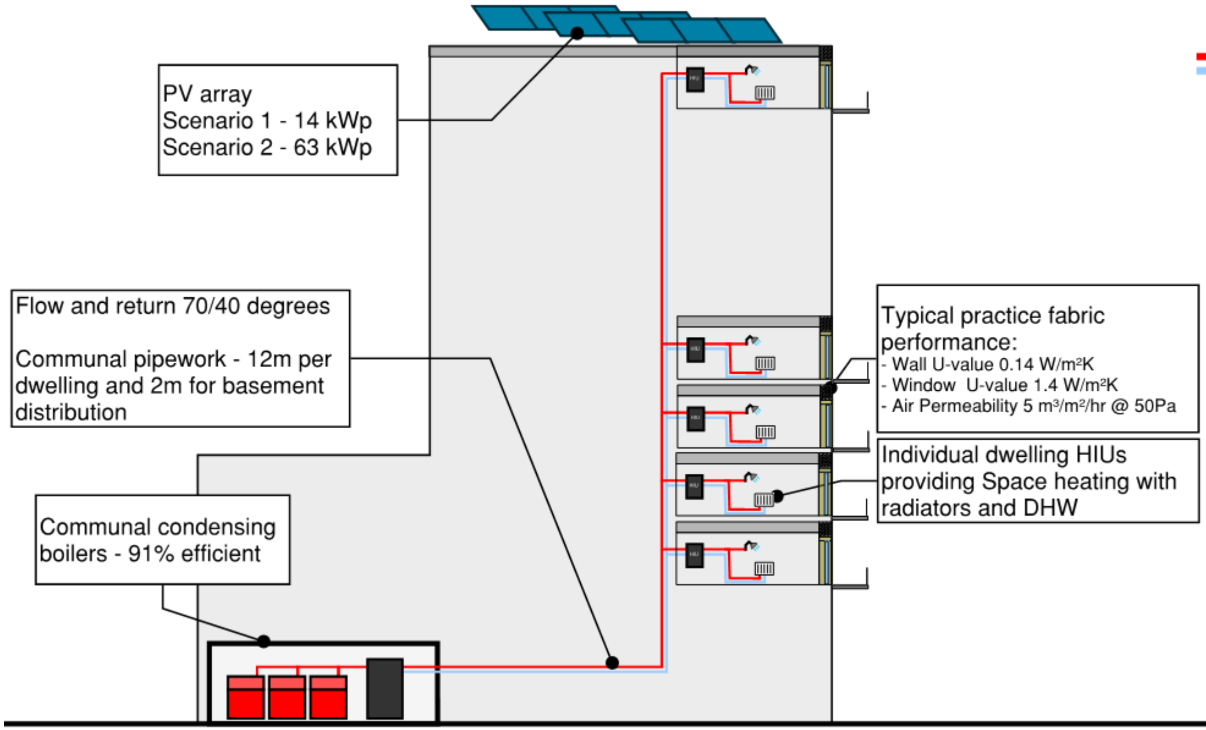
Scenario 2 - Mixed Use Development	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex (£)	Year 1 Investment	£ 4,310,000	£ 4,590,000	£ 6,270,000	£ 4,690,000	£ 3,200,000	£ 7,410,000
Yr 1 on-site Carbon savings over baseline at the time (Tonnes CO_2)	2013 - 2017	99	541	32	213	- 677	16
	2017 - 2020	- 111	60	247	222	- 296	236
	2020 - 2023	- 96	- 251	452	355	40	443

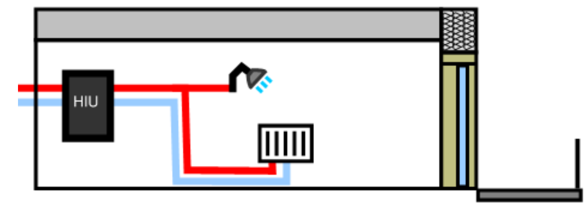
Scenario 2 - Mixed Use Development	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex	Year 1 Investment	£ 4,310,000	£ 4,590,000	£ 6,270,000	£ 4,690,000	£ 3,200,000	£ 7,410,000
On-site CAPEX per Tonne of Carbon saved (£/Tonne CO_2)	2013 - 2017	£ 3,101	£ 4,841	£ 4,303	£ 3,676	£ 1,478	£ 5,033
	2017 - 2020	£ 2,921	£ 3,519	£ 5,611	£ 4,105	£ 1,927	£ 6,563
	2020 - 2023	£ 3,087	£ 2,960	£ 7,395	£ 4,962	£ 2,539	£ 8,649

Scenario 2 - Mixed Use Development	Year of Part L	Communal Boilers	Communal gas engine CHP	Individual ASHP	Communal Heat Pumps	Passive fabric - All direct electric	Passive fabric - ASHP + direct electric
Capex	Year 1 Investment	£ 4,310,000	£ 4,590,000	£ 6,270,000	£ 4,690,000	£ 3,200,000	£ 7,410,000
Total Marginal Abatement Cost (£/Tonne CO_2)	2013 - 2017	£ 4,768	£ 6,641	£ 6,103	£ 5,476	£ 3,278	£ 6,833
	2017 - 2020	£ 4,621	£ 5,319	£ 7,411	£ 5,905	£ 3,727	£ 8,363
	2020 - 2023	£ 4,887	£ 4,760	£ 9,195	£ 6,762	£ 4,339	£ 10,449

APPENDIX C
SERVICING OPTIONS OUTLINE

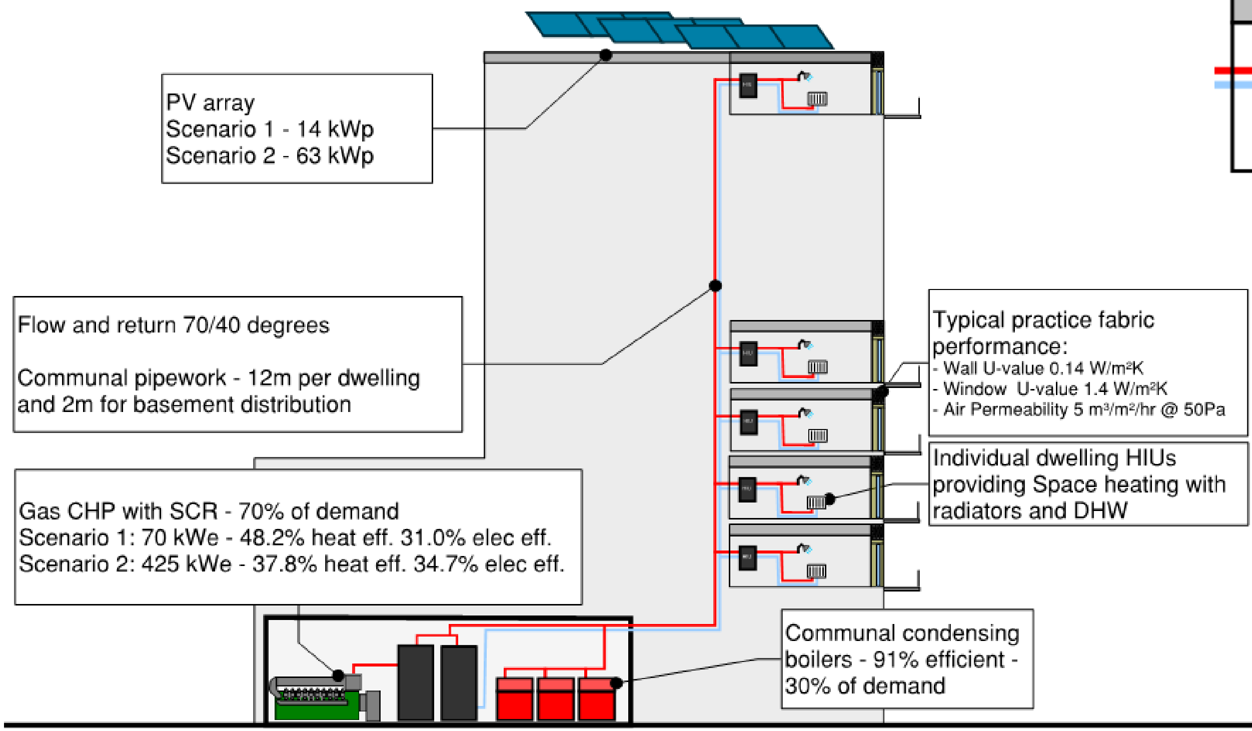
SERVICING OPTION 1:
COMMUNAL BOILERS

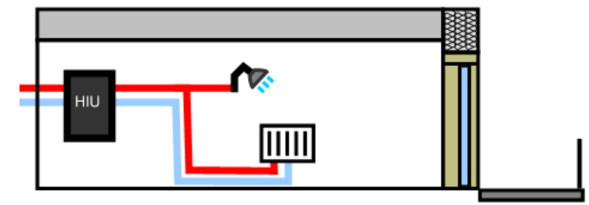




- This option is to provide a counterfactual case if no Low or Zero Carbon (LZC) heat sources are provided
- This case is considered in line with GLA ‘Be lean’ element of the energy hierarchy with additional PV panels to a reasonable level for the available roof area
- Fabric specification is provided to meet the Fabric Energy efficiency (FEE) criterion of Part L1A

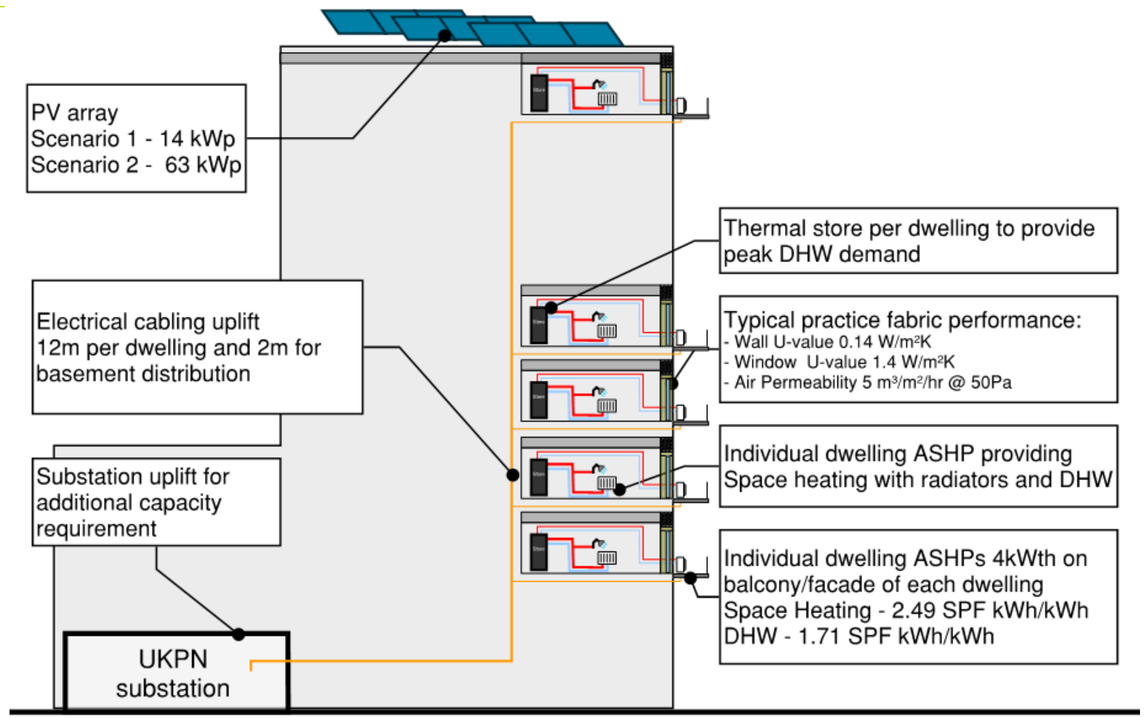
SERVICING OPTION 2:
COMMUNAL HEATING WITH GAS ENGINE CHP AND BOILERS

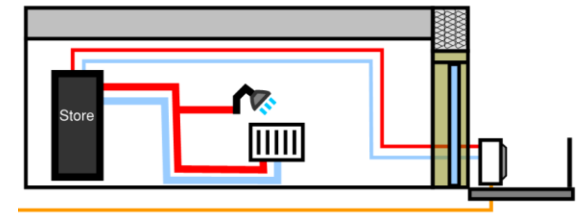




- This case is considered in line with GLA 'Be Clean' element of the energy hierarchy with additional PV panels
- gas engine CHP engines are sized to meet 70% of total heat demand
- A single plant room per development is considered with a 3rd generation communal heating system operating at 70/40^{o}C
- Communal pipework losses assumed 30% of delivered heat demand

SERVICING OPTION 3:
INDIVIDUAL DWELLING ASHPS FOR SPACE HEATING AND DOMESTIC HOT WATER

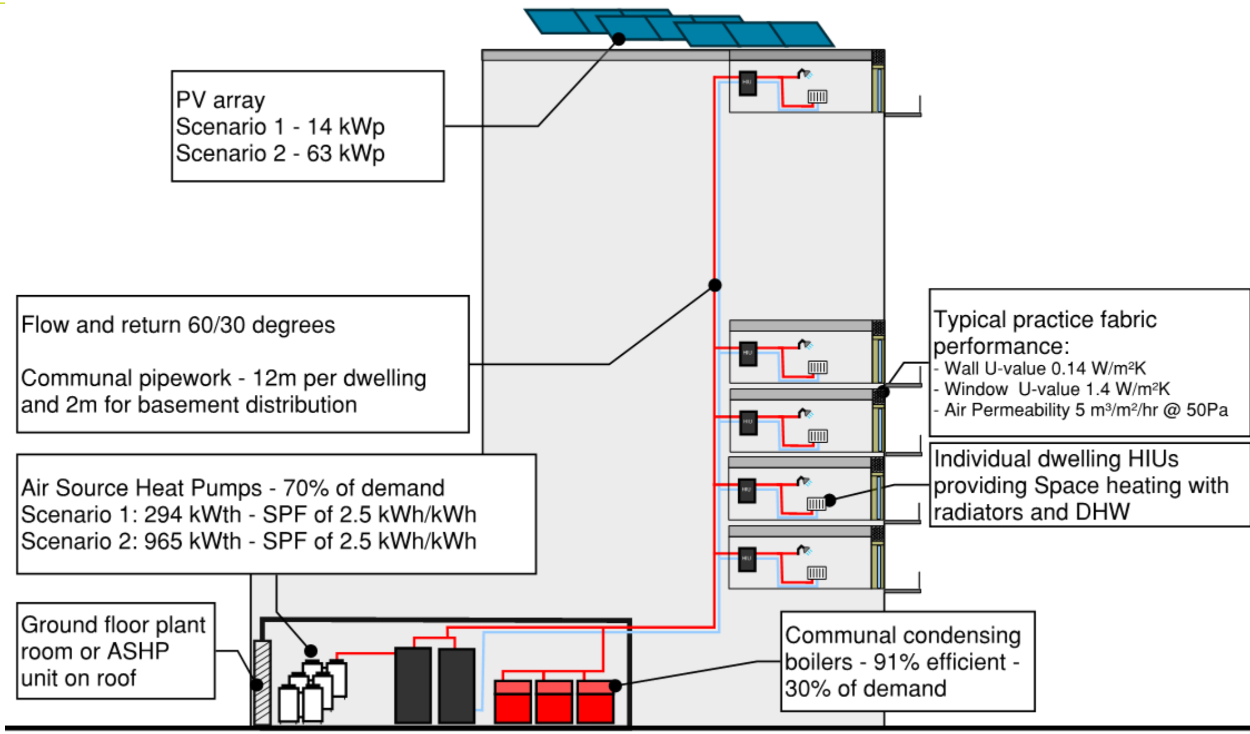


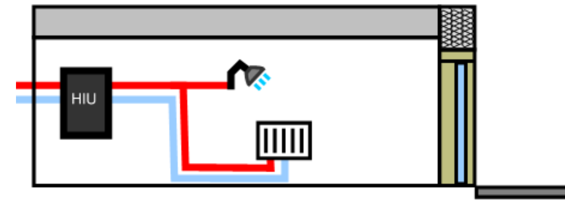


- This case is considered in line with GLA ‘Be Green’ element of the energy hierarchy with additional PV panels
- Individual ASHP are sized to meet 100% of total heat demand with the use of a thermal store per dwelling
- Operating temperatures of >55^{0}C within the dwelling
- Electric cases include substation uplift and reinforcement costs to allow for additional peak capacity to be added on site
- Heat pump SPFs from Product Characteristics database (PCDBS)

Sources:
1. BRE and DECC Product Characteristics Database http://www.ncm-pcdb.org.uk/sap/seargas engine CHPod.jsp?id=17

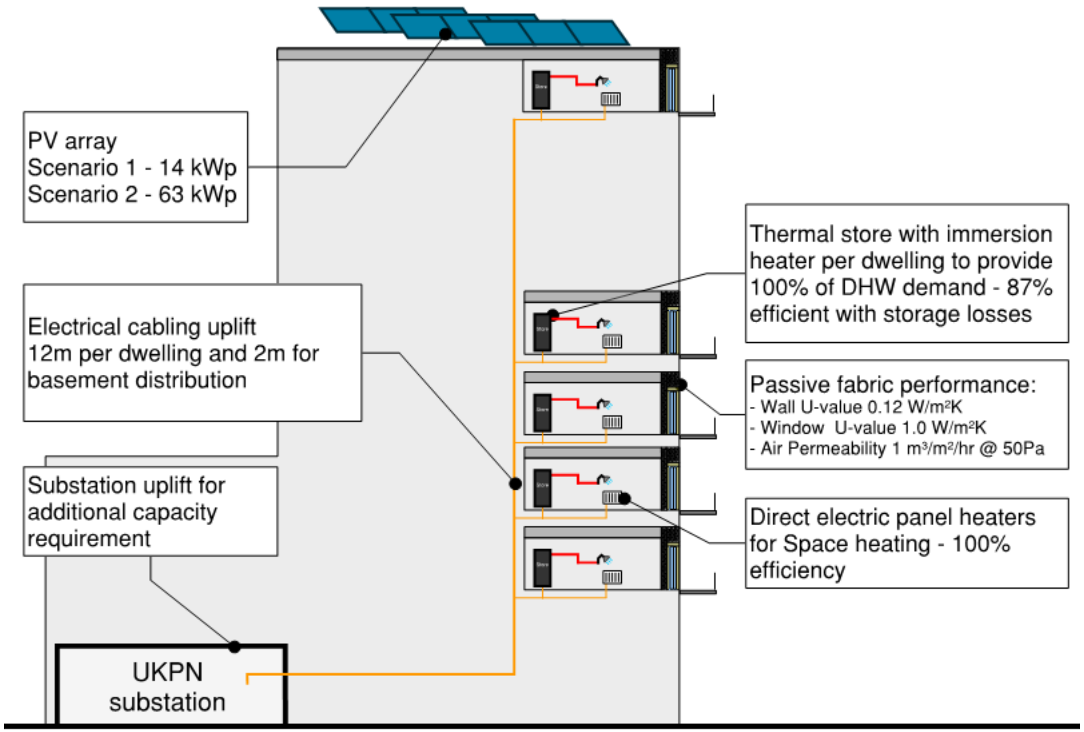
SERVICING OPTION 4:
COMMUNAL ASHPS AND GAS BOILERS FOR ALL HEAT

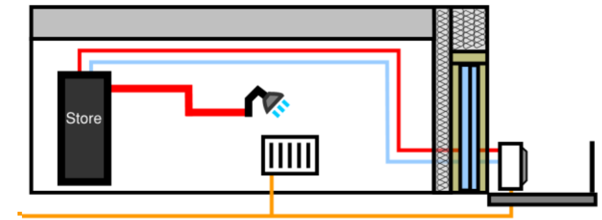




- This case is considered in line with GLA 'Be Green' element of the energy hierarchy with additional PV panels
- ASHP are sized to meet 70% of total heat demand with gas boiler back-up, operating at coldest times instead of the ASHP to help maintain a high SPF even at 60/30°C flow and return
- Communal Heat Pump Seasonal Performance factor of 2.5 kWh/ kWh as this is the minimum to achieve RHI payments
- Communal pipework losses assumed 20% of delivered heat demand

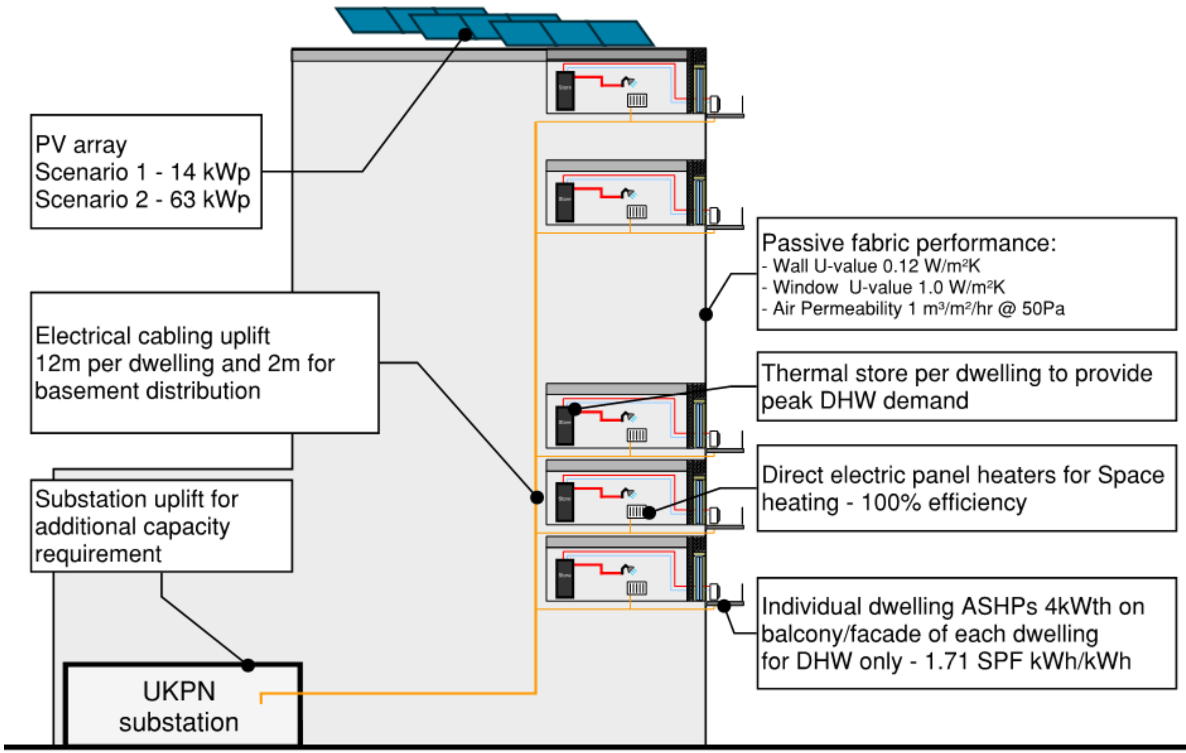
SERVICING OPTION 5:
PASSIVE FABRIC STANDARDS WITH DIRECT ELECTRIC SPACE HEATING AND DHW

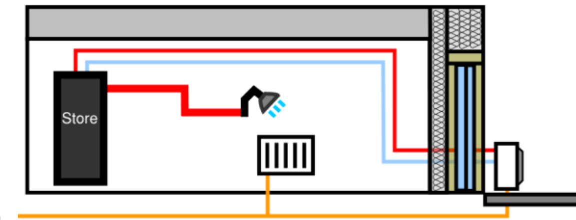




- This case is considered in line with GLA 'Be Green' element of the energy hierarchy with additional PV panels
- Panel heaters provide 100% of space heating, using 4 heaters per dwelling
- Domestic Hot Water (DHW) provided at 100% efficiency however overall system efficiency of 87% accounting for storage losses
- Passive fabric specification, in line with Passivhaus levels; walls include increased thickness of insulation (+20mm), triple glazing and air tightness to 1 $m^3/m^2/hr$ @ 50Pa

SERVICING OPTION 6:
PASSIVE FABRIC STANDARDS WITH INDIVIDUAL ASHP FOR DHW AND ELECTRIC SPACE HEATING





- This case is considered in line with GLA 'Be Green' element of the energy hierarchy with additional PV panels
- Individual ASHP are sized to meet 100% of DHW demand with the use of a thermal store per dwelling.
- Panel heaters provide 100% of space heating, using 4 heaters per dwelling.
- Passive fabric specification, in line with Passivhaus levels; walls include increased thickness of insulation (+20mm), triple glazing and air tightness to 1 $m^3/m^2/hr$ @ 50Pa.

APPENDIX D

SAP CONSULTATION AND RESPONSES

WHAT ARE DISTRIBUTION LOSS FACTORS

- "Heat loss in the distribution network is allowed for by increasing the heat to be delivered by the community heat network by a 'distribution loss factor' (DLF)." The DLF is a factor that the overall heat demand of dwelling is multiplied by to account for the losses in pipework and heat exchange. The DLF and the losses within a system of heat as % of heat demand are not the same. It is calculated by the following:

  Distribution Loss Factor = Heat generated ÷ Heat delivered

- SAP 2012 allows the default DLF, 1.05, for communal networks to be used if pipework is insulted and a certain line density of the DHN is achieved. This approach can be easy to comply with and as a result many SAP assessments on communal heating and DHN would use this factor.
- The SAP 2016 Consultation outlines an updated approach that tiers the DLF based on a series of design and as-built criteria, which radically increases the losses to be considered. This study tracks this increase and uses varying DLF depending upon the proposed flow and return temperatures of the communal systems.
  - Communal heat pumps operating at flow and return of at 60/30 – DLF 1.2 (20% of demand)
  - Communal gas engine CHP 70/40 – DLF of 1.42 (30% of demand)

Sources:
1. DRAFT SAP 2016 edition for consultation https://www.bre.co.uk/filelibrary/SAP/2016/SAP-2016-10.00--July-2016--CONSULTATION-VERSION-14-07-2016.pdf

HOW ARE HEAT LOSSES PROPOSED TO BE INPUTTED INTO SAP 2016 (CONSULTATION)

SAP Version	Communal Heat loss SAP input	Losses as % of total network demand	Requirements
2012	Distribution loss factor of 1.05	Of heat delivered – 5% Of heat generated - 4.75%	• Pipework fully insulated • Line density of DHN > 2MWh/m
2016	DLF no less than 1.2 (minimum that can be input)	Of heat delivered – 20% Of heat generated - 17%	• Primary and secondary losses considered • As measured data used; or • Design data multiplied by in-use factor of (1.15)
	DLF of 1.5	Of heat delivered – 50% Of heat generated - 33%	• CIBSE/ADE guidance (Heat Networks: Code of Practice for the UK) followed
	DLF of 2.0	Of heat delivered – 100% Of heat generated - 50%	• CIBSE/ADE guidance NOT followed (Heat Networks: Code of Practice for the UK) • punishment for not following guidance or using as designed values • Incentivising 'as designed' information input through harsh punishment

SAP 2016 CONSULTATION RESPONSE:
THE GREATER LONDON AUTHORITY

The Greater London Authority provided an official response to the SAP consultation. The key points outlined were as follows:

- Supportive of increased accuracy provided by the changes proposed
- Concerns about unintended consequences on delivery of heat networks which will be negative for gas engine CHP DHN
- Urges BEIS to understand:
  - support mechanisms for new DHNs
  - ensure gas engine CHP does not become stranded asset over buildout of phases developments
- Supportive of DLFs change however it should recognise the commercial, contractual and design boundaries when inputting DLFs, with spate factors for primary and secondary losses
- Supports the use of the PCDBs for inputting DHNs

MAYOR OF LONDON

Neil Witney
Department for Business, Energy and Industrial Strategy
3 Whitehall Place,
London,
SW1A 2AW

Our ref:

Date: 27th January 2016

Dear Neil

The GLA is supportive of changes to SAP which improves the accuracy of the modelling methodology. This consultation does however raise some concerns that the resulting impact will have unintended consequences regarding the delivery of new heat network infrastructure unless these are addressed by UK Government.

We have set out responses to questions 1 and 3 of the proposed amendments, considering their impact for infrastructure, major planning applications and future policy development in London.

Q1: Do you agree with the proposal to use the methodology set out in the technical working paper for calculating carbon emission factors and update the figures?

The GLA is supportive of the proposed changes, which bring SAP in line with changes to the average electricity grid emission factor.

SAP 2016 CONSULTATION RESPONSE:
THE LONDON LEGACY DEVELOPMENT CORPORATION (LLDC)

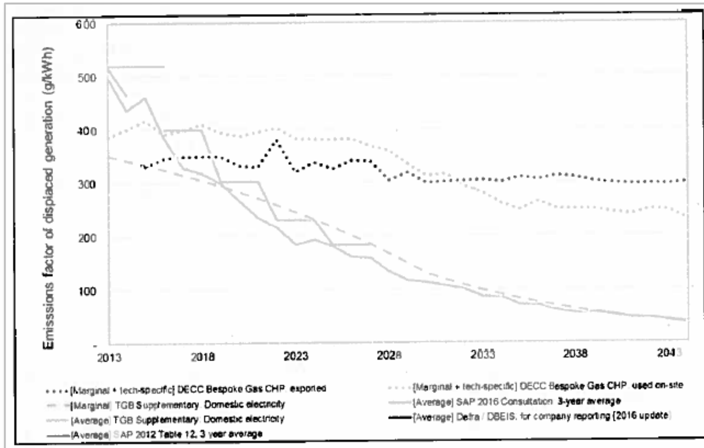


Figure 1: Projected Electrical Emissions Factors

The LLDC provided an official response to the SAP consultation. The comments were split into two main sections; impacts on existing DHN networks and electricity emissions factors:

Impact on existing DHNs

- DHNs have designed and constructed to older versions of SAP
- Planning and construction EPCs for building connecting will use varying factors due to phasing
- The increased emissions, due to gas engine CHP, could lead to refusal to connect to networks
- In short term Heat pumps are not alternative to gas engine CHP for carbon reductions

Choice of Emission Factors associated with electricity

- Governmental approach 'long-run' marginal emission factor for electricity in line with HM treasury Green Book
- If used on site carbon emissions from gas engine CHPs still showing reduction on gas engine CHP with export to grid until 2032
- Adopt consistent approach between Green Book and SAP to avoid conflict in industry

SAP 2016 CONSULTATION RESPONSE:
BUROHAPPOLD ENGINEERING

BuroHappold Engineering provided an official response to the SAP consultation the following points were made in relation to DHNs and carbon factors.

- It provided a positive response to the carbon factor change to electricity, as it represented the current national grid average performance.
- A response was also provided regarding DLFs. It proposed that the SAP consultation should recognise the commercial, contractual and design boundaries when inputting DLFs.
  - DHN losses should be separated for Primary and Secondary systems
- Following CIBSE CP1 'Best Practice' DLF ~ 1.2 could be achieved which agrees with the minimum input proposed

Plot designed to CIBSE/ADE 'Best Practice':

- Heat demand to be delivered to Dwelling = 100 kWh/a
- Secondary losses = 10%
- Heat demand to be delivered to building heat exchanger = 110 kWh/a
- Primary losses = 10%
- Total heat supplied to the network = 121 kWh/a
- Distribution Loss factor = 1.21

Plot designed to Business As Usual:

- Heat demand to be delivered to Dwelling = 100 kWh/a
- Secondary losses = 27%
- Heat demand to be delivered to building heat exchanger = 127 kWh/a
- Primary losses = 10%
- Total heat supplied to the network = 140 kWh/a
- Distribution Loss factor = 1.4

Sources:
1. Heat Networks: Code of Practice for the UK CP1 2015, CIBSE & ADE, 2015

APPENDIX E

LESSONS LEARNT FROM OTHER POLICY AND TECHNICAL STUDIES

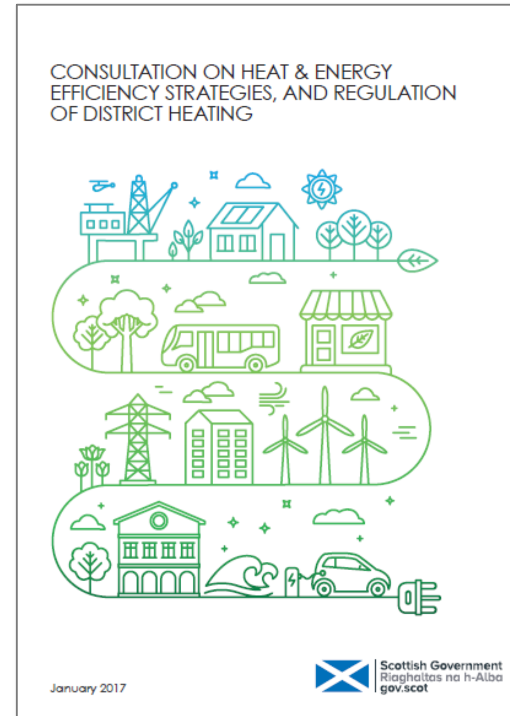
POLICY CONTEXT

- Leading voices in the sustainable built environment industry are calling for strong public policy to drive the transition to a low carbon economy
- Member organisations including UK Green Building Council and Aldersgate Group have submitted evidence to government relating to the UK Emission Reduction Plan and the Industrial Strategy, citing the importance of a focus on operational energy performance of buildings and not just theoretical compliance modelling as is currently used for planning.
- Best practice examples from Scotland, Australia and New York demonstrate new public policy approaches that could be considered further for potential replication in London and enabled through the London Plan. However, the London Mayor’s existing powers would mean that some of the policies/mandates enforced by other authorities around the world would not be possible in London.
- These include:
  - Scottish Government - Consultation on Heat and Energy Efficiency Strategies, and Regulation of District Heating
  - Energy Technology Institute Decarbonising Heat for UK Homes 2015
  - NABERs – Australia – Mandatory Performance based reporting
  - Greener, Greater Buildings Plan (GGBP)– New York City – In use performance audits
  - Carbon Culture – UK based in use data platform

SCOTTISH GOVERNMENT
- CONSULTATION ON HEAT AND ENERGY EFFICIENCY STRATEGIES, AND REGULATION OF DISTRICT HEATING

Scottish Government
Riaghaltas na h-Alba
gov.scot

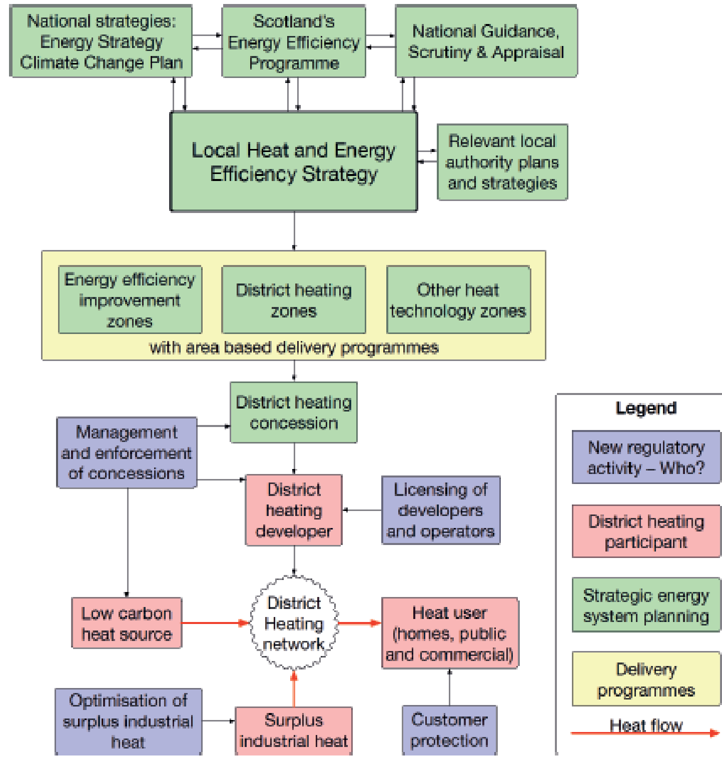
- Energy efficiency as a national infrastructure priority in June 2015
- Reduction of demand and decarbonisation of supply equal importance
- Scotland's Energy Efficiency Programme (SEEP) – cross party group to help national objectives and local planning and delivery of programmes by local authorities and their partners
- Acceptance that gas engine CHP may provide short term carbon benefits but transition plans to other lower carbon assets should be considered
- Two main sections:
  - Section A – local heat & energy efficiency strategies to Support delivery of energy efficiency and heat objectives of SEEP
  - Section B - Heat Network Regulation
- Statutory **Local Heat & Energy Efficiency Strategies** (LHEES) from LAs created with consistent socio-economic analysis, for 20 year life span, central audit and regular reporting, every 3-5 years
  - Strategies would link to long term carbon reductions of SEEP



Sources:
1. Consultation on heat & energy efficiency strategies, and regulation of district heating, Scottish Government, January 2017 https://consult.scotland.gov.uk/energy-and-climate-change-directorate/local-heat-and-energy-efficiency/

SCOTTISH GOVERNMENT
- CONSULTATION ON HEAT AND ENERGY EFFICIENCY STRATEGIES, AND REGULATION OF DISTRICT HEATING

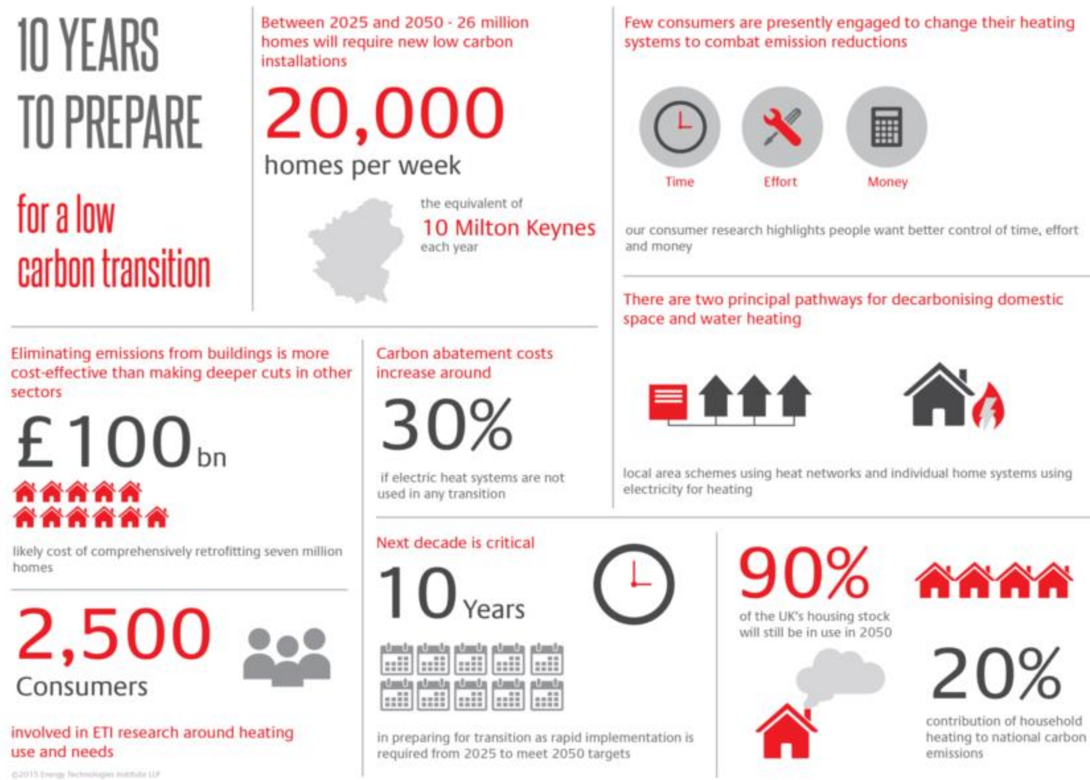
- **Heat Network Regulation** zone applicable locations, concessions and provisions for connecting users to district heating networks within these zones and set minimum technical and consumer protection standards
- **District heating zones** – All LAs create LHEES that identify applicable DH zones in line with consistent KPIs, inter connection of DHNs key
- **Concessions** – LAs grant concessions to organisations for long term with competitive tender process
- **Connecting users to DHN** - public authorities could be given the power to compel building owners to connect to district heating where supply would meet a minimum socio-economic KPIs. A concession holder could apply for this power to be exercised.
- **Technical and consumer protection standards** – monopolies risk to customers, proposed creation of a licensing system, covering consumer protection and technical standards, licenses could be revoked – requires devolved powers from UK government



Sources:
1. Consultation on heat & energy efficiency strategies, and regulation of district heating, Scottish Government, January 2017 https://consult.scotland.gov.uk/energy-and-climate-change-directorate/local-heat-and-energy-efficiency/

ENERGY TECHNOLOGY INSTITUTE
DECARBONISING HEAT FOR UK HOMES 2015

- There are two key solutions for low carbon home heating – local area schemes using **heat** networks and **individual home systems** using electric heat
- The most cost effective solutions involve decarbonisation of the energy supply combined with efficiency measures that are selectively rather than universally applied **– technology agnostic**
- **Identify areas to be supplied by area based schemes,** and those areas where individual home solutions are appropriate
- **Spatial plans** should consider energy supply and **societal factors** also.



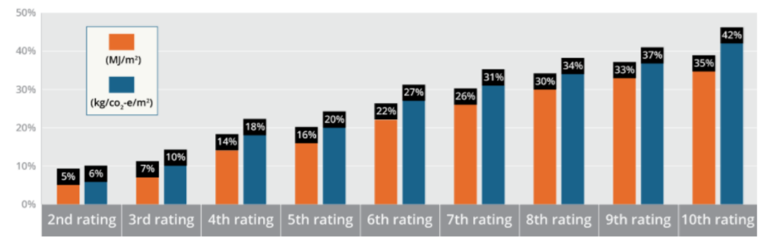
Sources:
1. http://www.eti.co.uk/insights/heat-insight-decarbonising-heat-for-uk-homes/

NABERS – AUSTRALIA – MANDATORY PERFORMANCE BASED REPORTING

- National Australian Built Environment Rating System
- includes a guarantee for performance, a rating for easy comparison to other surrounding buildings
- Simple 6 star rating system for simple metrics and understandable by all
- incorporates a "design for operation" process and requires recurring verification of **performance in operation**, and in addition it separates the base building and any tenant
- Tenants and local government use NABERS targets in lease agreements
- Creates **commercial value to well performing buildings** and building owners upgraded assets to use resources more efficiently to increase ratings
- Cross-industry work has looked at the feasibility of introducing such a scheme to the UK

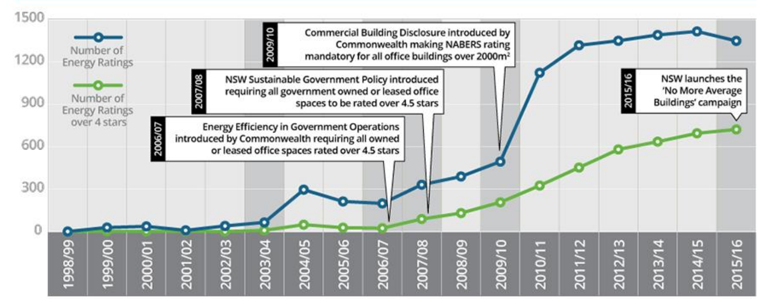
Average reduction in energy use after multiple ratings

NABERS ENERGY FOR OFFICES (Base and Whole Buildings)



Ratings and government policy

COUNT BUILDINGS AND TENANCIES WITH NABERS OFFICE ENERGY RATINGS CERTIFIED



Sources:
1. UK-GBC Task Group Report Delivering Building Performance – May 2016
2. https://www.youtube.com/watch?v=eYb1jmPNJZY&feature=youtu.be

GREENER, GREATER BUILDINGS PLAN (GGBP)– NEW YORK CITY – IN USE PERFORMANCE AUDITS

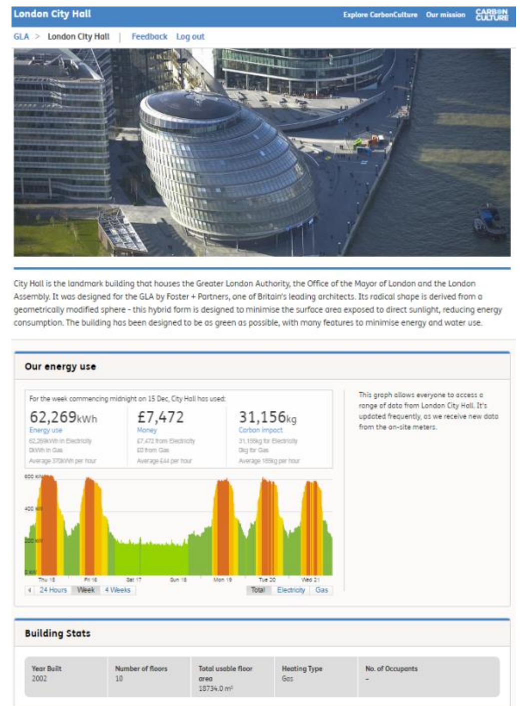
NYC
Mayor's Office of Sustainability

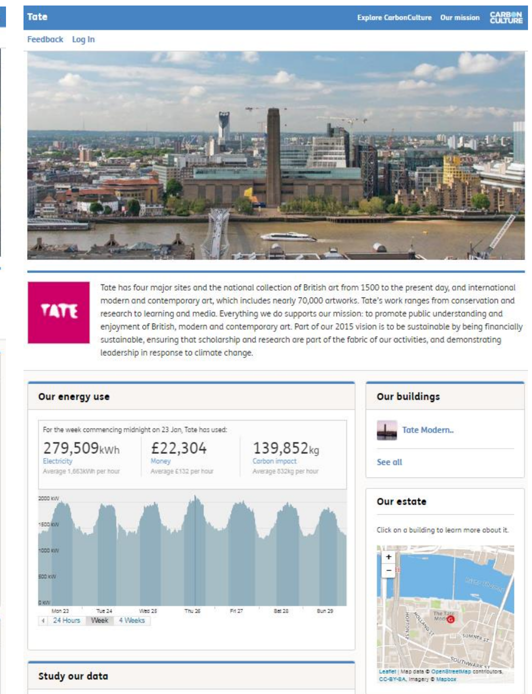
- Used for new construction and retrofit
- 2% of cities properties account for almost 50% of New York City's square footage and as much as 48% of New York City's total energy use
- 4 Laws:
  - Benchmarking
  - NYC Conservation Code
  - Energy Audits & retro-commissioning
  - Lighting and sub-metering
- Information is key policy driver to increase energy performance
- Clear and targeted strategy for most effective measures

Sources:
1. NYC Mayor's Office of Sustainability http://www.nyc.gov/html/gbee/html/plan/plan.shtml

CARBON CULTURE
– UK BASED IN USE DATA PLATFORM

- CarbonCulture is a community platform that is designed to help people use resources more efficiently
- measuring and reporting your organisation's carbon and energy performance
- Contributors in include:
  - The GLA and City Hall
  - Several national and local government departments
  - Public sector institutes
  - Higher education bodies
  - Publicly accessible metered data with mapping capabilities
- https://platform.carbonculture.net/landing/





Sources:
1. https://platform.carbonculture.net/communities/tate/177/
2. https://platform.carbonculture.net/places/city-hall/9130/

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