chapmanbdsp

Pentavia Mill Hill: Case 3756a
GLA Stage 3 Consultation
Energy Statement Addendum

Revision 00
June 2019
Ref: 54397

54397 – Pentavia Mill Hill

GLA Stage 3 Consultation – Energy Statement Addendum

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Revision Table

Rev	Date	Section	Amendment(s)

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Contents

1 Introduction

This Addendum Report has been prepared in response to the comments regarding carbon and energy performance received 11/04/2019 from the GLA on the Energy Statement prepared in support of the Pentavia Retail Park planning submission. It also addresses the second set of comments received on 29/04/2019 on chapmanbdsp's Energy Response.

2 Modelling Revision

In order to address the comments received by the GLA and improve the development's performance and efficiency, the facade and building fabric have been revisited in order to reduce energy demand through the fabric first approach and to mitigate overheating.

The revised facade design proposes opaque insulated panels on the bottom half of windows to reduce solar gains and minimise the risk of overheating. This was proposed in critical areas where the previous simulation showed high overheating risk levels. All glazing facing outwards from the development (where windows are fixed due to noise and pollution issues) have been further reduced to 0.35. Private amenity areas were created for all inward facing units, allowing these dwellings to benefit from self-shading from either balconies or by having a recessed glazing. The balconies have opaque walls to at least one of its sides, providing both sun protection and privacy.

Both domestic and non-domestic models have been fully updated to reflect the changes mentioned above. The overheating assessment was also updated and has been submitted to the GLA on 10/05/2019. Results have shown a significant improvement, increasing the overall 'pass' rate from 61% submitted in the Energy Statement to 85% in the revised assessment. The submitted overheating report can be found in Appendix 1 and the GLA has confirmed via email on the 16/05/2019 that the outcome is acceptable.

2.1 Fabric Performance

The revised fabric performance for the domestic and non-domestic areas of the development is presented in the table below.

	Domestic		Non-domestic	
	Part L1A - TER	Pentavia, Mill Hill proposed - DER	Part L2A - BER	Pentavia, Mill Hill proposed - TER
External wall U-value	0.18	0.13	0.26	0.16
Exposed wall U-value (corridor/staircase)	n/a	0.16	N/A	N/A
Exposed floor U-value	0.13	0.12	0.22	0.16
Exposed roof U-value	0.13	0.13	0.18	0.13
Windows U-value	1.40	1.40	1.60	1.40
Windows g-value	0.63	0.55 inward glazing 0.35 outward glazing	0.40	0.45
y-value	0.05	0.15 (default)	N/A	N/A
Air permeability rate	5	3	5 if area <250m^2 3 if area >250m^2	3

Table 2.1 – Fabric performance of domestic and non-domestic areas of the development

Enhancements made to the building fabric has demonstrated compliance with both the Fabric Energy Efficiency (FEE) and Lean targets.

2.2 FEE compliance

The improvements to the façade design and thermal performance have not only contributed to mitigating overheating but also to increase the efficiency of the building envelope. The development's average TFEE is 43.29 kWh/m² and the DFEE is 41.30 kWh/m², therefore an improvement of 5% is achieved overall.

	Target Fabric Energy Efficiency (kWh/m²)	Dwelling Fabric Energy Efficiency (kWh/m²)	Improvement (%)
Development total	43.29	41.30	5%

A summary table with all typologies modelled, their multiplication factors and FEE results can be found in Appendix 2. SAP worksheets will also be submitted electronically.

2.3 Lean compliance

The tables below show the carbon reduction percentages for each step of the energy hierarchy for both the domestic and on-domestic assets of Pentavia Mill Hill. Figures are shown considering carbon factors from SAP 2012 and SAP10.

Domestic		Regulated carbon dioxide savings			
		SAP 2012		SAP10	
		(Tonnes CO_2 per annum)	%	(Tonnes CO_2 per annum)	%
Be Lean	Savings from demand reduction	93	9%	123	13%
Be Clean	Savings from CHP	329	30%	-141	-15%
Be Green	Savings from renewable energy	69	6%	31	3%
Total cumulative savings		492	45%	13	1%

Table 2.2 - Regulated CO_2 savings from each stage of the energy hierarchy for domestic buildings

Non-domestic		Regulated carbon dioxide savings			
		SAP 2012		SAP10	
		(Tonnes CO_2 per annum)	%	(Tonnes CO_2 per annum)	%
Be Lean	Savings from demand reduction	53	22%	27	21%
Be Clean	Savings from CHP	26	11%	-5	-5%
Be Green	Savings from renewable energy	0	0%	0	0%
Total cumulative savings		78	32%	21	16%

Table 2.3 - Regulated CO_2 savings from each stage of the energy hierarchy for non-domestic buildings

Domestic savings at Lean are 13% considering SAP10 carbon factors, while the non-domestic savings at Lean are over 21%, also in both carbon factors. Besides improvements to the façade, including reduced glazing and enhanced insulation, the non-domestic model also featured improved lighting controls and efficacy.

3 Feasibility Study – Energy Strategy

In addition to the energy strategy presented on the Energy Statement submitted for planning (community gas-fired CHP with top-up gas boilers and PV panels on the roof), cbdsp has tested various other energy strategies for the development, considering carbo factors from both SAP 2012 and SAP10.

A summary of these strategies and assumptions made on efficiencies of the various systems can be found in table 3.1.

		Description	Efficiency (%)	Cylinder
Central CHP, boilers + PV	Heating	Combined system, central CHP + boiler plant. CHP covering 0.66 heat fraction	CHP heat efficiency 45.3 elec efficiency 35 boiler 95.7	
	Hot water			none. HIU only
Boiler only + PV	Heating	Combined system, boilers	boiler 95.7	
	Hot water			none. HIU only
Direct Electric + PV	Heating	Electric underfloor heating	100	
	Hot water	Electric immersion, 180L cylinder in each apartment	100	Yes 180L, 100mm jacket insulation, factory fitted
2No. ASHP + PV	Heating	Central ASHP system distributing ~45degC	300	
	Hot water	Separate central ASHP system distributing ~65degC	250	none. HIU only
ASHP and boilers + PV	Heating	Combined heating/hot water system. Lead ASHP with top-up gas fired boiler. ASHP ~45degC + boiler top-up	HP 300	
	Hot water		boiler 95.7	none. HIU only
ASHP and immersion + PV	Heating	Central ASHP system distributing ~45degC	300	
	Hot water	Connected to central system via HIU, immersion coil in cylinder for top-up	Combined efficiency ~220	Yes 180L, 100mm jacket insulation, factory fitted & HIU
Cascade HP + PV (Daikin/Dimplex)	Heating	Combined system, central ASHP distributing ambient water. Secondary water source heat pump within the dwelling and connected to ambient loop to provide heating AND hot water. 180L cylinder and WSHP combined as a single unit (Daikin)	Central ASHP 350	
	Hot water		dwelling side WSHP 400-500	Yes 180L, 100mm jacket insulation, factory fitted

Table 3.1 – Energy Strategies tested as part of the feasibility study

While the CHP based strategy provides decent savings under the SAP 2012 carbon factors, it is no longer viable once the greener grid electricity is taken into account, as it then provides only 4% site-wide carbo emission savings. Table 3.2 presents site-wide savings under all 7 energy strategies tested and the carbon offset payment associated with each case.

The results of the feasibility study have been discussed with the Design Team during an energy workshop, where the conclusion was that further feasibility investigation is required to select the final strategy. However, it became clear that a Heat Pump solution will be the way forward. Table 3.3 provides a high-level list of the advantages and disadvantages of each energy strategy.

System	Carbon emission savings – SITE WIDE										
	SAP2012						SAP10				
	Lean	Clean	Green	Cumu lative	Cash in lieu contribution		Lean	Clean	Green	Cumu lative	Cash in lieu contribution
Central CHP, boilers + PV	11%	27%	5%	43%	£ 1,094,040.00		14%	-13%	3%	4%	£ 1,758,420.00
Boiler only + PV	10%	0%	7%	17%	£ 1,729,620.00		12%	0%	4%	16%	£ 1,490,880.00
Direct Electric + PV	- 58%	-3%	5%	-56%	£ 3,465,480.00		12%	0%	3%	15%	£ 1,529,520.00
2No. ASHP + PV	10%	0%	16%	26%	£ 1,515,540.00		12%	0%	47%	59%	£ 654,120.00
ASHP and boilers + PV	11%	0%	12%	23%	£ 1,577,820.00		14%	0%	23%	37%	£ 1,088,100.00
ASHP and immersion + PV	10%	0%	6%	16%	£ 1,755,900.00		12%	0%	41%	53%	£ 762,000.00
Cascade HP + PV	10%	0%	20%	30%	£ 1,397,760.00		12%	0%	50%	62%	£ 601,260.00

Table 3.2 – Site-wide carbon emission savings under SAP2012 and SAP10 carbon factors

System	Description		
Central CHP, boilers + PV	Central plant, CHP, boilers and rooftop photovoltaics	Pros	Business as usual Low operating cost
		Cons	Will not meet London Plan carbon targets May not meet future Part L Building Regulations On site combustion Distribution pipework could contribute to overheating in corridors
Boiler only + PV	Central plant, boilers and rooftop photovoltaics	Pros	Simple system incorporating an efficient boiler Gas system that isn't reliant on CHP electrical energy generation savings Low operating cost
		Cons	Requires significant improvement of building fabric to meet GLA targets Some on site combustion Distribution pipework could contribute to overheating in corridors
Direct Electric + PV	Electric underfloor heating, Electric immersion hot water within cylinder	Pros	Simple system, reduced maintenance Low capital cost for the system No on-site combustion No distribution outside of apartments
		Cons	Not in line with London Plan policy for central plant. Does not enable future connectivity to other networks Requires significant improvement of building fabric to meet GLA targets High operational cost
2No. ASHP + PV	1No. central ASHP feeding a low temperature hot water loop for space heating (40oC) 1No. ASHP feeding a separate low temperature hot water loop for DHW (65oC)	Pros	Exceeds London Plan emissions targets (reduced carbon offset fee required) No on-site combustion
		Cons	Additional distribution pipework needed. Greater risk of overheating corridors Duplicated infra-structure: spatial and financial feasibility compromised
ASHP and boilers + PV	Central ASHP system with top-up boilers. Single distribution network	Pros	Meets London Plan emissions targets No on-site combustion
		Cons	Some on site combustion Distribution pipework could contribute to overheating in corridors
ASHP and immersion + PV	Central ASHP system feeding a low temp hot water loop for space heating Electric immersion hot water within cylinder	Pros	Exceeds London Plan emissions targets (reduced carbon offset fee required) No on-site combustion
		Cons	Hot water cylinder required Distribution pipework could contribute to overheating in corridors
Cascade HP + PV	Central ASHP system feeding a low temp hot water loop and Altherm hydrobox inside dwelling for hot water and space heating top-up	Pros	Exceeds London Plan emissions targets (reduced carbon offset fee required) No on-site combustion
		Cons	Only two systems such as this on the market currently Hot water cylinder required (as part of Daikin system) Financial viability requires further investigation Potential higher capital cost

Table 3.3 – Advantages and disadvantages for each energy strategy tested

4 Conclusion

Following the GLA's advice to consider the Pentavia Mill Hill's energy strategy based on the latest carbon factors, it becomes clear that a CHP solution would no longer meet the London Plan targets (and possibly the upcoming new Building Regulations). Looking at the SAP10 carbon savings results from the Feasibility Study, the best performing options are 1) Cascade Heat Pump solution, 2) Double ASHP loop solution and 3) ASHP and immersion solution. The ASHP and boilers strategy does meet the London Plan targets but leaves a very small safety margin. The relatively low savings, when compared to the other heat pump solutions, also means that a larger sum is required as an offset payment to the Local Authority. Gas fired boilers could play a part in the energy strategy as a temporary back up heat source prior to the scheme being linked to any future district heating network.. This would be investigated at the next stage of design.

The double ASHP loop solution, whilst presenting very good carbon savings and a reduced offset payment, would potentially increase capital costs. The various costs of different solutions will need to be investigated to reach the best cost-benefit solution. Spatial requirements for plant and distribution pipework are similar for all ASHP strategies.

chapmanbdsp's recommendation would be to proceed with a heat pump solution, either the 'Cascade' or the 'ASHP and immersion' options. Both strategies would require more in-depth feasibility investigation during the next design stage in order to accurately account for the impact on other disciplines, such as financial viability, air quality, detailed plant specifications (especially given one of the strategies to be considered is relatively new in the market) and spatial implications. Detailed modelling has been performed for both strategies and results demonstrate that the development would achieve at least 53% carbon savings site-wide, being 12% at Lean stage alone (11% for the domestic and 21% for the on-domestic on both solutions). The final layout and position of external plant needs to be carefully considered in order to allow the systems to function correctly. This will be part of the next stage of design.

Below are the items listed as 'outstanding' in the second set of comments received, with our response to address each one:

6. The domestic element development is estimated to achieve a reduction of 36 tonnes per annum 3.6% in regulated CO2 emissions compared to a 2013 Building Regulations compliant development. The applicant should note that the new draft London Plan includes a target of a 10% improvement on 2013 Building Regulations from energy efficiency which applicants should be aiming towards. The applicant should therefore model additional energy efficiency measures and commit to higher carbon savings through energy efficiency alone.

The CHP based energy strategy achieves 13% domestic savings from energy demand reductions alone under the SAP10 carbon factors. Both other energy strategies we intend to proceed with also comply with this target, achieving 11% domestic savings. Results for the GLA tables for the CHP strategy and the two Heat Pump solutions proposed can be found in Appendix 3.

9. The applicant has reported the Part L Fabric Energy Efficiency (FEE) performance for the baseline and the 'be lean' scenarios and it is estimated that the development will achieve an increase of 3% in annual heating and cooling demand. Consequently, the applicant should focus on increase the development's fabric energy efficiency.

As a result from the façade re-design and fabric improvements, the average DFEE is now 5% lower than the TFEE. FEE values for all dwelling types can be found in Appendix 2.

13. The results show that the design proposals are not anticipated to meet the CIBSE recommendations for comfort due to significant levels of failure of all design years modelled. The applicant is required to investigate and adopt significant further passive measures (in line with the Cooling Hierarchy) to avoid the risk of overheating now and in future climate.

Façade re-design and enhancements to the building fabric have significantly reduced the overheating risk. The revised overheating assessment already submitted to the GLA can be found in Appendix 1.

14. The area weighted average (MJ/m2) and total (MJ/year) cooling demand for the actual and notional building has been provided and the applicant has demonstrated that the actual building's *cooling demand is higher than the notional. The applicant is therefore required to implement further passive design measures to reduce the cooling demand.*

The cooling demand has decreased due to additional passive measures implemented and relevant tables in Appendix 3 show that the cooling demand for the CHP strategy, the ASHP immersion strategy and the Cascade Heat Pump strategy have significantly reduced from the scheme submitted at planning. Although the actual demand is still higher than the notional demand, the latest CHP strategy shows a 339,334.38 MJ/year reduction. The reduction is even greater on the two Heat Pump solutions.

16. The applicant has provided a commitment to ensure that the development is designed to allow future connection to a district heating network. Drawings demonstrating how the site is to be future-proofed for a connection to a district heating network should be provided; these should include space provision for heat exchangers in the plant room, isolation valves, safe-guarded pipe route to the site boundary etc.

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17. The applicant is proposing to install a site-wide heat network. However, the applicant should confirm that all apartments and non-domestic building uses will be connected to the site-wide heat network. A drawing showing the route of the heat network linking all buildings on the site should be provided.

A drawing showing the plant location and route of the CHP heat network has been submitted to the GLA, but can also be found in Appendix 4. These were drawn based on a CHP energy strategy and a variation of this will be detailed in the next design stage, as the energy strategy is finalised.

19. The applicant has provided a SAP 10 carbon emissions calculation that demonstrates that CHP has a negative impact on the overall carbon emission of the development, likely to increase with further grid decarbonisation. The applicant's commitment to review of a bio-liquid CHP is welcomed; however, the applicant is required to demonstrate that it has considered additional low carbon alternatives to the proposed CHP.

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23. The applicant has stated that it has not further investigated use of heat pumps as they are not compatible with the proposed CHP, which is higher in the energy hierarchy. Given that the updated GLA Energy Guidance 2018 no-longer includes CHP higher in the energy hierarchy, further consideration of heat pumps or other renewable energy as an alternative would be welcomed.

The feasibility study presented in Chapter 3 investigates various other energy strategy solutions, including the use of Heat Pumps. The results of this study indicate that a centralised ASHP plant will be the way forward but further design detailing and feasibility investigation is required in the next design stage.

24. 246 kWp of PV is being proposed. A roof layout has been provided demonstrating that the roof's potential for a PV installation has been not been maximised. The applicant is required to maximise the on-site savings from renewable energy technologies, regardless of the London Plan targets having been met, and therefore the PV proposals should be reviewed. It should be noted that PV panels are compatible with green roofs.

Due to the re-design of the roof spaces and additional allocation of roof spaces as private amenity areas, the area available for PV panels has reduced. In order to maximise their output, the 447 panels proposed will be installed south facing, at a 25-30 angle. These will be above green/brown roofs.

28. The applicant is required to confirm either the amount of funding that will be paid into the borough's carbon offset fund or that an agreement has been reached with the borough that the applicant will undertake a carbon reduction project off-site to meet the shortfall. In both cases evidence of correspondence with the borough confirming the approach should be provided.

We anticipate that the carbon offset contribution will range between £600,000.00 and £ 762,000.00, depending on the heat pump solution to be implemented. As explained earlier, further feasibility investigation is required and input from other consultants must be taken into account prior to finalising the energy strategy. Therefore, we suggest that the offset contribution figure is confirmed at the next design stage.

30. The carbon dioxide savings fall short of the target within Policy 5.2 of the London Plan. The applicant should consider the scope for additional measures aimed at achieving further carbon reductions.

The CHP based energy strategy achieves 21% non-domestic savings from energy demand reductions alone under the SAP10 carbon factors. Both other energy strategies we intend to proceed with also comply with this target, achieving 21% non-domestic savings. Results for the GLA tables for the CHP strategy and for the two Heat Pump solutions to be further investigated can be found in Appendix 3.

31. The applicant is required to confirm either the amount of funding that will be paid into the borough's carbon offset fund or that an agreement has been reached with the borough that the applicant will undertake a carbon reduction project off-site to meet the shortfall. In both cases evidence of correspondence with the borough confirming the approach should be provided.

Please see response for item #28.

5 Appendices

5.1 Appendix 1: Revised Overheating Assessment

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Pentavia Mill Hill: Case 3756a
GLA Stage 3 Consultation
Domestic Overheating Assessment Update

Revision 01
May 2019
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54397 – Pentavia Mill Hill
GLA Stage 3 Consultation – Domestic Overheating Assessment Update

Revision	Issued For	Date	Author	Checked By
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Revision Table

Rev	Date	Section	Amendment(s)
01	10/05/2019	all	New TM59 run for improved scheme

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Contents

1 Introduction

This document has been prepared in response to the comment regarding domestic overheating received 11/04/2019 from the GLA on the Energy Statement prepared in support of the Pentavia Retail Park planning submission.

Comment 13 referred to the significant levels of failure in meeting the CIBSE criteria and required further investigation and the inclusion of additional passive measures, in line with Cooling Hierarchy, to avoid the risk of overheating in the current and future climate scenarios. The Design Team have reviewed the facade and layout in order to reduce glazing areas without compromising the appearance of the development or the quality of internal spaces proposed. Balconies and winter-gardens have been optimised to provide passive self-shading benefits and solve privacy issues.

The following chapters present the latest TM59 domestic overheating results and a comparison with the previous results submitted as part of the Energy Statement, quantifying the reduction achieved in both overheating zones and hours of occurrence.

2 Updated Domestic Overheating Results for DSY1

As previously done for the Energy Statement, living rooms and bedrooms, as the main occupied zones in the apartments, have been assessed using the London Heathrow DSY1, 2020s, high emissions, 50% percentile weather data and the results are presented in the table below. Detailed results for each zone simulated can be found in the Appendix.

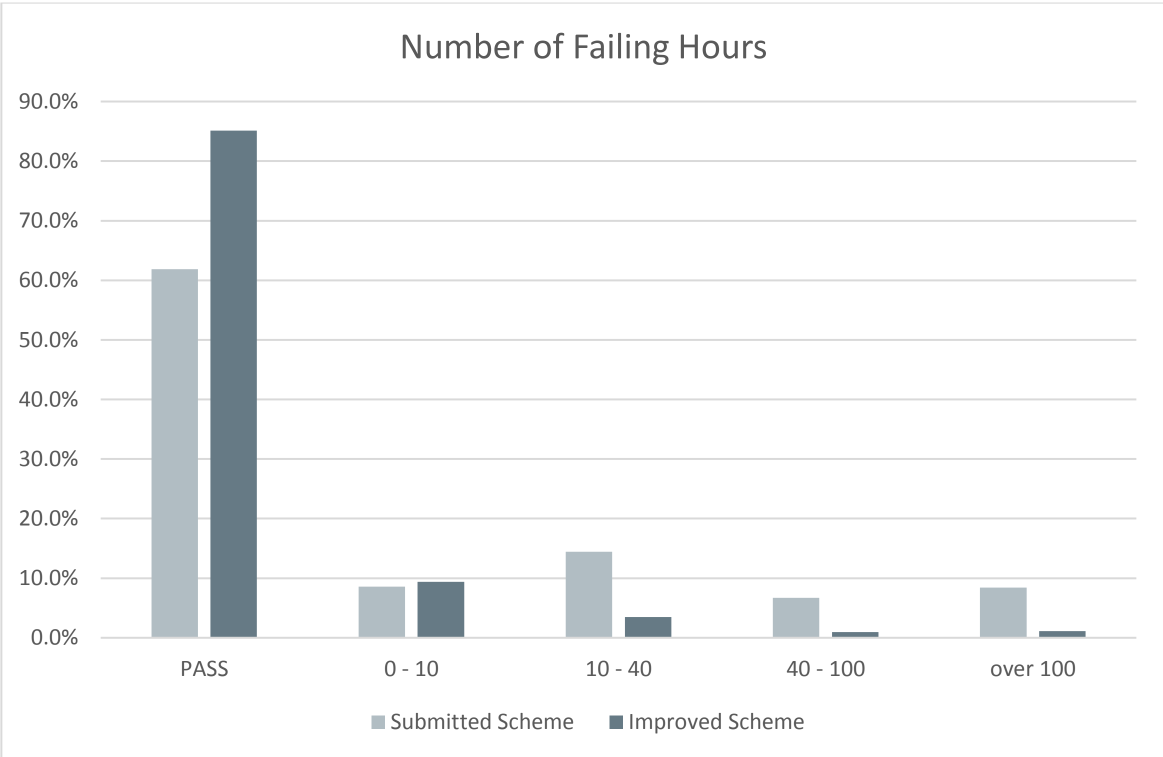
	Fail	Pass
Bedroom		
Inner	11%	89%
Outer	26%	74%
Living Room / Kitchen		
Inner	10%	90%
Outer	0%	100%
Grand Total	**15%**	**85%**

The revised facade design proposes opaque insulated panels on the bottom half of windows to reduce solar gains and minimise the risk of overheating. This was proposed in critical areas where the previous simulation showed high overheating risk levels. Private amenity areas were created for all inward facing units, allowing these dwellings to benefit from self-shading from either balconies or by having a recessed glazing. The balconies have opaque walls to at least one of its sides, providing both sun protection and privacy.

3 Comparison between simulations

The proposed inclusion of passive measures has increased the overall 'pass' rate from 61% submitted in the Energy Statement to 85%. In addition to a reduction in the number of failing rooms, the amount of hours by which a certain room fails is also significantly reduced. The table below illustrates the percentage of rooms and ranges of hours above the exceedable limit.

A significant part of the failing rooms for the improved scheme falls under the margin of 0-10 hours failure (9.4% of all rooms and 63% of failing rooms), which could be considered as a marginal failure and acceptable at this point. Bearing in mind that layouts and build-ups are likely to be further improved in detailed design and that overheating in these rooms could be mitigated, then only 5.5% of rooms would be overheating.



4 Appendix

4.1 Detailed Domestic Overheating Updated Results for DSY1

Zone Name	Room Use	Orientation	Max. Exceedable Hours	Criterion 1: #Hours Exceeding Comfort Range	Max Exceedable Night Hours	Criterion 2: Number of Night Hours Exceeding 26 °C for Bedrooms.	Result
Levels 01 to top							
A_BD_02 1	Bedroom	Inner	110	23	32	11	Pass
A_BD_02 2	Bedroom	Inner	110	24	32	14	Pass
A_BD_02 3	Bedroom	Inner	110	24	32	11	Pass
A_BD_02 4	Bedroom	Outer	110	36	32	41	Fail
A_BD_02 5	Bedroom	Outer	110	112	32	60	Fail
A_BD_02 6	Bedroom	Outer	110	29	32	44	Fail
A_BD_02 7	Bedroom	Outer	110	24	32	35	Fail
A_BD_02 8	Bedroom	Outer	110	25	32	31	Pass
A_BD_02 9	Bedroom	Outer	110	23	32	28	Pass
A_BS_02 1	Bedroom	Inner	110	23	32	14	Pass
A_LK1_02 1	Living Room / Kitchen	Inner	59	14	N/A	N/A	Pass
A_LK1_02 2	Living Room / Kitchen	Inner	59	14	N/A	N/A	Pass
A_LK2_02 1	Living Room / Kitchen	Inner	59	16	N/A	N/A	Pass
A_LK3_02 1	Living Room / Kitchen	Inner	59	25	N/A	N/A	Pass
A_LK3_02 2	Living Room / Kitchen	Outer	59	37	N/A	N/A	Pass
B_BD_02 1	Bedroom	Outer	110	27	32	38	Fail
B_BD_02 2	Bedroom	Outer	110	21	32	31	Pass
B_BD_02 3	Bedroom	Outer	110	12	32	24	Pass
B_BD_02 4	Bedroom	Outer	110	31	32	34	Fail
B_BD_02 5	Bedroom	Inner	110	103	32	10	Pass
B_BD_02 6	Bedroom	Inner	110	68	32	16	Pass
B_BD_02 7	Bedroom	Inner	110	79	32	9	Pass
B_BS_02 1	Bedroom	Inner	110	97	32	11	Pass
B_LK1_02 1	Living Room / Kitchen	Inner	59	29	N/A	N/A	Pass
B_LK1_02 2	Living Room / Kitchen	Inner	59	29	N/A	N/A	Pass
B_LK2_02 1	Living Room / Kitchen	Inner	59	53	N/A	N/A	Pass
B_LK2_02 2	Living Room / Kitchen	Inner	59	32	N/A	N/A	Pass
B_LK2_02 3	Living Room / Kitchen	Inner	59	56	N/A	N/A	Pass
C_BD_02 1	Bedroom	Inner	110	46	32	8	Pass
C_BD_02 2	Bedroom	Inner	110	31	32	12	Pass
C_BD_02 3	Bedroom	Inner	110	48	32	8	Pass
C_BD_02 4	Bedroom	Outer	110	23	32	32	Pass
C_BD_02 5	Bedroom	Outer	110	12	32	26	Pass
C_BD_02 6	Bedroom	Outer	110	11	32	24	Pass
C_BD_02 7	Bedroom	Outer	110	15	32	32	Pass
C_BS_02 1	Bedroom	Inner	110	35	32	10	Pass
C_LK1_02 1	Living Room / Kitchen	Inner	59	19	N/A	N/A	Pass
C_LK1_02 2	Living Room / Kitchen	Inner	59	19	N/A	N/A	Pass
C_LK2_02 1	Living Room / Kitchen	Inner	59	29	N/A	N/A	Pass
C_LK2_02 2	Living Room / Kitchen	Inner	59	13	N/A	N/A	Pass
C_LK2_02 3	Living Room / Kitchen	Inner	59	25	N/A	N/A	Pass
D_BD_02 1	Bedroom	Outer	110	4	32	25	Pass
D_BD_02 10	Bedroom	Inner	110	4	32	26	Pass
D_BD_02 11	Bedroom	Inner	110	0	32	17	Pass
D_BD_02 12	Bedroom	Inner	110	5	32	21	Pass
D_BD_02 13	Bedroom	Inner	110	17	32	36	Fail
D_BD_02 14	Bedroom	Inner	110	8	32	27	Pass
D_BD_02 2	Bedroom	Outer	110	25	32	11	Pass
D_BD_02 3	Bedroom	Outer	110	42	32	14	Pass
D_BD_02 4	Bedroom	Outer	110	30	32	9	Pass
D_BD_02 5	Bedroom	Outer	110	37	32	8	Pass
D_BD_02 6	Bedroom	Outer	110	19	32	12	Pass
D_BD_02 7	Bedroom	Inner	110	31	32	16	Pass
D_BD_02 8	Bedroom	Inner	110	23	32	12	Pass
D_BD_02 9	Bedroom	Inner	110	16	32	11	Pass
D_BS_02 1	Bedroom	Inner	110	44	32	10	Pass
D_LK1_02 1	Living Room / Kitchen	Outer	59	0	N/A	N/A	Pass
D_LK1_02 2	Living Room / Kitchen	Inner	59	38	N/A	N/A	Pass
D_LK1_02 3	Living Room / Kitchen	Inner	59	21	N/A	N/A	Pass
D_LK2_02 1	Living Room / Kitchen	Outer	59	4	N/A	N/A	Pass
D_LK2_02 2	Living Room / Kitchen	Inner	59	76	N/A	N/A	Fail
D_LK2_02 3	Living Room / Kitchen	Inner	59	65	N/A	N/A	Fail
D_LK3_02 1	Living Room / Kitchen	Outer	59	0	N/A	N/A	Pass
D_LK3_02 2	Living Room / Kitchen	Inner	59	22	N/A	N/A	Pass
E_BD_02 1	Bedroom	Inner	110	49	32	8	Pass
E_BD_02 2	Bedroom	Outer	110	19	32	31	Pass
E_BD_02 3	Bedroom	Outer	110	5	32	17	Pass
E_LK1_02 1	Living Room / Kitchen	Inner	59	19	N/A	N/A	Pass
E_LK2_02 1	Living Room / Kitchen	Inner	59	28	N/A	N/A	Pass
G_BD_02 1	Bedroom	Inner	110	37	32	12	Pass

G_BS_02 1	Bedroom	Inner	110	33	32	11	Pass
G_LK2_02 1	Living Room / Kitchen	Inner	59	11	N/A	N/A	Pass
I_BD_02 1	Bedroom	Inner	110	18	32	7	Pass
I_BD_02 2	Bedroom	Inner	110	30	32	15	Pass
I_BD_02 4	Bedroom	Inner	110	13	32	24	Pass
I_BD_02 5	Bedroom	Outer	110	7	32	15	Pass
I_BD_02 6	Bedroom	Outer	110	9	32	17	Pass
I_BD_02 7	Bedroom	Outer	110	10	32	17	Pass
I_BS_02 1	Bedroom	Outer	110	41	32	19	Pass
I_LK1_02 1	Living Room / Kitchen	Inner	59	28	N/A	N/A	Pass
I_LK2_02 1	Living Room / Kitchen	Inner	59	48	N/A	N/A	Pass
I_LK2_02 2	Living Room / Kitchen	Inner	59	33	N/A	N/A	Pass
I_LK2_02 3	Living Room / Kitchen	Inner	59	19	N/A	N/A	Pass
J_BD_02 1	Bedroom	Inner	110	22	32	12	Pass
J_BD_02 2	Bedroom	Outer	110	30	32	16	Pass
J_BD_02 3	Bedroom	Outer	110	11	32	10	Pass
J_BD_02 5	Bedroom	Inner	110	30	32	11	Pass
J_BD_02 6	Bedroom	Inner	110	23	32	32	Pass
J_BD_02 7	Bedroom	Inner	110	29	32	38	Fail
J_BD_02 8	Bedroom	Inner	110	15	32	33	Fail
J_BD_02 9	Bedroom	Outer	110	16	32	41	Fail
J_BS_02 1	Bedroom	Outer	110	22	32	18	Pass
J_BS_02 2	Bedroom	Outer	110	60	32	180	Fail
J_BS_02 3	Bedroom	Outer	110	47	32	126	Fail
J_LK1_02 1	Living Room / Kitchen	Inner	59	21	N/A	N/A	Pass
J_LK2_02 1	Living Room / Kitchen	Inner	59	43	N/A	N/A	Pass
J_LK2_02 2	Living Room / Kitchen	Inner	59	48	N/A	N/A	Pass
J_LK3_02 1	Living Room / Kitchen	Inner	59	33	N/A	N/A	Pass
J_LK3_02 2	Living Room / Kitchen	Inner	59	16	N/A	N/A	Pass
K_BD_02 1	Bedroom	Outer	110	34	32	40	Fail
K_BD_02 2	Bedroom	Outer	110	25	32	31	Pass
K_BD_02 3	Bedroom	Outer	110	27	32	36	Fail
K_BD_02 4	Bedroom	Outer	110	46	32	47	Fail
K_BD_02 5	Bedroom	Inner	110	43	32	16	Pass
K_BD_02 6	Bedroom	Inner	110	28	32	18	Pass
K_BD_02 7	Bedroom	Inner	110	62	32	16	Pass
K_BS_02 1	Bedroom	Inner	110	50	32	15	Pass
K_LK1_02 1	Living Room / Kitchen	Inner	59	22	N/A	N/A	Pass
K_LK1_02 2	Living Room / Kitchen	Inner	59	24	N/A	N/A	Pass
K_LK2_02 1	Living Room / Kitchen	Inner	59	30	N/A	N/A	Pass
K_LK2_02 2	Living Room / Kitchen	Inner	59	35	N/A	N/A	Pass
K_LK2_02 3	Living Room / Kitchen	Inner	59	43	N/A	N/A	Pass
L_BD_02 1	Bedroom	Outer	110	32	32	33	Fail
L_BD_02 2	Bedroom	Outer	110	15	32	30	Pass
L_BD_02 3	Bedroom	Outer	110	16	32	30	Pass
L_BD_02 4	Bedroom	Outer	110	39	32	40	Fail
L_LK2_02 1	Living Room / Kitchen	Inner	59	23	N/A	N/A	Pass
L_LK2_02 2	Living Room / Kitchen	Inner	59	20	N/A	N/A	Pass
M_BD_02 1	Bedroom	Outer	110	9	32	27	Pass
M_BD_02 10	Bedroom	Inner	110	14	32	35	Fail
M_BD_02 11	Bedroom	Inner	110	15	32	35	Fail
M_BD_02 2	Bedroom	Outer	110	5	32	21	Pass
M_BD_02 3	Bedroom	Outer	110	0	32	17	Pass
M_BD_02 4	Bedroom	Outer	110	7	32	27	Pass
M_BD_02 5	Bedroom	Outer	110	7	32	27	Pass
M_BD_02 6	Bedroom	Outer	110	41	32	10	Pass
M_BD_02 7	Bedroom	Outer	110	41	32	9	Pass
M_BD_02 8	Bedroom	Outer	110	88	32	16	Pass
M_BD_02 9	Bedroom	Inner	110	58	32	15	Pass
M_BS_02 1	Bedroom	Inner	110	36	32	99	Fail
M_LK1_02 1	Living Room / Kitchen	Outer	59	0	N/A	N/A	Pass
M_LK1_02 2	Living Room / Kitchen	Inner	59	9	N/A	N/A	Pass
M_LK1_02 3	Living Room / Kitchen	Inner	59	47	N/A	N/A	Pass
M_LK1_02 4	Living Room / Kitchen	Inner	59	37	N/A	N/A	Pass
M_LK2_02 1	Living Room / Kitchen	Inner	59	42	N/A	N/A	Pass
M_LK3_02 1	Living Room / Kitchen	Outer	59	6	N/A	N/A	Pass
M_LK3_02 2	Living Room / Kitchen	Inner	59	2	N/A	N/A	Pass
N_BD_02 1	Bedroom	Inner	110	7	32	9	Pass
N_BD_02 2	Bedroom	Inner	110	20	32	12	Pass
N_BD_02 3	Bedroom	Inner	110	34	32	17	Pass
N_BD_02 4	Bedroom	Inner	110	14	32	41	Fail
N_BS_02 1	Bedroom	Outer	110	36	32	23	Pass
N_BS_02 2	Bedroom	Outer	110	33	32	118	Fail
N_BS_02 3	Bedroom	Outer	110	43	32	160	Fail
N_LK2_02 1	Living Room / Kitchen	Inner	59	32	N/A	N/A	Pass
N_LK2_02 2	Living Room / Kitchen	Inner	59	53	N/A	N/A	Pass
N_LK3_02 1	Living Room / Kitchen	Inner	59	6	N/A	N/A	Pass
O_BD_02 2	Bedroom	Inner	110	22	32	12	Pass
O_BD_02 3	Bedroom	Inner	110	16	32	7	Pass
O_BD_02 4	Bedroom	Inner	110	6	32	15	Pass
O_BD_02 5	Bedroom	Outer	110	8	32	20	Pass
O_BS_02 1	Bedroom	Outer	110	24	32	14	Pass

O_LK1_02 1	Living Room / Kitchen	Inner	59	38	N/A	N/A	Pass
O_LK2_02 1	Living Room / Kitchen	Inner	59	42	N/A	N/A	Pass
O_LK2_02 2	Living Room / Kitchen	Inner	59	19	N/A	N/A	Pass
P_BD_02 1	Bedroom	Outer	110	5	32	15	Pass
P_BD_02 2	Bedroom	Outer	110	17	32	27	Pass
P_BD_02 3	Bedroom	Outer	110	20	32	25	Pass
P_BD_02 4	Bedroom	Inner	110	77	32	10	Pass
P_BD_02 5	Bedroom	Inner	110	33	32	8	Pass
P_BD_02 6	Bedroom	Inner	110	48	32	9	Pass
P_BD_02 7	Bedroom	Inner	110	55	32	8	Pass
P_BD_02 8	Bedroom	Outer	110	16	32	22	Pass
P_BD_02 9	Bedroom	Outer	110	3	32	10	Pass
P_LK1_02 1	Living Room / Kitchen	Outer	59	8	N/A	N/A	Pass
P_LK1_02 2	Living Room / Kitchen	Inner	59	68	N/A	N/A	Fail
P_LK2_02 1	Living Room / Kitchen	Inner	59	35	N/A	N/A	Pass
P_LK2_02 2	Living Room / Kitchen	Inner	59	38	N/A	N/A	Pass
P_LK3_02 1	Living Room / Kitchen	Inner	59	58	N/A	N/A	Pass
R_BD_02 1	Bedroom	Inner	110	7	32	9	Pass
R_BD_02 10	Bedroom	Outer	110	20	32	12	Pass
R_BD_02 11	Bedroom	Inner	110	32	32	15	Pass
R_BD_02 2	Bedroom	Inner	110	15	32	48	Fail
R_BD_02 3	Bedroom	Inner	110	11	32	24	Pass
R_BD_02 4	Bedroom	Inner	110	19	32	28	Pass
R_BD_02 8	Bedroom	Outer	110	32	32	29	Pass
R_BD_02 9	Bedroom	Outer	110	43	32	9	Pass
R_BS_02 1	Bedroom	Outer	110	33	32	22	Pass
R_BS_02 2	Bedroom	Outer	110	42	32	144	Fail
R_BS_02 3	Bedroom	Outer	110	46	32	209	Fail
R_LK1_02 1	Living Room / Kitchen	Inner	59	21	N/A	N/A	Pass
R_LK2_02 1	Living Room / Kitchen	Inner	59	45	N/A	N/A	Pass
R_LK2_02 2	Living Room / Kitchen	Inner	59	53	N/A	N/A	Pass
R_LK3_02 1	Living Room / Kitchen	Inner	59	22	N/A	N/A	Pass
R_LK3_02 2	Living Room / Kitchen	Inner	59	55	N/A	N/A	Pass

5.2 Appendix 2: FEE Summary Results

Unit identifier (e.g. plot number, dwelling type etc.)	Model total floor area (m^2)	Number of units	Target Fabric Energy Efficiency (TFEE) (kWh/m^2)	Dwelling Fabric Energy Efficiency (DFEE) (kWh/m^2)
Development average	-	-	43.29	41.30
				-5%
Type01 G	116.86	1	53.8	59.4
Type01 M	116.86	13	42.3	46.9
Type01 T	116.86	1	53.8	59.9
Type02 G	63.71	1	49.1	47.3
Type02 M	63.71	27	37.2	33.7
Type02 T	63.71	1	49.1	47.8
Type03 G	75.45	1	51.3	48.9
Type03 M	75.45	13	39	35.1
Type03 T	75.45	1	51.3	49.4
Type04 G	110.81	1	60.8	58.2
Type04 M	110.81	13	48.8	44.8
Type04 T	110.81	1	60.8	58.7
Type05 G	117.34	1	60.8	59.5
Type05 M	117.34	9	49	46.2
Type05 T	117.34	1	60.8	60
Type06sw G	52.29	1	40.8	42.4
Type06sw M	52.29	38	29.1	28.7
Type06sw T	52.29	2	40.8	42.9
Type06ne G	52.29	4	48.9	47.4
Type06ne M	52.29	72	36.6	33.3
Type06ne T	52.29	27	48.9	47.9
Type07sw G	57.41	1	47.1	48.2
Type07sw M	57.41	18	35.2	34.7
Type07sw T	57.41	2	47.1	48.7
Type07ne G	57.41	4	54.9	53
Type07ne M	57.41	34	42.6	39.2
Type07ne T	57.41	4	54.9	53.4
Type08 G	72.86	1	54.9	53.8
Type08 M	72.86	9	43.1	40.6
Type08 T	72.86	1	54.9	54.3
Type09sw G	73.1	3	56.2	56
Type09sw M	73.1	28	44.6	43
Type09sw T	73.1	3	56.2	56.5
Type09nw G	73.1	2	57.7	56.7
Type09nw M	73.1	20	46.1	43.6

Type09nw T	73.1	2	57.7	57.1
Type09se G	73.1	0	53.3	53.4
Type09se M	73.1	9	41.9	40.4
Type09se T	73.1	1	53.3	53.9
Type09ne G	73.1	0	54.7	54
Type09ne M	73.1	9	43.2	41
Type09ne T	73.1	1	54.7	54.5
Type10 G	73.1	2	54.8	53.6
Type10 M	73.1	18	43	40.3
Type10 T	73.1	2	54.8	54.1
Type11 G	88.89	3	46.1	45
Type11 M	88.89	23	33.5	30.7
Type11 T	88.89	3	46.1	45.5
Type12 G	77.65	3	52.1	51.4
Type12 M	77.65	23	40	37.5
Type12 T	77.65	3	52.1	51.9
Type13 G	47.24	4	54.1	55
Type13 M	47.24	26	42.2	41.8
Type13 T	47.24	4	54.1	55.5
Type14 G	56.1	4	52.4	53
Type14 M	56.1	26	40.2	39
Type14 T	56.1	4	52.4	53.5
Type15se G	81.55	0	48.4	48.2
Type15se M	81.55	28	36.8	35
Type15se T	81.55	4	48.4	48.6
Type15nw G	81.55	0	52.8	50.9
Type15nw M	81.55	28	41	37.6
Type15nw T	81.55	4	52.8	51.3
Type16nw G	66.16	2	58.3	57.1
Type16nw M	66.16	23	46.2	43.8
Type16nw T	66.16	3	58.3	57.6
Type16se G	66.16	0	48.2	50.4
Type16se M	66.16	5	36.7	37.4
Type16se T	66.16	1	48.2	50.9
Type17 G	123.88	2	53.2	49.8
Type17 M	123.88	28	40.1	35.3
Type17 T	123.88	4	53.2	50.3
Type18 G	73.1	1	53.1	52.2
Type18 M	73.1	6	41.3	38.8
Type18 T	73.1	1	53.1	52.7
Type19 G	61.87	1	48.4	46.7
Type19 M	61.87	21	35.8	32.6
Type19 T	61.87	1	48.4	47.3
Type20se G	98.86	1	55.1	57

Type20se M	98.86	6	43.6	44
Type20se T	98.86	1	55.1	57.4
Type20nw G	98.86	1	58	59
Type20nw M	98.86	6	46.4	46
Type20nw T	98.86	1	58	59.5
Type21se G	67.34	3	50.4	51.9
Type21se M	67.34	18	39	39.4
Type21se T	67.34	3	50.4	52.4
Type21nw G	67.34	2	57.1	56.9
Type21nw M	67.34	14	45.4	44.2
Type21nw T	67.34	2	57.1	57.4
Type22nw G	64.29	2	57.8	54.9
Type22nw M	64.29	11	45.2	40.9
Type22nw T	64.29	2	57.8	55.4
Type22se G	64.29	1	55	53.1
Type22se M	64.29	6	42.5	39.2
Type22se T	64.29	1	55	53.6
Type23 G	88.44	2	54.1	51.8
Type23 M	88.44	7	41.5	37.8
Type23 T	88.44	2	54.1	52.4
Type24 G	76.28	2	53.8	53.1
Type24 M	76.28	7	42	39.7
Type24 T	76.28	2	53.8	53.6
Type25 G	50.81	3	53.9	52
Type25 M	50.81	10	41.3	37.9
Type25 T	50.81	3	53.9	52.5
Type26se G	80.3	1	53.3	52.2
Type26se M	80.3	8	41.9	39.4
Type26se T	80.3	1	53.3	52.6
Type26nw G	80.3	2	59.8	56.1
Type26nw M	80.3	12	48.2	43.2
Type26nw T	80.3	2	59.8	56.6
Type27nw G	110.52	1	57.6	56.2
Type27nw M	110.52	8	45.5	42.7
Type27nw T	110.52	1	57.6	56.7
Type27se G	110.52	2	54.8	54.4
Type27se M	110.52	12	42.9	40.9
Type27se T	110.52	2	54.8	54.9
Type28 G	51.38	1	45.6	46.7
Type28 M	51.38	3	33.3	32.7
Type28 T	51.38	1	45.6	47.2
Type29 G	94.13	1	53.9	51.8
Type29 M	94.13	3	41.7	38.1
Type29 T	94.13	1	53.9	52.3

Type30 G	58.93	1	47.5	47.6
Type30 M	58.93	3	35.6	33.9
Type30 T	58.93	1	47.5	48.1
Type31 G	80.19	1	54.8	55
Type31 M	80.19	5	43.1	42.1
Type31 T	80.19	1	54.8	55.5
Type32 G	89.77	0	53.4	53
Type32 M	89.77	5	42	40.2
Type32 T	89.77	1	53.4	53.5
Type33 G	50.06	0	52	53.7
Type33 M	50.06	2	40.3	40.6
Type33 T	50.06	1	52	54.2
Type34 G	114.84	0	60.1	58.4
Type34 M	114.84	2	48.4	45.6
Type34 T	114.84	1	60.1	58.9
Type35 G	89.32	1	60.4	58.7
Type35 M	89.32	3	48.9	45.8
Type35 T	89.32	1	60.4	59.2

5.3 Appendix 3: GLA spreadsheet results for:

Central CHP, boilers + PV
ASHP and immersion + PV
Cascade Heat Pump + PV

Central CHP, boilers + PV

SAP 2012 PERFORMANCE

DOMESTIC

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	1,094	1,249
After energy demand reduction	1,000	1,249
After heat network / CHP	671	1,249
After renewable energy	601	1,249

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	93	9%
Savings from heat network / CHP	329	30%
Savings from renewable energy	69	6%
Cumulative on site savings	**492**	**45%**
Annual savings from off-set payment	601	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**18,044**	-
Cash in-lieu contribution (£)	**1,082,666**	

SAP10 PERFORMANCE

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	965	561
After energy demand reduction	842	561
After heat network / CHP	983	561
After renewable energy	952	561

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	123	13%
Savings from heat network / CHP	-141	-15%
Savings from renewable energy	31	3%
Cumulative on site savings	**13**	**1%**
Annual savings from off-set payment	952	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**28,560**	-
Cash in-lieu contribution (£)	**1,713,612**	

Central CHP, boilers + PV

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	242	386
After energy demand reduction	189	386
After heat network / CHP	164	386
After renewable energy	164	386

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	53	22%
Savings from heat network / CHP	26	11%
Savings from renewable energy	0	0%
Total Cumulative Savings	**78**	**32%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	**85**	-
Shortfall	6	189
Cash in-lieu contribution (£)	**11,368**	-

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	131	173
After energy demand reduction	104	173
After heat network / CHP	110	173
After renewable energy	110	173

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	27	21%
Savings from heat network / CHP	-6	-5%
Savings from renewable energy	0	0%
Total Cumulative Savings	**21**	**16%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	46	-
Shortfall	25	747
Cash in-lieu contribution (£)	**44,807**	-

Central CHP, boilers + PV

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,336		
Be lean	1,189	146	11%
Be clean	834	355	27%
Be green	765	69	5%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**18,234**	-

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,096		
Be lean	946	150	14%
Be clean	1,093	-147	-13%
Be green	1,062	31	3%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**29,307**	-

Building use	Energy demand following energy efficiency measures (MWh/year)						
	Space Heating	Hot Water	Lighting	Auxilary	Cooling	Unregulated electricity	Unregulated gas
Domestic	1352	1819	289	190	0	2406.2	0
Non-domestic	0	0	0	0	0	744.4	0

	Target Fabric Energy Efficiency (kWh/m²)	Dwelling Fabric Energy Efficiency (kWh/m²)	Improvement (%)
Development total	43.29	41.30	5%

	Area weighted average non-domestic cooling demand (MJ/m^2)	Total area weighted non-domestic cooling demand (MJ/year)
Actual	35.244	578036.844
Notional	27.54	451683.54

ASHP, immersion + PV

SAP 2012 PERFORMANCE

DOMESTIC

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	1,094	1,063
After energy demand reduction	1,018	1,063
After heat network / CHP	1,018	1,063
After renewable energy	955	1,063

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	76	7%
Savings from heat network / CHP	0	0%
Savings from renewable energy	63	6%
Cumulative on site savings	**139**	**13%**
Annual savings from off-set payment	955	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**28,649**	-
Cash in-lieu contribution (£)	**1,718,915**	

SAP10 PERFORMANCE

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	965	477
After energy demand reduction	859	477
After heat network / CHP	859	477
After renewable energy	429	477

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	106	11%
Savings from heat network / CHP	0	0%
Savings from renewable energy	431	45%
Cumulative on site savings	**537**	**56%**
Annual savings from off-set payment	429	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**12,862**	-
Cash in-lieu contribution (£)	**771,690**	

ASHP, immersion + PV

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	242	386
After energy demand reduction	189	386
After heat network / CHP	189	386
After renewable energy	178	386

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	53	22%
Savings from heat network / CHP	0	0%
Savings from renewable energy	11	5%
Total Cumulative Savings	**64**	**27%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	**85**	-
Shortfall	21	616
Cash in-lieu contribution (£)	**36,987**	-

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	131	173
After energy demand reduction	104	173
After heat network / CHP	104	173
After renewable energy	80	173

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	27	21%
Savings from heat network / CHP	0	0%
Savings from renewable energy	24	19%
Total Cumulative Savings	**51**	**39%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	46	-
Shortfall	-5	-161
Cash in-lieu contribution (£)	**-9,661**	-

ASHP, immersion + PV

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,336		
Be lean	1,207	129	10%
Be clean	1,207	0	0%
Be green	1,133	74	6%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**29,265**	-

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,096		
Be lean	964	133	12%
Be clean	964	0	0%
Be green	509	455	41%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**12,700**	-

Building use	Energy demand following energy efficiency measures (MWh/year)						
	Space Heating	Hot Water	Lighting	Auxilary	Cooling	Unregulated electricity	Unregulated gas
Domestic	1352	1819	289	190	0	2048.313911	0
Non-domestic	0	0	0	0	0	744.4	0

	Target Fabric Energy Efficiency (kWh/m²)	Dwelling Fabric Energy Efficiency (kWh/m²)	Improvement (%)
Development total	43.29	41.30	5%

	Area weighted average non-domestic cooling demand (MJ/m^2)	Total area weighted non-domestic cooling demand (MJ/year)
Actual	34.992	573,904
Notional	27.54	451,684

Cascade HP + PV

SAP 2012 PERFORMANCE

DOMESTIC

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	1,094	1,063
After energy demand reduction	1,018	1,063
After heat network / CHP	1,018	1,063
After renewable energy	760	1,063

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	76	7%
Savings from heat network / CHP	0	0%
Savings from renewable energy	258	24%
Cumulative on site savings	**334**	**31%**
Annual savings from off-set payment	760	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**22,789**	-
Cash in-lieu contribution (£)	**1,367,350**	

SAP10 PERFORMANCE

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	965	477
After energy demand reduction	859	477
After heat network / CHP	859	477
After renewable energy	341	477

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	106	11%
Savings from heat network / CHP	0	0%
Savings from renewable energy	518	54%
Cumulative on site savings	**624**	**65%**
Annual savings from off-set payment	341	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**10,231**	-
Cash in-lieu contribution (£)	**613,858**	

Cascade HP + PV

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	242	386
After energy demand reduction	189	386
After heat network / CHP	189	386
After renewable energy	174	386

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	53	22%
Savings from heat network / CHP	0	0%
Savings from renewable energy	15	6%
Total Cumulative Savings	**68**	**28%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	**85**	-
Shortfall	17	507
Cash in-lieu contribution (£)	**30,398**	-

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	131	173
After energy demand reduction	104	173
After heat network / CHP	104	173
After renewable energy	78	173

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	27	21%
Savings from heat network / CHP	0	0%
Savings from renewable energy	26	20%
Total Cumulative Savings	**53**	**40%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	46	-
Shortfall	-7	-210
Cash in-lieu contribution (£)	**-12,619**	-

Cascade HP + PV

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,336		
Be lean	1,207	129	10%
Be clean	1,207	0	0%
Be green	934	273	20%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**23,296**	-

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	1,096		
Be lean	964	133	12%
Be clean	964	0	0%
Be green	419	544	50%
	-	**CO_2 savings off-set (Tonnes CO_2)**	-
Off-set	-	**10,021**	-

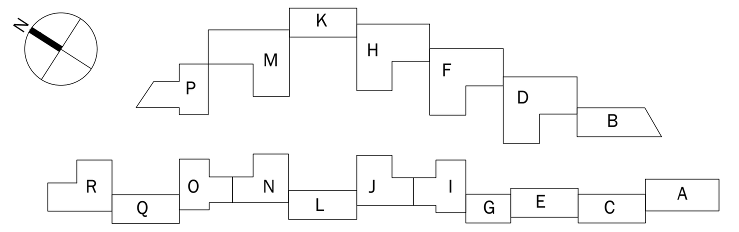
Building use	Energy demand following energy efficiency measures (MWh/year)						
	Space Heating	Hot Water	Lighting	Auxilary	Cooling	Unregulated electricity	Unregulated gas
Domestic	1352	1819	289	190	0	2048.313911	0
Non-domestic	0	0	0	0	0	744.4	0

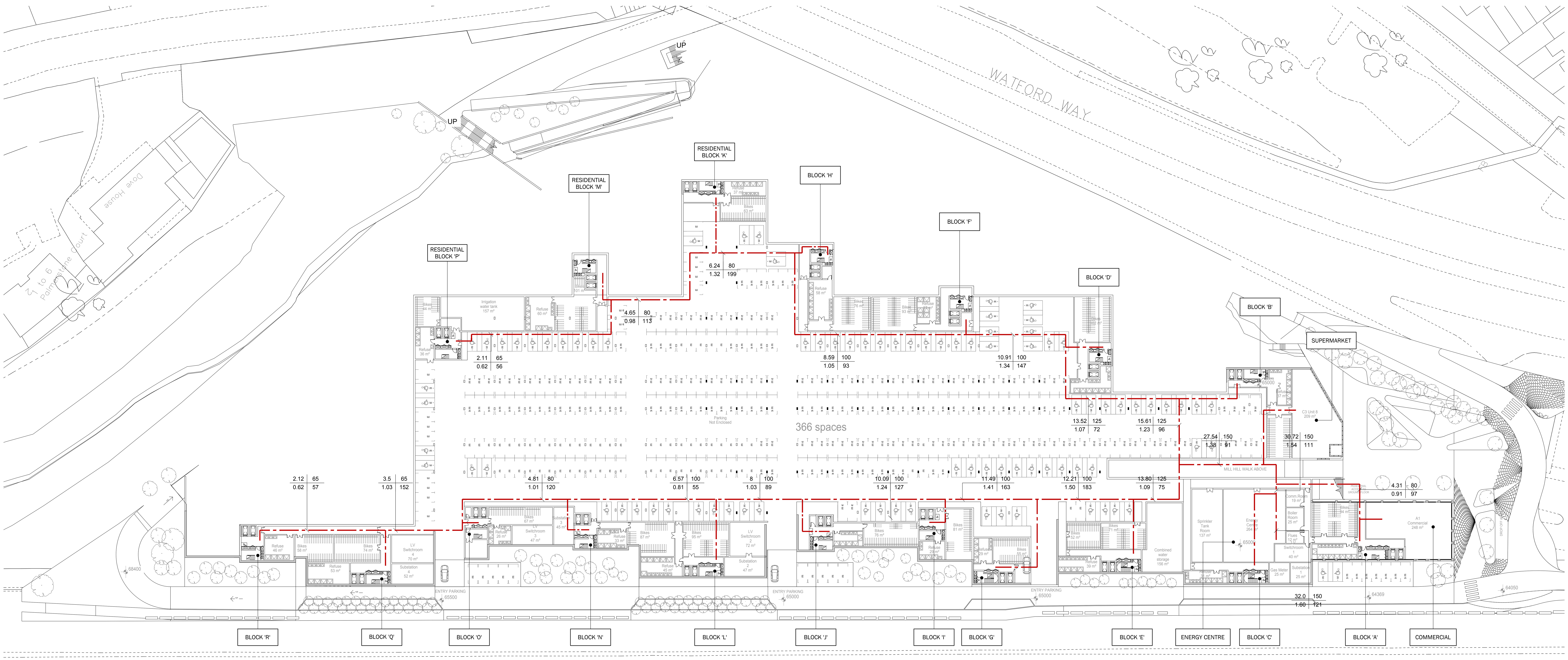
	Target Fabric Energy Efficiency (kWh/m²)	Dwelling Fabric Energy Efficiency (kWh/m²)	Improvement (%)
Development total	43.29	41.30	5%

	Area weighted average non-domestic cooling demand (MJ/m^2)	Total area weighted non-domestic cooling demand (MJ/year)
Actual	34.992	573903.792
Notional	27.54	451683.54

5.4 Appendix 4: District Heating Network drawings for CHP strategy

KEY PLAN





Important:

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This drawing shall not be scaled.

Unless stated otherwise, all dimensions are in millimetres.

Where applicable, all dimensions shall be checked by the contractor onsite, prior to commencement of any works.

This drawing shall be read in conjunction with all other drawings and the services specification document(s).

All materials and workmanship shall conform with the relevant British & European Standards, Specifications and Codes of Practice.

Notes:

Legend:

Litre / Sec	F&R Pipe Size
Vel / m / s	Pa / m

Denotes Flow & Return Pipework

Rev	Date	Description	Drn	Chkd
P02	June '19	Preliminary Issue	RH	PH
P01	Apr '18	Preliminary Issue	GBW	PE

Reference files

Client: Meadow Residential

Project: Mill Hill, London

Production software: Autocad

Chapman BDSP

www.chapmanbdsp.com | info@chapmanbdsp.com

Status: Preliminary Issue

Drawing title: Lower Ground Floor District Heating Distribution Pipes

Drawn	Engineer	Approved	Date origin
hawksr	PE	PH	Apr '18

Scale @ A1: 1:500

File/BIM ref: 54397-SKM-001-180417-PE-District Heating.dwg

Drawing number: 54397-SKM-001-180417-PE-District Heating

Revision: P02