EVORA EDGE

BUILDING SIMULATION REPORT FOR GUILDFORD BOROUGH COUNCIL

A Mixed-Use Scheme – Domestic Properties (flats & houses)

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EVORA EDGE

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1. INTRODUCTION

In 2017 Guildford Borough Council (GBC) commissioned EVORA EDGE to determine what the additional cost would be for a developer to reduce carbon dioxide (CO_2) emissions if the target detailed in Action 4 of its Sustainable Design and Construction Supplementary Planning Document (SPD) was strengthened from 10% to 15% or 20%. Following this study GBC has set this target at 20% with the exception of in town retail. GBC has now asked EVORA EDGE to extend its study to include increased targets of 25%, 30% and 35%.

GBC is not alone in its ambitions to reduce CO_2 emissions. As of June 2019, the UK Government amended the Climate Change Act[1] committing the UK to zero carbon emissions by 2050 while the London Plan's Policy 5.2 already mandates zero carbon construction for residential properties.

The purpose of this extension is to provide an evidence base to GBC to identify typical costs of construction for new build properties that comply with the requirements of Building Regulations Part L *Conservation of fuel and power*, together with the additional costs to developer for meeting the proposed revised targets now under consideration by GBC.

The purpose of EVORA EDGE's study is therefore to answer three questions:

1. Is it technically feasible to construct buildings that go beyond the requirements of a Target Emission Rate (TER) by between 25% and 35%?
2. What are the indicative cost implications of this type of enhanced policy for developers?
3. What will be the impact of mandating the BRE HQM on residential developments?

[1] Climate Change Act 2008 (2050 Target Amendment) Order 2019

This report summarises the findings of up to seven simulations on four global building energy models of a residential scheme which includes different types of flats and houses, all covered by Part L1A. Each global simulation has in turn generated over 31 SAP asset specific models to cover the different types of property. These models are based on an adapted residential development provided to EVORA EDGE by GBC in 2017 for the purpose of this study.

The simulations study the performance of four different but typical building services solutions for residential properties, which we refer to throughout this report as Systems 1, 2, 3 and 4.

The base building (the starting point) of the 2017 study was a construction that would comply with Part L1A's Notional Dwelling - this is our fabric first approach. It also allowed us to establish a base build cost. In all building energy models occupancy and some services such as lighting remained the same but the heating, ventilation, air conditioning (HVAC) and domestic hot water strategy in each building varies in order to pass the target rates. This includes the use of Low and Zero Carbon (LZC) technologies which are incorporated to augment or replace conventional non-LZC technologies.

1.1. The simulations

Part L1A has five criterion and a requirement for any developer to analyse and take into account the technical, environmental and economic feasibility of using high-efficiency alternative systems in construction, if available[2]. For a building to pass the exacting requirements of Part L1A it must be designed and constructed to a standard that meets or betters the TER of a Notional Dwelling (DER ≤ TER). A building that is constructed to the limiting parameters of Part L1A will fail Criterion 1, which is the Criterion that requires the DER ≤ TER.

[2] These systems are to include decentralised energy supply systems based on energy from renewable sources, cogeneration, district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources, and heat pumps

Each model simulated is identical in every respect other than its building services, which may or may not include renewable energy systems, and building fabric which is improved when the target exceeds 20%.

System 1 starts with the least number of LZC technologies possible for a typical services solution, and as the targets become more challenging, then more efficient conventional systems and/or LZC technologies are incorporated into the model(s) to augment or replace less efficient and/or non LZC technologies. Systems 2 to 4 on the other hand, start with LZC technologies, for example primary fossil fuel heating is typically replaced with heat pumps or district heating.

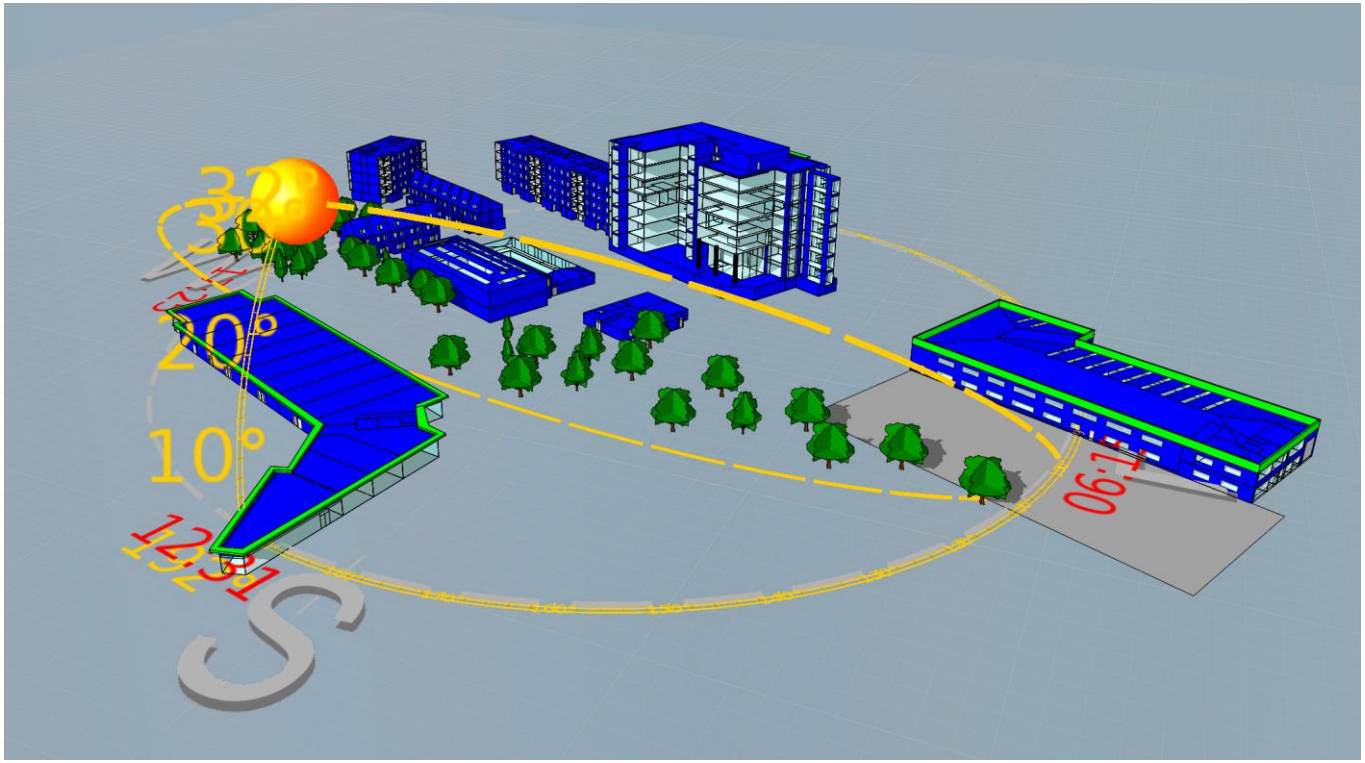
The main key difference between this and the 2017 study are the target rates of 25%, 30% and 35%. The models we used were the ones created in 2017. However, they were updated to the latest version of IES and SAP which accounts for modifications and improvements to the software and the NCM. This resulted in a variation of an average of 1.4% between the 2020 simulations and the 2017 simulations which were created in IES VE 2016. We also updated costs using SPONS 2020 as explained further in Section 4.7.

1.2. Building information model (BIM)

To prepare this report we have used building information models or BIMs created in IES engineering software - the Virtual Environment or VE. PDF drawings were provided to EVORA EDGE by GBC on a proposed residential development in Guildford adapted for this study. These were converted into DWG files and scaled using AutoDesk AutoCad, and then in turn converted to DXF drawings so that they could be imported into the VE. We then imported additional models of commercial buildings from previous projects using gbXML and/or GEM files to create a 'virtual mixed-use scheme'. This allowed us to model various types and numbers of buildings using a federated or global BIM which was shared between two principal energy modellers.

The DER and TER and calculations and costs were all undertaken in the same model(s) and these are in turn available as IES and SAP Files for future use. A representation of the federated/global BIM is shown below. Those persons wishing to inspect these models must have access to appropriate SAP and IES software and must have an IMPACT licence which is available from IES.

Picture 1; EVORA EDGE's federated/global BIM of a mixed-use scheme



1.3. Report structure

This report has been arranged into the following sections. An executive summary, a more detailed tabulated section with basic technical information on our energy simulations, a summary of our costing methodology, and our cost calculations and cost sources. Methodologies and sources of data have been clearly stated, however, it is important to note project limitations, which are expanded on in the section below.

1.4. Disclaimers / limitations

With any building, existing or proposed, there are almost an infinite number of design parameters for architects and engineers to consider including:

- Structure
- Orientation and Massing
- HVAC and Lighting Types
- Combination of HVAC and Fuel Types
- LZC Technologies

Whilst we have considered many scenarios, it is not possible to cover all potential design parameters. The aim of this research is to identify if it is possible to pass target benchmarks for buildings which are proposed as part of a planning application; while assuming common design parameters and HVAC systems which are based upon a Notional Building or best (typical) market practice.

To do this we have looked at a number of building and system types adopting a hierarchical ‘fabric first’ approach to favour the most efficient system(s). Where values or efficiencies are detailed in the Notional Building these are adopted. However, where these values are not provided, or where they seem

low when assessed against technologies readily available in the market, then these were replaced by values or efficiencies detailed in either Part L1A, or the Energy Technology List (ETL)[3], or other reputable or market sources.

In any scenario a range of costs exists. Costs are therefore indicative and for benchmarking purposes only. They exclude VAT and fees associated with design, professional services and project management including CDM. They do however include for preliminaries, profit and overheads for the services contractor. Greater detail and information on our costing methodology is provided in Section 4. of this report.

[3] The ETL (or Energy Technology Product List, ETPL) is a government-managed list of energy-efficient plant and machinery, such as boilers, electric motors, and air conditioning and refrigeration systems that qualify for full tax relief.

2. EXECUTIVE SUMMARY

We find that it is technically feasible to construct buildings to the most stringent of the proposed target rates of 35%. We also find that this will attract a cost premium (an extra over cost to the developer) of up to 9.30% when compared to a Part L compliant property, or up to 5.60% when compared to a property that complies with the existing 20% target. A further finding is that properties with the higher targets rates are likely to have the lowest life cycle costs.

Secondly, as part of our remit, we are required to consider the potential impact of BRE Home Quality Mark (HQM) on carbon targets (see Section 6). As with all BRE schemes HQM is a holistic sustainability accreditation scheme and standard and it covers more than just energy. Based on evidence available from previous schemes for sustainable house building, this will affect construction costs while reducing whole life cycle costs. BRE HQM is intended to replace, on a voluntary basis, the Code for Sustainable Homes (CfSH). To meet the existing GBC target of 20% it will be necessary to construct a property to an equivalent CfSH Level of between 2 and 3 with additional LZC as/where necessary, but for targets over 25% then typically the equivalent of a CfSH Level 4 construction is required and this will increase construction costs.

2.1. Results

Extra over costs range from as low as 0.91% to a maximum of 9.3%. 0.91% is the lower end of the cost difference between the existing policy of 20% and a revised policy of 25%, while 9.3% is the study's maximum extra over cost of taking a Part L compliant property to 35% (see Table 1).

These results closely align with:

i. The results of the cost models from non-domestic assets, including residential care homes.
ii. Historic DCLG evidence on CfSH costs.

iii. Evidence produced by the Passivhaus Trust on the cost difference between Passivehaus and non-Passivhaus constructions – elements of which may have be incorporated to reach the 35% target (particularly so once SAP10 comes into force).

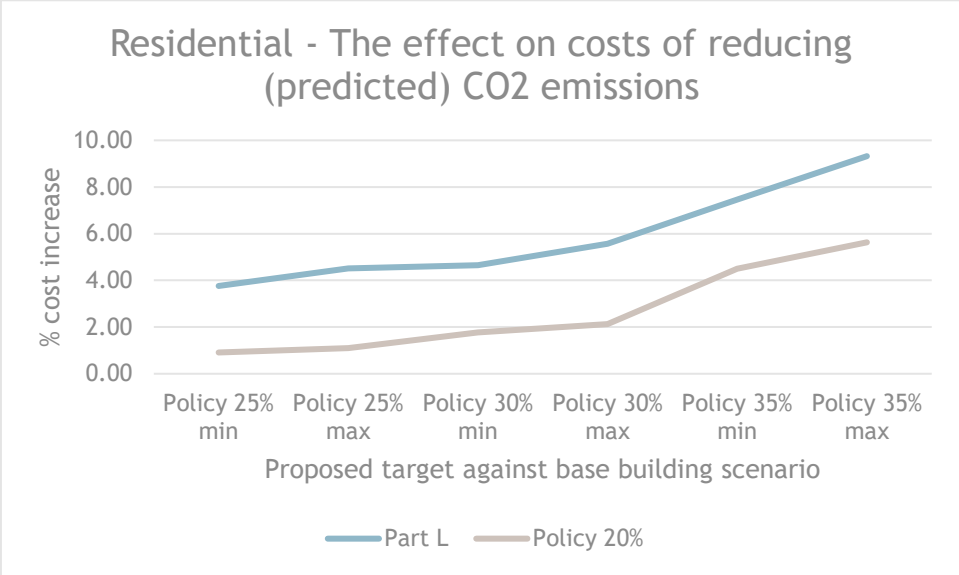
iv. Anticipated design changes that will be forced on developers if/when SAP 10 is adopted.

To establish these findings, we applied four different system types to 31 different SAP models. These included a conventional gas fired low temperature hot water system (LTHW), an air to water heat pump system, a ground source heat pump, and a district heating system using gas fired CHP. The details and the iterative results of each model/simulation are provided in Section 3.0.

Table 1: The table below shows in column 1 the base building scenario. This is the simulated building's DER set against the required TER. For example, base building scenario 'Part L1A' represents a model that had a DER which was equal to or lower than the TER. 'Existing policy (20% target)' represents a model that had a DER which is at least 20% lower than the Part L1A TER. The costs in the following columns represent the additional extra over cost(s) of increasing the target DER by the percentage stated (25%, 30% and 35%).

Base building scenario	The additional % cost increase between the base building scenario and a revised 25% target	The additional % cost increase between the base building scenario and a revised 30% target	The additional % cost increase between the base building scenario and a revised 35% target
Part L1A	3.76% to 4.51%	4.65% to 5.58%	7.46% to 9.3%
Existing policy (20% target)	0.91 to 1.10%	1.77% to 2.13%	4.50% to 5.6%

Drawing 1: Results shown as a line schematic



3.1. A Comparison of system performance (potential life cycle costs)

The table below compares the results of our simulations so that we can better understand cost-effectiveness alongside the impact on predicted CO2 emissions.

CO2 emission are linked to energy consumption (kWh) and therefore, potentially, operational costs and whole life costs. System performance can be judged in two ways. The first, and in all probability, the most relevant to developers is establishing the most cost-effective way to reach proposed targets. This is highlighted in purple. In this case System 1 is generally the most cost-effective.

The second metric assesses the cost (£) of reducing CO2 emissions. 0 = Zero operational carbon, the further away from zero the higher the cost (£) per Tonne (T) of CO2 saved[4]. In this case System 4 - highlighted in green, shows that for each £ invested per m2 a greater amount of CO2 savings are achieved. As a result, it is likely that operational running costs and life cycle costs will be the lowest for this system.

System 1 is generally most cost-effective until the 35% target rate is reached, at which point System 2 is more cost effective. System 4 offers the greatest opportunity for reduced life cycle costs.

It is important to note that the findings are based on the prevailing NCM which uses SAP 2012 emission factors (see 3.2 below). As and when a new NCM is adopted these findings will be materially altered as the grid emissions for electricity are out of date. In essence, the moment new emission factors are adopted for Part L (and EPC) purposes it will be difficult, if not impossible, to meet these targets where fossil fuels (primarily natural gas) are the primary fuel source for heating systems. This means that it will be more difficult to pass Building Regulations using system 1, and it may be impossible to pass the additional targets without improving building fabric.

Table 2: A review of potential life cycle costs

Benchmark	System 1 (GFCH) DER kg CO_2/m^2	System 2 (ASHP) DER kg CO_2/m^2	System 3 (GSHP) DER kg CO_2/m^2	System 4 (District Heat) DER kg CO_2/m^2	System 1 (GFCH) Cost per m^2 v carbon metric	System 2 (ASHP) Cost per m^2 v carbon metric	System 3 (GSHP) Cost per m^2 v carbon metric	System 4 (District Heat) Cost per m^2 v carbon metric
1. The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A	17.27	17.07	20.45	10.32	£2,280.00 / m^2 £39.40 / TCO_2	£2,334.00 / m^2 £39.80 / TCO_2	£2,407.00 / m^2 £49.20 / TCO_2	£2,394.00 / m^2 £24.70 / TCO_2

[4] Calculated as: BER * system cost / 1,000 (= Tonnes of CO_2)

Benchmark	System 1 (GFCH) DER kg CO_2/m^2	System 2 (ASHP) DER kg CO_2/m^2	System 3 (GSHP) DER kg CO_2/m^2	System 4 (District Heat) DER kg CO_2/m^2	System 1 (GFCH) Cost per m^2 v carbon metric	System 2 (ASHP) Cost per m^2 v carbon metric	System 3 (GSHP) Cost per m^2 v carbon metric	System 4 (District Heat) Cost per m^2 v carbon metric
2. The BER must be 20% lower than the TER. This is the Extant Policy	13.82		19.69		£2,436.00 / m^2 £33.70 / TCO_2		£2,516.00 / m^2 £49.50 / TCO_2	
3. The BER must be 25% lower than the TER. This is a proposed borough policy	12.96		18.11		£2,480.00 / m^2 £32.10 / TCO_2		£2,560.00 / m^2 £46.40 / TCO_2	
4. The BER must be 30% lower than the TER. This is a proposed borough policy	12.36		17.19		£2,483.00 / m^2 £30.70 / TCO_2		£2,640.00 / m^2 £45.40 / TCO_2	
5. The BER must be 35% lower than the TER. This is a proposed borough policy	11.46	15.8	15.90		£2,640.00 / m^2 £30.30 / TCO_2	£2,340.00 / m^2 £37.00 / TCO_2	£2,720.00 / m^2 £43.30 / TCO_2	

3.2. *Transitionary targets*

Building Regulations (and EPCs) as at the date of this report are based around emission factors that are set out in SAP 2012. BRE, authors of the SAP methodology, have released revised SAP10.1 'SAP 10'. It is not known when SAP 10 will come into effect. The new methodology will only supersede SAP 2012 when the Building Regulations Conservation of fuel and power: Approved Document L, is next updated, which is expected to be in 2020.

This is of relevance since the emissions factor of electricity will change considerably. SAP 2012 sets a value of 0.216 kg CO_2 per kWh for mains gas, and 0.519 kg CO_2 per kWh for electricity. SAP 10 changes this to 0.210 kg CO_2 per kWh for mains gas, and 0.136 CO_2 per kWh for electricity. This means that it will be very unlikely that a developer will be able to meet the upper end of the proposed targets when using fossil fuel systems (such as natural gas) without looking at increased LZC and increased (improved) fabric which is likely to increase costs.

GBC may be interested in the approach that has been adopted by the Greater London Authority (GLA). In October 2018, the GLA published updated Energy Assessment Guidance which applies from January 2019 and directly impacts on developers. All new planning submissions in London are now 'encouraged' to use the new emissions factors detailed in the government's latest Standard Assessment Procedure for Building Regulations (i.e. SAP 10) alongside PART L 2013 (i.e. SAP 12).

As part of a transitionary arrangement and to encourage the early adoption of electrical systems, GBC may wish to consider replicating the requirements of the Greater London Authority which requires developers to run co-terminus calculations using both SAP 2012 and SAP 10 (see Section 5). In order to meet future zero carbon targets, buildings will have to move from mains gas to electricity, or mains gas will have to altered to hybrid gas/hydrogen or hydrogen systems and both GBC and developers should be aware of this.

3. SIMULATION RESULTS

The following tables provide greater detail and granularity on the modelled buildings. The columns show the simulation number (1 to 7), the building type and target benchmark, the DER and TER, indicative costs and salient technical details. Again, it is important to note that as this study builds upon the 2017 study - we do not show all simulations since some are not relevant to the targets investigated in this study. For example, in System 1 below there is a jump from Simulation 1 to 4. This does not mean that Simulations 2 and 3 do not exist, it means that these simulations did not deliver the results required for this study. We have retained (and will issue) all simulations in their iterative order since they will form part of the evidence base.

3.1 System 1: Domestic LTHW heating system using gas fired boilers

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
1.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER ≤ TER. This is a requirement of Criterion 1 of Part L1A.	**DER:** 17.26 **TER:** 17.54	**DFEE:** 40.88 **TFEE:** 55.91	£2,280.00 per functional unit (m2)	**Building fabric** Air permeability 5 at 50 Pa (m3/(h.m2) = 5 Thermal Bridging, taken at SAP psi values of 0.05 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC**

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
	Summary – pass (both DER and DFEE are the averages of over 31 separate simulations of differing assets)				Heating A low temperature hot water system using radiators. The heat source is a gas fired condensing combination boiler(s) with a gross efficiency of 89.50% as per the requirements of the notional building. Air conditioning N/A Ventilation Ventilation is provided naturally with the exception of kitchens, bathrooms/WCs where mechanical extraction has been assumed at the SAP default rates. **Lighting** 100% efficient. **Lighting controls** Manually controlled.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
					Domestic Hot Water Domestic hot water is provided through the combination boiler(s). **Renewable energy systems** N/A **Design challenges/considerations** The key consideration will be that the current SAP uses SAP 2012 emissions factors which will be superseded by SAP 10 (see Section 20).
4.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER must be 20% lower than the TER. This is the Extant Policy.	**DER:** 13.82 (estimated based on the application of an algorithm) **TER:** 14.00 (i.e. 20%	**DFEE:** 40.88 **TFEE:** 55.91	£2,314.00 to £2,436.00 per functional unit (m2)	As per simulation 1 but with an additional 1 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
	Summary - pass	lower than the TER is simulation 1)			
5.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic house and blocks of flats. **Benchmark** The DER must be 25% lower than the TER. **Summary - pass**	**DER:** 12.96 (estimated based on the application of an algorithm) **TER:** 13.20 (i.e. 25% lower than the TER is simulation 1)	**DFEE:** 40.88 **TFEE:** 55.91	£2,317.00 to £2,480.00 per functional unit (m2)	As per simulation 4 but with an additional 1.25 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.
6.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic house and blocks of flats.	**DER:** 12.3 **TER:** 12.3 (i.e. 30% lower than the TER is	**DFEE:** 40.88 **TFEE:** 55.91	£2,320.00 to £2,483.00 per functional unit (m2)	As per simulation 5 but with an additional 1.5 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
	Benchmark The DER must be 30% lower than the TER. **Summary - pass**	simulation 1)			Sufficient roof space is available for this purpose on our models.
7.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic house and blocks of flats. **Benchmark** The DER must be 35% lower than the TER. **Summary - pass**	**DER:** 11.4 **TER:** 11.4 (i.e. 35% lower than the TER is simulation 1)	**DFEE:** 40.88 **TFEE:** 55.91	£2,323.00 to £2,640.00 per functional unit (m2)	As per simulation 5 but with an additional 1.75 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.

3.2 System 2: Air to water air source heat pump (ASHP) system

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
1 to 6.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER ≤ TER. This is a requirement of Criterion 1 of Part L1A. **Summary – pass** (both DER and DFEE are the averages of over 31 separate simulations of differing assets) The DER is 30.60% less than the TER meaning that this simulation covers the additional targets of 25% and 30%	**DER:** 17.07 **TER:** 24.60 The DER is 30.60% lower than the TER	**DFEE:** 47.41 **TFEE:** 55.80	£2,313.00 per functional unit (m2)	**Building fabric** Air permeability 5 at 50 Pa (m3/(h.m2) = 5 Thermal Bridging, taken at SAP psi values of 0.05 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC** <u>Heating</u> An air to water heat pump system using a low temperature hot water hydronic circuit with radiators (increased in size to account for appropriate flow/return temps). Typical CoP[5] of the ASHP is >4.6. This is based on a system available in SAP Appendix Q. <u>Air conditioning</u> N/A <u>Ventilation</u>

[5] Coefficient of Performance (CoP). For each unit of energy input 4.6 units of heat are transferred as an output under test conditions.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
					Ventilation is provided naturally with the exception of kitchens, bathrooms/WCs where mechanical extraction has been assumed at the SAP default rates. **Lighting** 100% efficient. **Lighting controls** Manually controlled **Domestic Hot Water** Hot water is heated indirectly by the ASHP and stored in a 150 litre calorifier with heat loss calculated at 1.89 kWh/day. **Design challenges/considerations** Heat pumps are designed to deliver water often at lower levels than conventional boiler systems. However, for condensing boilers to condense, flow and return temperatures should also be low, with return temperatures at <55°C. When sizing pipework and radiators there should be little cost differential between System 1 and System 2

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
					but many developers still size radiators around higher flow and return temperatures typical to non-condensing boilers. Nevertheless, in terms of our cost analysis we have chosen to increase costs associated with LTHW infrastructure to account for any difference in flow and return temperatures.
7.	**Building type** Typical residential properties including detached, terrace and end-of-terrace domestic house and blocks of flats. **Benchmark** The DER must be 35% lower than the TER. **Summary - pass**	**DER:** 15.8 **TER:** 16.0 (i.e. 35% lower than the TER is simulation 1)	**DFEE:** 47.41 **TFEE:** 55.80	£2,340.00 per functional unit (m2)	As per simulations 1 to 6 but with an additional 0.50 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.

3.4 System 3: Ground to water heat pump system (GSHP)

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
1 to 3.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER ≤ TER. This is a requirement of Criterion 1 of Part L1A. **Summary - pass**	**DER:** 20.45 **TER:** 24.60	**DFEE:** 47.41 **TFEE:** 55.80	£2,367.00 to £2,407.00 per functional unit (m2)	**Building fabric** Air permeability 5 at 50 Pa (m3/(h.m2) = 5 Thermal Bridging, taken at SAP psi values of 0.05 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC** <u>Heating</u> A ground to water heat pump system using a low temperature hot water hydronic circuit with radiators (increased in size to account for appropriate flow/return temps). Typical CoP of the ASHP is >4.0. This is based on a system available in SAP Appendix Q (which is lower than the CoP of an alternative ASHP in Appendix Q, and somewhat counter intuitive). <u>Air conditioning</u> N/A

Simulation Building	DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
				Ventilation Ventilation is provided naturally with the exception of kitchens, bathrooms/WCs where mechanical extraction has been assumed at the SAP default rates. **Lighting** 100% efficient. **Lighting controls** Manually controlled **Domestic Hot Water** Hot water is heated indirectly by the ASHP and stored in a 150 litre calorifier with heat loss calculated at 1.89 kWh/day **Design challenges/considerations** The performance of systems is determined by the SAP Appendix Q database. Systems in the database are assigned through SAP and the efficiencies are fixed (unlike with SBEM and DSM commercial models where efficiencies are entered by the modeller). In this case the CoP of the GSHP is lower than ASHP (System 2) assigned and the DER is therefore worse. In practice annual system efficiencies are based on Seasonal CoP (SCoP) and we

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
					would expect these to be higher (better) for the GSHP than the ASHP as there is a lower temperature difference between ground temperatures and air temperatures and room temperatures. We assume that with additional modelling and/or research against the Appendix Q database that the DER can be reduced further without impacting on development costs.
4.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER must be 20% lower than the TER. This is the Extant Policy. **Summary - pass**	**DER:** 19.70 **TER:** 19.70 The DER is 20.00% lower than the TER	**DFEE:** 47.41 **TFEE:** 55.80	£2,394.00 to £2,516.00 per functional unit (m2)	As per simulations 1 to 3 but with an additional 0.50 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.
5.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark**	**DER:** 18.11 **TER:** 18.50	**DFEE:** 47.41 **TFEE:** 55.80	£2,397.00 to £2,56000 per functional unit (m2)	As per simulation 4 but with an additional 0.75 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
	The DER must be 25% lower than the TER. This is the Extant Policy. **Summary - pass**	The DER is 20.00% lower than the TER			Sufficient roof space is available for this purpose on our models.
6.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** The DER must be 30% lower than the TER. This is the Extant Policy. **Summary - pass**	**DER:** 17.20 **TER:** 17.20	**DFEE:** 47.41 **TFEE:** 55.80	£2,400.00 to £2,640.00 per functional unit (m2)	As per simulation 5 but with an additional 1 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.
7.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark**	**DER:** 15.90 **TER:** 16.00	**DFEE:** 47.41 **TFEE:** 55.80	£2,404.00 to £2,720.00 per functional unit (m2)	As per simulation 5 but with an additional 1.25 kWp mono crystalline PV system on pitched roofs, or on flat roof mounts facing due south-east at a 30 degree incline. Sufficient roof space is available for this purpose on our models.

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
	The DER must be 35% lower than the TER. This is the Extant Policy. **Summary - pass**				

3.5 System 4: District or block heating using gas fired CHP as the principal heat source

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
1 to 7.	**Building type** Typical residential properties including terrace and end-of-terrace domestic houses and blocks of flats. **Benchmark** It is possible to comply with all benchmarks through the use of district or block heating where the primary source of heating is a gas fired CHP. **Summary - pass**	**DER:** 10.32 **TER:** 17.40	**DFEE:** 47.41 **TFEE:** 55.80	£2,394.00 per functional unit (m2)	**Building fabric** Air permeability 5 at 50 Pa (m3/(h.m2) = 5 Thermal Bridging, taken at SAP psi values of 0.05 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC** <u>Heating</u> A low temperature hot water system using radiators via a block or district heating system. The primary heat source is a gas fired combined heat and power unit with the following details. Thermal seasonal efficiency 50%

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail
					Heat fraction 1 (100% of heat supplied) Electric efficiency 30% <u>Air conditioning</u> N/A <u>Ventilation</u> Ventilation is provided naturally with the exception of kitchens, bathrooms/WCs where mechanical extraction has been assumed at the SAP default rates. **Lighting** 100% efficient. **Lighting controls** Manually controlled. **Domestic Hot Water** Hot water is provided through the heat network and a heat interface unit (HIU). **Design challenges/considerations** N/A

Simulation Building		DER v TER kg CO_2/m^2	DFEE v TFEE kg CO_2/m^2	Indicative costs of construction	Technical detail

4. COSTS

The costs detailed over the following pages have been taken from the BIMs which are available as cabinet files (CAB files). The headings include an ID, a code which defines the basis of the cost multiplier, a rate (£), quantity, weight, base cost, cost £, and cost £ /. Explanations are provided below:

5.1. ID

The ID is based on the nomenclature of the RICS New Rules of Measurement.

5.2. Code

The code is assigned through the VE and informs the quantity. Code 11, as an example, is the code for multiplying the rate by the quantity which is based on the Gross Internal Floor Area (GIFA), while Code 1 measures the quantity by item. For example, 1 or 2 No. boilers etc.

5.3. Rate

This is the rate (£) to be multiplied by the quantity.

5.4. Quantity

This is the basis of the cost multiplier.

5.5. Weight

This applies a weighted value to the quantity, a weight of 1 = 100% as a multiplier against the quantity. In the costs below a rate of £1,262.50 per m^2 has been adopted as a base build cost, however this sum includes building services. Using BSRIA Rules of thumb as a guide, we have applied a discount rate to allow us to extract typical building services costs from the inclusive development cost. This is so that we can analyse the impact of different building services (on costs). For example, an adjusted weighting of 0.18 results in a weighting of 0.82 (1 – 0.18 = 0.82). The purpose of the exercise is to provide a consistent 'base build cost' across the simulations with the final project inclusive cost (i.e. with building services) reassessed against the range of costs provided in SPONS 2017[6]. The following weighting rules have been adopted throughout the project:

Property type	HVAC system type	Unadjusted BSRIA weighting	Less allowance for lifts[7] etc.	Adjusted weighting
Commercial (Offices)	Natural ventilation and no air conditioning	0.30	0.05	0.25
Commercial (Offices)	Mechanical ventilation and air conditioning	0.34	0.05	0.29
Commercial (Retail)	Mechanical ventilation and air conditioning	0.21	N/A	0.21
Commercial (Care Homes etc.)	Natural ventilation and no air conditioning	0.23	0.05	0.18

[6] In other words we would expect the project Cost per m2 to be within the range provided by SPONS 2017 after an adjustment for location.
[7] Items included in the BSRIA weighting have been added in our cost modelling as separate line items using the RICS NRM and therefore an allowance needs to be made (discounted) to avoid double counting.

Property type	HVAC system type	Unadjusted BSRIA weighting	Less allowance for lifts[7] etc.	Adjusted weighting
Residential	Natural ventilation and no air conditioning	0.23	0.025	0.205

5.6. Base cost

The base cost is an unadjusted cost (rate x quantity).

5.7. Cost

This is the adjusted cost. It is the cost multiplied by a location adjustment factor, a quality factor, and a complexity factor. In SPONS the location adjustment factor for the south east is 0.96, while a quality and complexity factor of unity (1) has been applied in the BIM representing a medium quality, medium complexity development for the type of building modelled.

Costs are based on SPONS 2020. The base build construction cost is taken verbatim from the 2020 iteration, but the other mechanical, electrical and public health services (MEP) costs were adjusted by (typically) 10% to raise the values identified in 2017 to the values in SPONS 2020. There may therefore be a variation if each item is looked at independently but our comparison of the two cost guides identified 10% as a typical increase for MEP services.

5.8. Cost £ /

This is the cost per functional unit. In this case the functional unit is taken as m^2.

5. ADVISORY NOTE ON SAP AND THE GREATER LONDON AUTHORITY

Building Regulations (and EPCs) as at the date of this report are based around emission factors that are set out in SAP 2012. BRE, authors of the SAP methodology, have released revised SAP10.1 'SAP 10'. It is not known when SAP 10 will come into effect. The new methodology will only supersede SAP 2012 when the Building Regulations Conservation of fuel and power: Approved Document L, is next updated, which is expected to be in 2020.

This is of relevance since the emissions factor of electricity will change considerably. SAP 2012 sets a value of 0.216 kg CO_2 per kWh for mains gas, and 0.519 kg CO_2 per kWh for electricity. SAP 10 changes this to 0.210 kg CO_2 per kWh for mains gas, and 0.136 CO_2 per kWh for electricity. This means that it will be very unlikely that a developer will be able to meet the upper end of the proposed targets when using fossil fuel systems (such as natural gas) without looking at increased LZC and increased (improved) fabric which is likely to increase costs.

GBC may be interested in the approach that has been adopted by the Greater London Authority (GLA). In October 2018, the GLA published updated Energy Assessment Guidance which applies from January 2019 and directly impacts on developers. All new planning submissions in London are now 'encouraged' to use the new emissions factors detailed in the government's latest Standard Assessment Procedure for Building Regulations (i.e. SAP 10) alongside PART L 2013 (i.e. SAP 12).

This is a highly unusual step for GLA to have taken, given SAP 10 has yet to be incorporated into official Building Regulations. However, the GLA guidance states that any energy assessments which do not use SAP10 will be expected to provide a justification as to why not and presumably this will be a consideration in planning approval.

The reason behind this policy change is England's rapid decarbonisation of the National Grid which has seen the amount of electricity sourced from wind and solar technologies increase year on year, while at the same time there is a move away from coal fired generation to gas fired generation.

The GLA believe the new SAP 10 factors more accurately reflect actual carbon emissions as the electricity emissions factor in SAP 10 is now 55% lower than that specified in PART L 2013. In practical terms, any PART L 2013 compliance should be accompanied by a separate spreadsheet document, supplied by the Greater London Authority (GLA), that translates energy consumption to SAP 10 carbon emissions.

The changes, detailed in the GLA's Energy Assessment Guidance, affect both residential and non-residential applications referred to the Mayor of London from January this year including:

- Developments of 150 residential units or more
- Development over 30 metres in height (outside the City of London)
- Development on Green Belt or Metropolitan Open Land

Applications for commercial developments also need to show at least a further 35% reduction in carbon emissions on top of those specified in PART L of Building Regulations 2013. However, the Mayor has already said that he intends to introduce zero carbon emissions for commercial developments in the final version of the London Plan.

Domestic / residential developments are already required to achieve zero carbon emissions. However, if this is not feasible or viable then developers must show how they will reduce emissions on-site by a minimum of 35% on top of those specified in Part L 2013. The remainder of the target needs to be met via carbon-offsetting either elsewhere in London (for example photovoltaic panels on a local school) or by contributing a carbon offset payment.

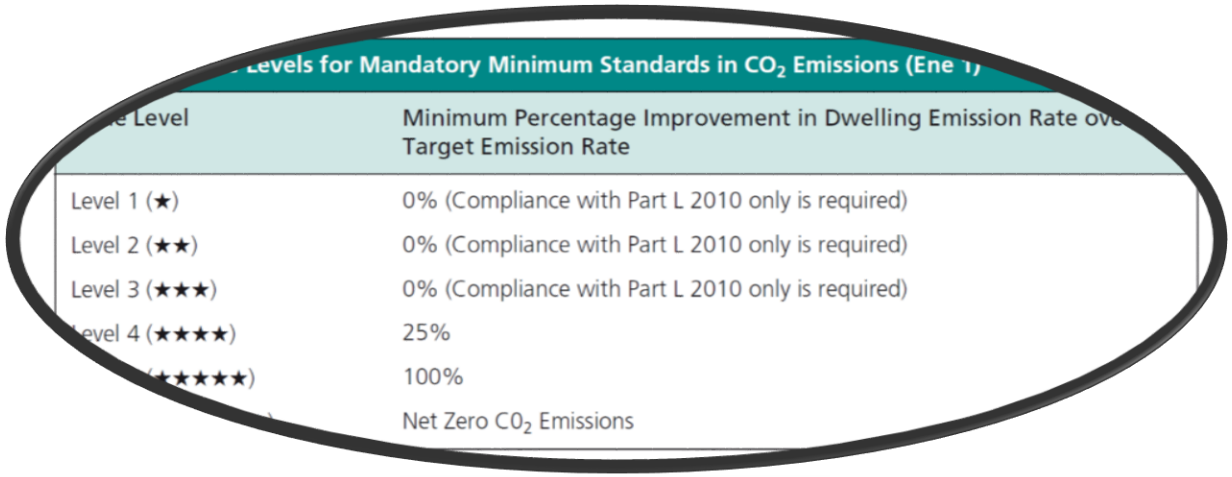
6. BRE HOME QUALITY MARK (HQM) – AND CODE FOR SUSTAINABLE HOMES

In 2015 the Government announced the conclusion to the Housing Standards Review. This review aimed to simplify government regulations and standards into one key set, driven by Building Regulations. As part of this review the Government also clarified the future of the Code for Sustainable Homes (CfSH) – a Government owned standard for sustainable house building. The written ministerial statement withdrew the Code (in England) so Local Authorities should no longer require it as a planning condition for new approvals.

Following this announcement BRE announced (also in 2015) that it was developing a Home Quality Mark (HQM) which would be a voluntary standard and accreditation scheme designed as a natural replacement for CfSH to maintain sustainability-driven house building standards. As part of this study GBC has asked EVORA EDGE to consider the effect of BRE HQM on CO_2 targets and in turn potential impact to developer's costs of construction.

EVORA EDGE has undertaken some research into the popularity of BRE HQM which included consulting with BRE HQM experts Encon Associates[8], and we have concluded that to-date take up of the scheme is low in comparison to CfSH. The relevance of this is that while there was previous evidence of the effect of CfSH on the costs of construction, there is no evidence that we are aware of showing the effect of BRE HQM on the costs of construction. Further, while previous studies by DCLG showed a clear link between Code levels and DER target rates, BRE HQM is opaque around this. For example, Table 1.2 of DCLG Code for Sustainable Homes Technical Guide 2010 (see below) shows that typically a Level 4 property is required to meet the first revised target rate of 25%, but no equivalent information is available in respect of BRE HQM without undertaking a BRE HQM assessment. The targets under the previous EVORA EDGE study and the existing GBC targets can be reached with a code Level 2 to 3 equivalent property with additional LZC as/when required.

[8] https://www.enconassociates.com/



Levels for Mandatory Minimum Standards in CO_2 Emissions (Ene 1)

Level	Minimum Percentage Improvement in Dwelling Emission Rate over Target Emission Rate
Level 1 (★)	0% (Compliance with Part L 2010 only is required)
Level 2 (★★)	0% (Compliance with Part L 2010 only is required)
Level 3 (★★★)	0% (Compliance with Part L 2010 only is required)
Level 4 (★★★★)	25%
(★★★★★)	100%
	Net Zero CO_2 Emissions

Indeed, BRE itself on its website states “It is difficult to draw comparisons between Code for sustainable homes (CfSH) and Home Quality Mark (HQM) schemes as it is not a like for like comparison. Although in principle CfSH and HQM seem similar in terms of some of the technical areas they consider, fundamentally their approaches and structures are very different. For example, specific technical content is very different and HQM is much more flexible as a scheme with only one mandatory requirement, which is important as a voluntary scheme. The outputs are also very different with any star rating considered as ‘better’ than minimum standards. The indicator scores within HQM also allow value to be drawn out from dwellings to a deeper level, while using a language that is consumer friendly”.

It is therefore not possible to directly link BRE HQM to this study since energy only forms one element of a HQM (and any BREEAM) assessment, but with our experience of dealing with other BREEAM (commercial) schemes it is our view that if GBC mandates Very Good + for BRE HQM, then this will affect

the cost of accreditation and the cost of construction. A practical example would be the inclusion of refrigeration leak detection to achieve a POL 1 credit which could add tens of thousands of pounds on to a large commercial heat pump installation.

In our cost models we have therefore sought to draw an equivalence in terms of BRE HQM and CfSH with a Code Level 4 building used as the revised benchmark for having to achieve targets of between 25% and 35%.

7. REPORT SOURCES / REFERENCES

The following resources have informed this study:

- DCLG, Cost for Sustainable Homes, cost review, July 2011
- DCLG, Cost of building to the Code for Sustainable Homes, Updated cost review, August 2011
- Passivhaus Trust, PassivHaus Construction Costs, October 2019
- SPONS, Architects and Builders Price Book, 2020
- SPONS, Mechanical and Electrical Services Price Book, 2020

8. SYSTEM 1, SIMULATION 1

Guildford Project	Simulation V1 - Simulation 1.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,138.19	5,935	0.795	10,088,659.31	9,685,112.94	1,631.86
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and control systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
	Project cost						**13,530,138.30**	**2,279.72**

9. SYSTEM 1, SIMULATION 2

Guildford Project	Simulation V1 - Simulation 2.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,191.64	5,935	0.795	10,340,875.80	9,927,240.76	1,672.66
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	26.0	1	39,540.45	37,958.84	6.40
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**13,935,572.16**	**2,348.03**

10. SYSTEM 1, SIMULATION 3

Guildford Project	Simulation V1 - Simulation 3.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,245.10	5,935	0.795	10,593,092.28	10,169,368.59	1,713.46
5	Services (BES)	11	0	0	1	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	39.1	1	59,310.68	56,938.25	9.59
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**14,196,679.40**	**2,392.03**

11. SYSTEM 1, SIMULATION 4

Guildford Project	Simulation V1 - Simulation 4.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,298.55	5,935	0.795	10,845,308.76	10,411,496.41	1,754.25
5	Services (BES)	11	0	0	1	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	52.1	1	79,080.91	75,917.67	12.79
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**14,457,786.64**	**2,436.02**

12. SYSTEM 1, SIMULATION 5

Guildford Project	Simulation V1 - Simulation 5.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,352.01	5,935	0.795	11,097,525.24	10,653,624.23	1,795.05
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	65.1	1	98,851.13	94,897.09	15.99
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**14,718,893.88**	**2,480.02**

13. SYSTEM 1, SIMULATION 6

Guildford Project	Simulation V1 - Simulation 6.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,352.01	5,935	0.795	11,097,525.24	10,653,624.23	1,795.05
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	78.1	1	118,621.36	113,876.51	19.19
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**14,737,873.30**	**2,483.21**

14. SYSTEM 1, SIMULATION 7

Guildford Project	Simulation V1 - Simulation 7.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,552.99	5,935	0.795	12,045,859.22	11,564,024.85	1,948.45
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost) - based on affordable (no AC)	11	88	5,935	1	522,280.00	501,388.80	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	91.1	1	138,391.59	132,855.92	22.39
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**15,667,253.33**	**2,639.81**

15. SYSTEM 2, SIMULATIONS 1 TO 6

Guildford Project	Simulation V2 - Simulations 1.0 to 6.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,138.19	5,935	0.795	10,088,659.31	9,685,112.94	1,631.86
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £550 (per kW). Infrastructure costs accounted for seperately (5,6)	1	228497.5	1	1	228,497.50	219,357.60	36.96
5.6	Space heating and/or air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
	Project cost						**13,727,560.14**	**2,312.98**

16. SYSTEM 2, SIMULATION 7

Guildford Project	Simulation V2 - Simulations 7.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,138.19	5,935	0.795	10,088,659.31	9,685,112.94	1,631.86
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110.00	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £550 (per kW). Infrastructure costs accounted for seperately (5,6)	1	228497.50	1	1	228,497.50	219,357.60	36.96
5.6	Space heating and/or air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.80	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1,518.75	26.0	1	39,540.45	37,958.84	6.40
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.90	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.10	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**13,890,866.18**	**2,340.50**

17. SYSTEM 3, SIMULATIONS 1 TO 3

Guildford Project	Simulation V3 - Simulations 1.0 to 3.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,191.64	5,935	0.795	10,340,875.80	9,927,240.76	1,672.66
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Ground Source Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £1225 (per kW)	1	559818.875	1	1	559,818.88	537,426.12	90.55
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	0.0	1	0.00	0.00	0.00
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	0.00	1	0.00	0.00	0.00
	Project cost						**14,287,756.48**	**2,407.37**

18. SYSTEM 3, SIMULATION 4

Guildford Project	Simulation V3 - Simulation 4.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,298.55	5,935	0.795	10,845,308.76	10,411,496.41	1,754.25
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Ground Source Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £1225 (per kW)	1	559818.875	1	1	559,818.88	537,426.12	90.55
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	26.0	1	39,540.45	37,958.84	6.40
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and control systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**14,935,318.17**	**2,516.48**

19. SYSTEM 3, SIMULATION 5

Guildford Project	Simulation V3 - Simulation 5.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,352.01	5,935	0.795	11,097,525.24	10,653,624.23	1,795.05
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Ground Source Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £1225 (per kW)	1	559818.875	1	1	559,818.88	537,426.12	90.55
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	39.1	1	59,310.68	56,938.25	9.59
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and control systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additional reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**15,196,425.41**	**2,560.48**

20. SYSTEM 3, SIMULATION 6

Guildford Project	Simulation V3 - Simulation 6.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,452.50	5,935	0.795	11,571,692.23	11,108,824.54	1,871.75
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Ground Source Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £1225 (per kW)	1	559818.875	1	1	559,818.88	537,426.12	90.55
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	52.1	1	79,080.91	75,917.67	12.79
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additonal reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**15,670,605.13**	**2,640.37**

21. SYSTEM 3, SIMULATION 7

Guildford Project	Simulation V3 - Simulation 7.0		2020					
ID	Description	Code	Rate	Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,552.99	5,935	0.795	12,045,859.22	11,564,024.85	1,948.45
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Ground Source Heat source (HS) Heat pumps = 5935m2 * 70w / 1000 * £1225 (per kW)	1	559818.875	1	1	559,818.88	537,426.12	90.55
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	65.1	1	98,851.13	94,897.09	15.99
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
2.3.1	Roof structure (additonal reinforcement flat roofs)	11	22	5,935	1	130,570.00	125,347.20	21.12
	Project cost						**16,144,784.86**	**2,720.27**

22. SYSTEM 4, SIMULATIONS 1 TO 7

Guildford Project	System V4 - Simulations 1.0 to 7.0		2020					
ID	Description	Code		Quantity	Weight	Base cost £	Cost £	Cost £ / FU
6	Complete buildings and building units (SPONS A&B 2020 - median cost with weighting applied 72.6% (flats) & 27.4% (houses))	11	2,138.19	5,935	0.795	10,088,659.31	9,685,112.94	1,631.86
5.1	Sanitary installations (SA) (SPONS M&E 2020 - median cost)	11	110	5,935	1	652,850.00	626,736.00	105.60
5.3	Disposal installation (DI) (SPONS M&E 2020 - median cost)	11	26.95	5,935	1	159,948.25	153,550.32	25.87
5.4	Water installations (WI) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.5	Heat source (HS) - backup boiler (SPONS M&E 2020 - median cost)	11	12.65	5,935	1	75,077.75	72,074.64	12.14
5.5	Heat source (HS) CHP = 5935 * 70w / 1000 * £828 (see also 5.13.1 below). NB sized as a maximimum to ensure SAP outputs are maximisied and costs to developers are not discounted. In reality we would size this at 50% load.	1	344154.375	1	1	344,154.38	330,388.20	55.67
5.6	Space heating and/or air conditioning (SHAC) (SPONS M&E 2020 - median cost + 10%) - based on affordable (no AC)	11	96.8	5,935	1	574,508.00	551,527.68	92.93
5.7	Ventilation systems (VS) (SPONS M&E 2020 - median cost)	11	59.95	5,935	1	355,803.25	341,571.12	57.55
5.8	Electrical installations (EI) (SPONS M&E 2020 - median cost)	11	123.75	5,935	1	734,456.25	705,078.00	118.80
5.8.5	PV panels (SPONS M&E 2020 - median cost)	11	1518.75	0.0	1	0.00	0.00	0.00
5.9	Fuel installations / systems (FI) (SPONS M&E 2020 - median cost)	11	17.05	5,935	1	101,191.75	97,144.08	16.37
5.11	Fire and lightning protection (FLP) (SPONS M&E 2020 - median cost)	11	31.9	5,935	1	189,326.50	181,753.44	30.62
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2020 - median cost)	11	110.55	5,935	1	656,114.25	629,869.68	106.13
5.13	Special installations / Systems (SI) (SPONS M&E 2020 - median cost)	11	34.1	5,935	1	202,383.50	194,288.16	32.74
5.13.1	Specialist piped supply installations (heat network - £1250 per m)	11	1375	137	1	188,375.00	180,840.00	30.47

Guildford Project	System V4 - Simulations 1.0 to 7.0		2020					
5.14	Builder's work in connection with services (BWIC) (contribution towards and energy centre)	11	20.339	5,935	1	120,711.97	115,883.49	19.53
	Project cost						**14,207,388.87**	**2,393.83**

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