EVORA EDGE

BUILDING SIMULATION REPORT FOR GUILDFORD BOROUGH COUNCIL

A Mixed Use Scheme – Care Home

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EVORA EDGE

Contents

1. INTRODUCTION

This building simulation report summarises the findings of up to twelve simulations on two building energy models of a residential care home for the elderly. These models are based on an adapted residential development provided to EVORA EDGE by Guildford Borough Council for the purpose of this study.

The simulations study the performance of two different but common building services solutions for naturally ventilated properties, which we refer to throughout this report as System 1 and System 2. In both building models the building fabric and lighting are the same. However, the heating, ventilation, air conditioning (HVAC) and domestic hot water strategy in each building varies and Low and Zero Carbon (LZC) technologies are incorporated to augment or replace conventional non-LZC technologies.

The modelled simulations calculate a building's Built Emission Rate (BER) as a result of the energy it is predicted to consume. Templates around occupancy and occupational parameters, such as hours of operation and temperature set points, are provided in a National Calculation Method (NCM) which was developed by the Building Research Establishment (BRE) for government. To comply with Approved Document Part L2A *Conservation of fuel and power in buildings other than dwellings* of Building Regulations (Part L2A), a Target Emission Rate (TER) is set and the BER must achieve or better (≤) this target. The TER is based on the performance of the Notional Building which is also defined in the NCM.

In addition to building regulations, the TER is used in planning policy as a benchmark for sustainable development by setting out the maximum level of predicted CO_2 emissions that a building or development is permitted to emit. As part of an extant planning policy, Guildford Borough Council (GBC) requires the BER of a new building to be at least 10% lower than the TER, with any reduction achieved through the use of on-site LZC technologies.

GBC is currently in consultation to increase this target to either 15 or 20% and this document forms part of a series of reports to help determine if these targets are technically feasible, and if so, what the potential effect of revising this policy would be in terms of development costs to property developers.

1.1. The Simulations

Part L2A 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[1]. For a building to pass the exacting requirements of Part L2A it must be designed and constructed to a standard that meets or betters the TER of a Notional Building (BER ≤ TER). A building that is constructed to the limiting parameters of Part L2A will fail Criterion 1, which is the Criterion that requires the BER ≤ TER.

Each model simulated is identical in every respect other than its building services, which may or may not include renewable energy systems. To ensure that the model is capable of passing Part L2A the building fabric is based upon the requirements of a Notional Building, and these remain unchanged throughout the various iterations of the model(s). By ensuring that the building construction and fabric remain as a constant, we can calculate a 'base building' construction cost. This in turn allows us to identify where additional expenditure is required to facilitate the CO_2 reduction targets of four benchmarks, detailed below. 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.

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

System 2 on the other hand starts with LZC technologies, for example primary fossil fuel heating is typically replaced with heat pumps. Simulations have been run against four benchmarks, these are:

1) The Building Emission Rate is equal to or lower than the Target Emission Rate (BER≤ TER). This is a requirement of Criterion 1 of Approved Document Part L2A of Building Regulations 2010 (Part L)
2) The BER must be 10% lower than the TER. This is the Extant Policy
3) The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A
4) The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B

1.2. Building Information Model (BIM)

To prepare this report we have used a building information model or BIM using 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 BIM which was shared between two principal energy modellers.

The BER and TER calculations and costs were all undertaken in the same model(s) and these are in turn available as IES Cabinet Files for future use. Nomenclature of itemised costs are based on the RICS New Rules of Measurement *Order of cost estimating and cost planning for capital building works.* A representation of the federated BIM is shown below.

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 an extract from the BIMs showing 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

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

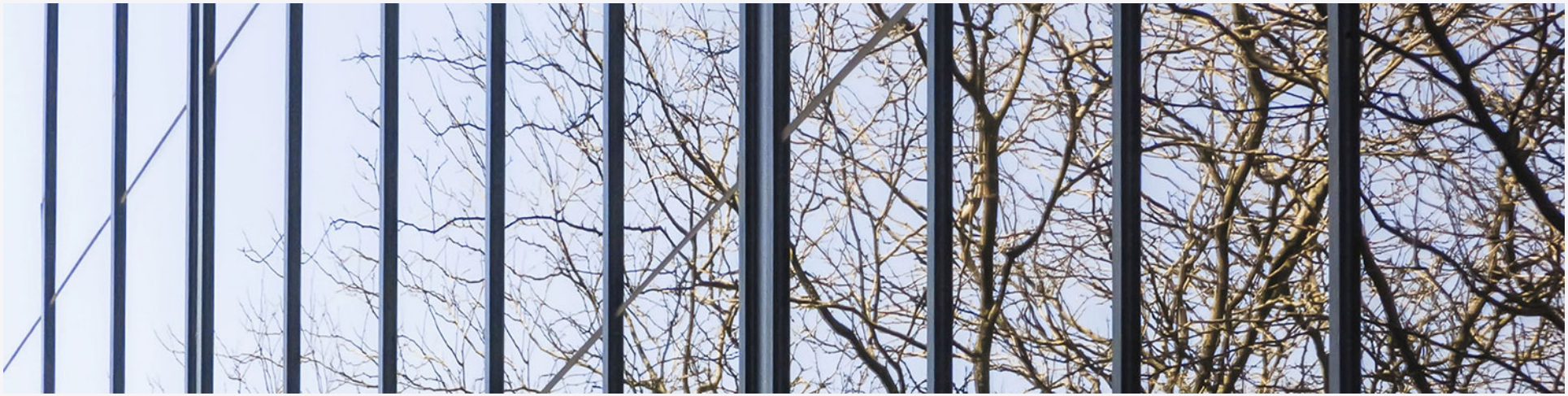
- Structure
- Orientation and Massing
- HVAC and Lighting Types
- Combination of HVAC and Fuel Types
- LZC Technologies

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 four benchmarks using the geometry and construction type of buildings which either already exist, or 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 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 L2A, or the Energy Technology List (ETL)[2], or other reputable or market sources.

[2] 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.

Costs are indicative and for benchmarking purposes only. They exclude VAT and fees associated with design, professional services and project management. They do however include for preliminaries, profit and overheads for the services contractor. Build costs have typically been taken at the median of a range of costs detailed in SPONS 2017 unless indicated otherwise. Greater detail and information on our costing methodology has been provided in Section 4. of this report.



2. EXECUTIVE SUMMARY

Our findings over the following pages are summarised in the form of three schematics, one for each type of HVAC system including; a common domestic low temperature hot water heating system, an air source heat pump system (air-to-water), and a heat network using gas fired combined heat and power or CHP. Each schematic shows the effect of each iterative simulation on the BER in order to meet or better a benchmark, the financial cost to the developer for each metre square (m2) of building space to achieve this. Finally the schematic shows, expressed as a percentage increase, the cost of improving a building from Part L2A and the Extant Policy to a building that can comply with Proposed Policy B – the most stringent of the proposed policies.

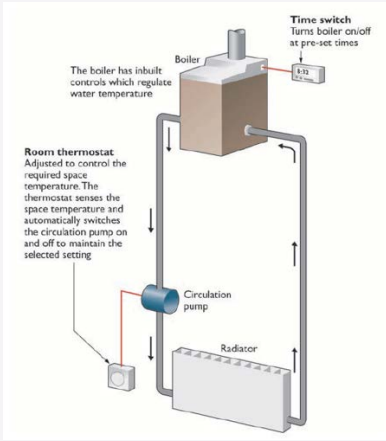
2.1 System 1: Results

System 1 is a common domestic low temperature hot water (LTHW) heating system using radiators and a gas fired central heating boiler as the heat source. Water is indirectly heated and stored in hot water storage tanks. Ventilation is delivered naturally with the exception of WCs and bathrooms, which have localised extraction units. System 1 is capable of passing Part L1A without any LZC technology, but requires photovoltaics (PV) in increasing capacity to pass the existing and proposed policies. The results of the case studies are as follows:

- The cost of Proposed Policy B is up to 3.52% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy B construction costs is up to 1.09%.
- The cost of Proposed Policy A is up to 3.01% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy A construction costs is up to 0.61%.

System 1: Results schematic

Shown below is a typical LTHW system arrangement.



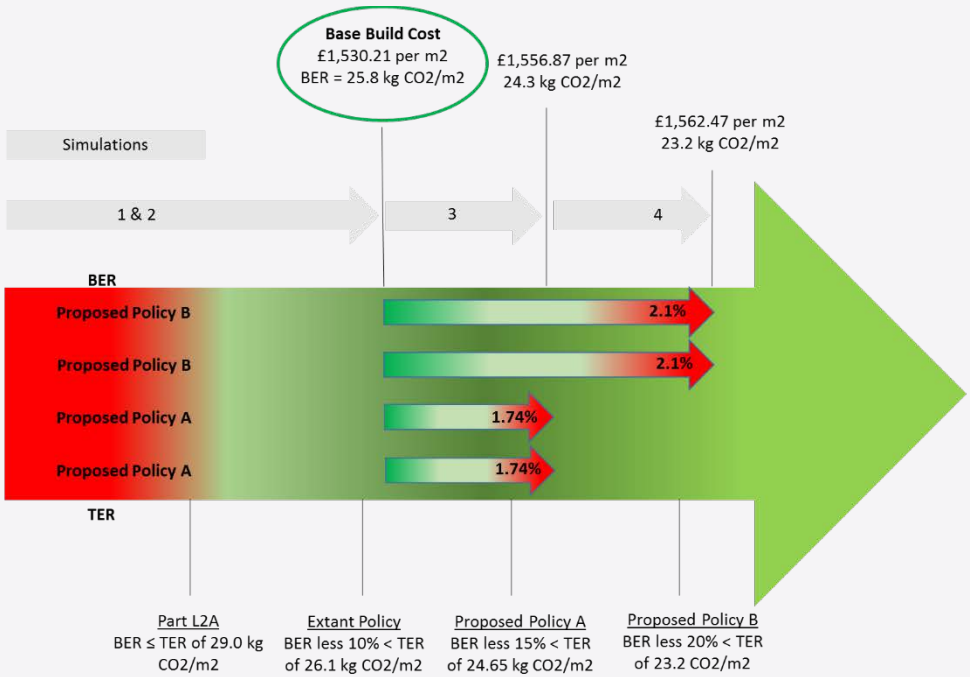
Source of pictures, the BSRIA *Illustrated Guide to Mechanical Building Services*

2.2 System 2: Results

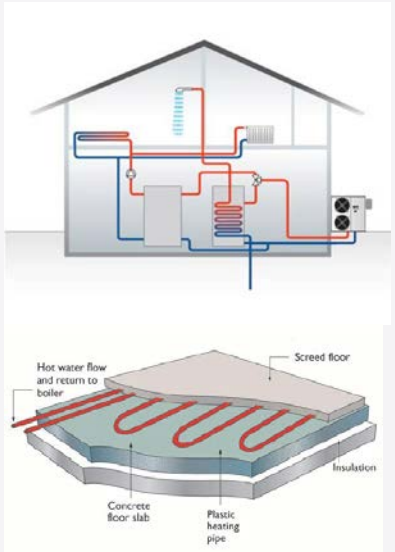
System 2 incorporates air to water air source heat pumps (ASHP), a LZC technology, as the primary source of heating. Heat is exchanged through a heat interface unit (HIU) to a LTHW hydronic circuit, and delivered to the heat load through underfloor heating or radiators which are (typically) larger in size than System 1. In System 2 we have modelled a commercial pumped secondary circulation domestic hot water system. As per System 1 ventilation is largely through natural means. The results of the case studies are as follows:

- The cost of Proposed Policy B is up to 2.1% more expensive than constructing a building that complies with both Criterion 1 of Part L2A AND the Extant Policy. This is because by using ASHP as the primary heat source our base model represents a building that can pass building regulations and GBC's existing policy.
- The cost of Proposed Policy A is up to 1.74% more expensive than constructing a building that complies with Criterion 1 of Part L2A AND the Extant Policy. This is because by using ASHP as the primary heat source our base model represents a building that can pass building regulations and GBC's existing policy.

System 2: Results schematic



Shown below is air to water ASHP system arrangement.



Source of pictures, the BSRIA *Illustrated Guide to Mechanical Building Services*

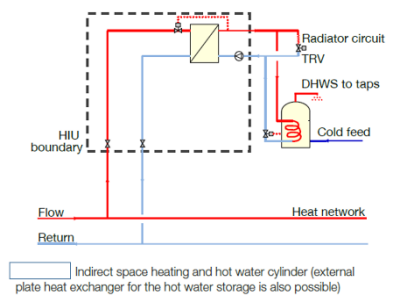
2.3 System 3: Results

System 3 incorporates a district or block heating scheme (a heat network) using primary and secondary hydronic low temperature hot water circuits with the primary heat source being a gas fired combined heat and power (CHP) engine. CHP is considered to be an LZC technology because our conventional energy supply system is based on the separate production of electricity in power stations and heat from boilers. CHP (also known as cogeneration) is the name applied to energy systems that produce both useful heat and electricity resulting in efficiencies due reduced electrical transmission losses. Heat networks can address the 'energy trilemma', reducing greenhouse gases through the use of LZC, improving security of energy supply by diversifying energy resources and, offering a supply of heat that is good value. Our findings are:

- The cost of Proposed Policy B is up to 3.02% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy B construction costs is up to 0.94%.
- The cost of Proposed Policy A is up to 2.54% more expensive than constructing a building that complies with Criterion 1 of Part L2A.
- The difference in cost between Extant Policy construction costs and Policy A construction costs is up to 0.47%.

System 3: Results schematic

Shown below, a schematic for a typical connection to a heat network



Source of schematic CIBSE CP1 *Heat networks: Code of Practice for the UK*

2.4 A Comparison of System Performance

The table below compares the results of our simulations so that we can better understand cost-effectiveness alongside the impact on predicted CO_2 emissions. CO_2 emission are linked to energy consumption (kWh) and therefore, potentially, operational 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 Policy A or B. **This is highlighted in green**. In this case System 1, below, is the most cost-effective. Boxes that have been blacked out indicate that the previous simulation was capable of passing the target benchmark, and as a result it is not necessary to run additional simulations. For example, the simulation run to pass benchmark 1 for System 2 also passes benchmark 2, so this has been blacked out.

The second metric assesses the cost (£) of reducing CO_2 emissions. 0 = Zero operational carbon, the further away from zero the higher the cost (£) per Tonne (T) of CO_2 saved[3]. In this case, as an example, although System 2 is the second most expensive of the systems, for each £ invested per m^2 a greater amount of CO_2 savings are achieved. As a result, it is likely that operational running costs will be the lowest of the two Systems.

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

Benchmark	System 1 BER kg CO_2/m^2	System 2 BER kg CO_2/m^2	System 3 BER kg CO_2/m^2	System 1 Cost per m^2 v carbon metric	System 2 Cost per m^2 v carbon metric	System 3 Cost per m^2 v carbon metric
1. The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A	30.2	25.8	30.0	£1,501.09 / m^2 £45.33 / TCO_2	£1,530.21 / m^2 £39.48 / TCO_2	£1,562.82 / m^2 £46.88 / TCO_2
2. The BER must be 10% lower than the TER. This is the Extant Policy	26.8		27.3	£1,537.08 £41.19 / TCO_2		£1,595.08 / m^2 £43.55 / TCO_2
3. The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A	25.1	24.3	25.8	£1,546.41/ m^2 £38.81 / TCO_2	£1,556.87 / m^2 £37.83 / TCO_2	£1,602.54 / m^2 £41.35 / TCO_2
4. The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B	23.5	23.2	24.3	£1,553.88/ m^2 £36.52 / TCO_2	£1,562.47 / m^2 £36.25 / TCO_2	£1,610.01 / m^2 £39.12 / TCO_2

3. SIMULATION RESULTS

The following two tables provide greater detail and granularity to the modelled buildings. The columns show the simulation number (1 to 4), the building type and target benchmark, the BER and TER, indicative costs and salient technical details.

3.1 System 1: Domestic Type LTHW Heating System Using Gas Fired Boilers

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
1.	**Building Type** Residential Care Home. **Benchmark** The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A. **Summary** - **pass** It is possible to comply with Part L2A using fossil fuel(s) only provided a decentralised HVAC system is used. I.e. multiple boilers and hot water tanks. See design challenges/considerations for more detail.	30.2 The BER is 9.3% less than the TER	33.3	£1,564,140.00 or £1,501.09 per functional unit (m^2)	**Building fabric** Air permeability 5 at 50 Pa ($m^3/(h.m^2)$ = 5. Fabric U values, as per the notional building. Glazing g values, as per the notional building. **HVAC** <u>Heating</u> A decentralized hydronic low temperature hot water (LTHW) system has been modelled. The boiler efficiency is taken at 91% gross and wider system details and efficiencies as per the notional building. Pumps are variable speed with multiple pressure sensors.

Simulation Building	BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
				<u>Ventilation</u> Ventilation is provided naturally with the exception of bathrooms/showers which have localized extraction. Air exchange rates for WC/bathroom areas have been taken at 10 air changes per hour, and the specific fan power (SFP) of local exhaust systems at 0.3 w/l/s as per the requirements of Part L2A, and it assumed that these will have an integral heat exchanger. **Domestic Hot Water** Locally sited calorifiers totalling 1700 litres. **Lighting** 60 lumens per circuit-watt, 100 lux – circulation space 60 lumens per circuit-watt, 300 lux all other spaces The light efficacy in the Notional Building is 60 lumens per circuit-watt. **Lighting controls** Photoelectric – typically yes Motion sensors – typically no, as this would be impractical (PIR to common areas and office area only)

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
					Design challenges/considerations Using BSRIA Rules of Thumb, we estimate that the total domestic hot water (DHW) requirement for this building is 1700 litres. Accounting for diversity (of use) we can reduce a centralized calorifier to circa 1100 litres. However, this system fails Part L2A as the act of introducing secondary circulation increases auxiliary power to more than the Notional Building.[4] To pass Part L2A, one must assume locally sited calorifiers totalling 1700 litres. A saving is made operationally since secondary circulation is not required. However, this may increase capital expenditure since multiple calorifiers and boilers are required. From an operational perspective a developer (or at least an owner/occupier) may choose to install a centralized system and this will require LZC technologies to pass Part L2A.

[4] NB this type of decentralised system has been modelled in System 2

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
2.	**Building type** Residential Care Home. **Benchmark** The BER must be 10% lower than the TER. This is the extant borough policy. **Summary** - **pass** The BER of simulation 1 is 9.3% lower than the TER without the use of any LZC technologies. It is possible therefore to reduce this further to 10% through a 2 kWp PV system. However, the result of this is that only 0.75 kg CO2 /m2 or 2.25% of a reduction is a result of LZC technologies. To ensure a 10% reduction against the BER through LZC, the PV system needs to be extended to 9kWp resulting in a reduction of 3.39 kg CO_2/m^2 or 10.18% against the TER.	26.8 The BER is 19.52% less than the TER (the TER detailed in simulation 1)	29.97 (this is the target under the Extant Policy. It is the TER less 10%)	£1,601,642.38 or £1,537.08 per functional unit (m2) This represents an increase over the base build cost of £37,502.30 or 2.40% NB the cost of adding the additional 7kWp to the PV system is £13,608.00 which is £13.06 per m^2. This is 1.08% of the 2.40% increase referenced above.	As per simulation 1 but with an additional 9kWp mono crystalline PV system on roof mounts facing due south-east at a 30 degree incline. This will require around 108 m2 of flat roof space – the flat roof of the proposed property extends to about 214 m^2.

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	The cumulative effect of this is that the BER is 19.52% lower than the TER.				
3.	**Building type** Residential Care Home. **Benchmark** The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A. **Summary - pass** To ensure a 15% reduction against the BER through LZC, the PV system needs to be extended to 13.5kWp resulting in a reduction of 5.08 kg CO_2/m^2 or 15.25% against the TER. The cumulative effect of Simulation 1 and this simulation is that the BER is now 24.62% lower than the TER.	25.1 The BER is 24.62% less than the TER (the TER detailed in simulation 1)	28.31 (this is the target under Proposed Policy A. It is the TER less 15%)	£1,611,362.38 or £1,546.41 per functional unit (m^2) This represents an increase over the base build cost of £47,222.30 or 3.02%	As per simulation 2, but with a PV system of increased capacity to 13.5 kWp requiring a flat roof area of 162 m^2 - the flat roof of the proposed property extends to about 214 m^2.
4.	**Building type** Residential Care Home.	TER (the TER detailed in	Policy A. It is the TER less 20%)	This represents an increase over the base build of	As per simulation 3, but with a PV system of increased capacity to 17.75 kWp requiring a flat roof area of 213 m2 -

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	Benchmark The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B. **Summary - pass** To ensure a 20% reduction against the BER through LZC, the PV system needs to be extended to 17.75 kWp resulting in a reduction of 6.68 kg CO_2/m^2 or 20 % against the TER. The cumulative effect of Simulation 1 and this simulation is that the BER is now 29.43% lower than the TER.	simulation 1)		£54,998.30 or 3.52%	the flat roof of the proposed property extends to about 214 m2. NB although this has resulted in a pass we note that ALL available roof space will now be occupied by a PV system. In practice building designers may look for alternative solutions to gain the 20% reduction, such as hybrid LZC solutions. In the meantime we have made an allowance to the construction costs to allow for the increased loading of PV on the roof structure.

3.2 System 2: Air to Water Air Source Heat Pump (ASHP) with Secondary Domestic Hot Water Circulation

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
1.	**Building type** Residential Care Home. **Benchmark** The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A. **Summary - pass** It is possible to (easily) comply with Part L2A using an ASHP (air to water) system. This is with the benefit of a decentralised heat source and domestic hot water system, which is likely to be a better design for this type of use.	25.8 The BER is 11% less than the TER	29.0	£1,594,478.50 or £1,530.21 per functional unit (m^2)	**Building fabric** Air permeability 5 at 50 Pa ($m^3/(h.m^2)$ = 5 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC** <u>Heating</u> A hydronic low temperature hot water (LTHW) system has been modelled. The heat source is an air to water ASHP, a LZC technology. The CoP has been modelled at 3.9[5] a requirement of the Energy Technology List (ETL)[6]. Pumps are variable speed with multiple pressure sensors.

[5] For each unit of energy input 3.9 units of heat is delivered as an output under test conditions
[6] 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

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
					<u>Ventilation</u> Ventilation is provided naturally with the exception of bathrooms/showers which have localized extraction. Air exchange rates for WC/bathroom areas have been taken at 10 air changes per hour, and the specific fan power (SFP) of local exhaust systems at 0.3 w/l/s as per the requirements of Part L2A, and it assumed that these will have an integral heat exchanger. **Lighting** 60 lumens per circuit-watt, 100 lux – circulation space. 60 lumens per circuit-watt, 300 lux all other spaces. The light efficacy in the Notional Building is 60 lumens per circuit-watt. **Lighting controls** Photoelectric – typically yes Motion sensors – typically no, as this would be impractical (PIR to common areas and office area only). **Design challenges/considerations** Using BSRIA Rules of Thumb, we estimate that the total domestic hot water (DHW) requirement for this building is 1700 litres. Accounting for diversity (of use) we can reduce a centralized calorifier to circa 1100 litres.

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
2.	**Building type** Residential Care Home. **Benchmark** The BER must be 10% lower than the TER. This is the extant borough policy. **Summary - pass** Simulation 1 has been adopted verbatim as the BER is 11.03 % less than the TER. The heating source is an LZC technology and this is responsible for 3.77 kg CO_2 / m2[7]. An alternative heat source of equal efficiency would therefore emit at least this much CO^2 – meaning that the reduction in emissions is equal to 3.77 kg CO^2 / m^2 or about 13% against the BER. The heat source for System 1 emitted 6.78 kg CO_2 / m^2.	25.8 The BER is 11.03% less than the TER (the TER detailed in simulation 1)	26.1 (this is the target under the Extant Policy. It is the TER less 10%)	£1,594,478.50 or £1,530.21 per functional unit (m^2)	As per Simulation 1.
3.	**Building type** Residential Care Home.	24.3	24.65 (this is the target under	£1,622,260.88 or £1,556.87 per	As per simulation 1 and 2 but with an additional 4kWp mono crystalline PV system on roof mounts facing due south-east at a 30 degree incline.

[7] Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	Benchmark The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A. **Summary - pass** The BER is 16.2 % less than the TER. The heating source is an LZC and this is responsible for 3.77 kg CO_2 / m^2[8]. An alternative heat source of equal efficiency would therefore emit at least this much CO_2 – meaning that the reduction in emissions is equal to 3.77 kg CO_2 / m^2 or about 13% against the BER. The additional CO_2 reduction comes from a 4kWp PV system.	The BER is 16.2% less than the TER (the TER detailed in simulation 1)	Proposed Policy A. It is the TER less 15%)	functional unit (m^2) This represents an increase over the base build of £27,782.30 or 1.74 % NB if costs seem high for a small PV system this is because we are also accounting for the fact the developer may have to factor into construction detail additional load-bearing capabilities for any roof	This will require around 48 m2 of flat room space –the flat roof of the proposed property extends to about 214 m^2.

[8] Electrical emissions taken at 0.519 kg CO_2 per kWh (SAP 2012)

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
4.	**Building type** Residential Care Home. **Benchmark** The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B. **Summary – pass** The BER is 16.2 % less than the TER. The heating source is an LZC and this is responsible for 3.77 kg CO^2 / $m^{29.}$ An alternative heat source of equal efficiency would therefore emit at least this much CO_2 – meaning that the reduction in emissions is equal to 3.77 kg CO_2 / m^2 or about 13% against the BER. The additional CO2 reduction comes from a 7kWp PV system.	23.2 The BER is the same as the TER (the TER detailed in Simulation 1)	23.2 (this is the target under Proposed Policy A. It is the TER less 20%)	£1,628,092.88 or £1,562.47 per functional unit (m2) Increase over base build of £33,614.30 or 2.11%	As per Simulation 3 but with a 7kWp PV system requiring 84m^2 of flat room space –the flat roof of the proposed property extends to about 214 m^2.

[9] Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

3.4 System 3: District heating using gas fired CHP

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
1.	**Building type** Residential Care Home. **Benchmark** The BER ≤ TER. This is a requirement of Criterion 1 of Part L2A. **Summary - pass** It is possible to comply with Part L2A using a district heating scheme with gas fired CHP. However due to 1) the way that the Notional Building is calculated[10] and 2) the low levels of hot water demand assumed by the NCM in this scenario compared to industry rules of thumb, it is necessary to make additional 'energy savings' or augment the system with additional building LZC such as PV, or use an alternative fuel	30.0 The BER is 1.64% less than the TER	30.5	£1,6282,460.63 or £1,562.82 per functional unit (m^2)	**Building fabric** Air permeability 5 at 50 Pa ($m^3/(h.m^2)$ = 5 Fabric U values, as per the notional building Glazing g values, as per the notional building **HVAC** <u>Heating</u> A hydronic low temperature hot water (LTHW) system has been modelled. The heat source is a district heating scheme using gas fired CHP. Heat is delivered through a primary circuit and transferred through a heat interface unit (HIU) to the secondary circuits to each demise. Pumps are variable speed with multiple pressure sensors. <u>Ventilation</u>

[10] Where the fuel source is gas we must use an emission factor of 0.216 kg CO_2 per kWh. Where the emission factor of heat supplied in the Actual building is greater than 0.15 kgCO2/kWh and less than 0.4 kgCO2/kWh, the Notional building will have the same emission factor of heat supplied as the Actual building

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	source such as biomass (to reduce the emission factoring). NB we observed that SAP domestic calculations show far greater emission reductions than NCM modelling such as SBEM. Unfortunately SAP software does not allow us to interrogate the emission factors in the same way as advanced NCM software, so we cannot explain why this may be the case. However we believe, in part at least, this is down to the difference between the NCM domestic hot water loads and our calculations. As we are replicating the processes a developer would go through, we have adopted our own calculations.				Ventilation is provided naturally with the exception of bathrooms/showers which have localized extraction. Air exchange rates for WC/bathroom areas have been taken at 10 air changes per hour, and the specific fan power (SFP) of local exhaust systems at 0.3 w/l/s as per the requirements of Part L2A, and it assumed that these will have an integral heat exchanger. **Lighting** 60 lumens per circuit-watt, 100 lux – circulation space. 60 lumens per circuit-watt, 300 lux all other spaces. The light efficacy in the Notional Building is 60 lumens per circuit-watt. **Lighting controls** Photoelectric – typically yes Motion sensors – typically no, as this would be impractical (PIR to common areas and office area only). **Design challenges/considerations** Using BSRIA Rules of Thumb, we estimate that the total domestic hot water (DHW) requirement for this building is 1700 litres. We have modelled this on the basis of locally sited calorifiers totalling 1700 litres.

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
2.	**Building type** Residential Care Home. **Benchmark** The BER must be 10% lower than the TER. This is the extant borough policy. **Summary – pass** The BER is 10.49% less than the TER. The heating source is an LZC and this is augmented by PV which is responsible for saving 2.64 kg CO^2 / m^{2}[11]. An alternative heat source of equal efficiency would therefore emit at least this much CO_2 – meaning that all of the 10.49% is a result of LZC technologies.	27.3 The BER is 11.7% less than the TER (the TER detailed in simulation 1)	27.45 (this is the target under the Extant Policy. It is the TER less 10%)	£1,662,075.00 or £1,595.08 per functional unit (m^2)	As per Simulation 1.0 but with a 7kWp mono crystalline PV system on roof mounts facing due south-east at a 30 degree incline. The system requires 84 m^2 of flat roof space and the flat roof of the proposed property extends to about 214 m^2.
3.	**Building type** Residential Care Home.	25.8 The BER is 18.22% less than	25.93 (this is the target under the Extant	£1,669,851.00 or £1,602.54 per functional unit (m^2)	As per Simulation 1.0 but with an 11kWp mono crystalline PV system on roof mounts facing due south-east at a 30 degree incline.

[11] Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	Benchmark The BER must be 15% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy A. **Summary - pass** The BER is 15.41% less than the TER. The heating source is an LZC and this is augmented by PV which is responsible for saving 4.14 kg CO^2 / $m^{212.}$ An alternative heat source of equal efficiency would therefore emit at least this much CO_2 – meaning that all of the 15.41% is a result of LZC technologies.	the TER (the TER detailed in simulation 1)	Policy. It is the TER less 15%)		The system requires 132 m^2 of flat roof space and the flat roof of the proposed property extends to about 214 $m^{2.}$
4.	**Building type** Residential Care Home. **Benchmark** The BER must be 20% lower than the TER. This is a proposed borough policy which we refer to as Proposed Policy B.	24.3 The BER is 25.51% less than the TER (the TER detailed in	24.4 (this is the target under the Extant Policy. It is the TER less 20%)	£1,677,627.00 or £1,610.01 per functional unit (m^2)	As per Simulation 1.0 but with a 15kWp mono crystalline PV system on roof mounts facing due south-east at a 30 degree incline. The system requires 180 m^2 of flat roof space and the flat roof of the proposed property extends to about 214 $m^{2.}$

[12] Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

Simulation Building		BER kg CO_2/m^2	TER kg CO_2/m^2	Indicative costs of construction	Technical detail
	Summary – pass The BER is 20.33% less than the TER. The heating source is an LZC and this is augmented by PV which is responsible for saving 5.65 kg CO^2 / $m^{213.}$ An alternative heat source of equal efficiency would therefore emit at least this much CO_2 – meaning that all of the 20.33% is a result of LZC technologies.	simulation 1)			

[13] Electrical emissions taken at 0.519 kg CO2 per kWh (SAP 2012)

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:

4.1 ID

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

4.2 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.

4.3 Rate

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

4.4 Quantity

This is the basis of the cost multiplier.

4.5 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 £1,080.00 per m^2 has been adopted as the 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[14]. The following weighting rules have been adopted throughout the project:

Property type	HVAC system type	Unadjusted BSRIA weighting	Less allowance for lifts[15] 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
Commercial (Care Homes etc.)	Mechanical ventilation and air conditioning	0.33	0.05	0.28
Residential	Natural ventilation and no air conditioning	0.23	0.025	0.205

[14] 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.
[15] 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.

4.6 Base Cost

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

4.7 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 2017 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.

4.8 Cost £ /

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

5. SYSTEM 1, SIMULATION 1

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) Boiler(s) (SPONS M&E 2017 - upper end cost to account for multiple heat sources)	11	12.70	1,042	1.00	13,233.40	12,704.06	12.19
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2017 - median cost)	11	80.00	1,042	1.00	83,360.01	80,025.61	76.80
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
							1,564,140.00	**1,501.09**
	CAPITAL COST						**1,564,140.00**	**1,501.09**

6. SYSTEM 1, SIMULATION 2

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) (SPONS M&E 2017 - upper end cost to account for multiple heat sources)	11	12.70	1,042	1.00	13,233.40	12,704.06	12.19
5.6	Space heating and air conditioning (SHAC)(SPONS M&E 2017 - median cost)	11	80.00	1,042	1.00	83,360.01	80,025.61	76.80
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	PV panels (SPONS M&E 2017 - median cost)	11	2,025.00	9	1.00	18,225.00	17,496.00	16.79
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,601,642.38	**1,537.08**
	CAPITAL COST						**1,601,642.38**	**1,537.08**

7. SYSTEM 1, SIMULATION 3

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) (SPONS M&E 2017 - upper end cost to account for multiple heat sources)	11	12.70	1,042	1.00	13,233.40	12,704.06	12.19
5.6	Space heating and air conditioning (SHAC)(SPONS M&E 2017 - median cost)	11	80.00	1,042	1.00	83,360.01	80,025.61	76.80
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	PV panels (SPONS M&E 2017 - median cost)	11	2,025.00	14	1.00	28,350.00	27,216.00	26.12
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,611,362.38	**1,546.41**
	CAPITAL COST						**1,611,362.38**	**1,546.41**

8. SYSTEM 1, SIMULATION 4

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) (SPONS M&E 2017 - upper end cost to account for multiple heat sources)	11	12.70	1,042	1.00	13,233.40	12,704.06	12.19
5.6	Space heating and air conditioning (SHAC)(SPONS M&E 2017 - median cost)	11	80.00	1,042	1.00	83,360.01	80,025.61	76.80
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	PV panels (SPONS M&E 2017 - median cost)	11	2,025.00	18	1.00	36,450.00	34,992.00	33.58
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,619,138.38	**1,553.88**
	CAPITAL COST						**1,619,138.38**	**1,553.88**

9. SYSTEM 2, SIMULATION 1 AND 2

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) - heat pump (taken at £500 per kW of estimated load @ 70 w x GIFA (source CIBS...	1	36,500.00	1	1.00	36,500.00	35,040.00	33.63
5.6	Space heating and air conditioning (SHAC) -(SPONS M&E 2017 - upper end cost to account for radiat...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
							1,594,478.50	**1,530.21**
	CAPITAL COST						**1,594,478.50**	**1,530.21**

10. SYSTEM 2, SIMULATION 3

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) - heat pump (taken at £500 per kW of estimated load @ 70 w x GIFA (source CIBS...	1	36,500.00	1	1.00	36,500.00	35,040.00	33.63
5.6	Space heating and air conditioning (SHAC) -(SPONS M&E 2017 - upper end cost to account for arger...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	Local electricity generation systems (SPONS M&E 2017 - median cost)	11	2,025.00	4	1.00	8,100.00	7,776.00	7.46
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,622,260.88	**1,556.87**
	CAPITAL COST						**1,622,260.88**	**1,556.87**

11. SYSTEM 2, SIMULATION 4

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) - heat pump (taken at £500 per kW of estimated load @ 70 w x GIFA (source CIBS...	1	36,500.00	1	1.00	36,500.00	35,040.00	33.63
5.6	Space heating and air conditioning (SHAC) -(SPONS M&E 2017 - upper end cost to account for large...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	Local electricity generation systems (SPONS M&E 2017 - median cost)	11	2,025.00	7	1.00	14,175.00	13,608.00	13.06
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,628,092.88	**1,562.47**
	CAPITAL COST						**1,628,092.88**	**1,562.47**

12. SYSTEM 3, SIMULATION 1

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) gas fired CHP via a heat network and site wide energy centre	11	69.00	1,042	1.00	71,898.01	69,022.09	66.24
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2017 - upper cost cost to account for larger...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
							1,628,460.63	**1,562.82**
							1,628,460.63	**1,562.82**

13. SYSTEM 3, SIMULATION 2

6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) gas fired CHP via a heat network and site wide energy centre	11	69.00	1,042	1.00	71,898.01	69,022.09	66.24
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2017 - upper cost cost to account for larger...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	Local electricity generation systems	11	2,025.00	7	1.00	14,175.00	13,608.00	13.06
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,662,075.00	**1,595.08**
	CAPITAL COST						**1,662,075.00**	**1,595.08**

14. SYSTEM 3, SIMULATION 3

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) gas fired CHP via a heat network and site wide energy centre	11	69.00	1,042	1.00	71,898.01	69,022.09	66.24
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2017 - upper cost cost to account for larger...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	Local electricity generation systems	11	2,025.00	11	1.00	22,275.00	21,384.00	20.52
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,669,851.00	**1,602.54**
	CAPITAL COST						**1,669,851.00**	**1,602.54**

15. SYSTEM 3, SIMULATION 4

ID	Description	Code	Rate	Quantity	Weight	Base cost	Cost £	Cost £ /
6	**Complete buildings and building units - Care Home**							
6.1.1	Complete buildings	5						
6.1.1	Complete buildings (SPONS A&B 2017 - median cost - accommodation for the elderly)	11	1,080.00	1,042	0.82	922,795.19	885,883.38	850.18
5	Services (BES) (typically based on apartment fit out (private)	11	0.00	0	1.00	0.00	0.00	0.00
5.1	Sanitary installations (SA) (SPONS M&E 2017 - median cost)	11	100.00	1,042	1.00	104,200.01	100,032.01	96.00
5.3	Disposal installation (DI) (SPONS M&E 2017 - median cost)	11	24.50	1,042	1.00	25,529.00	24,507.84	23.52
5.4	Water installations (WI) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.5	Heat source (HS) gas fired CHP via a heat network and site wide energy centre	11	69.00	1,042	1.00	71,898.01	69,022.09	66.24
5.6	Space heating and air conditioning (SHAC) (SPONS M&E 2017 - upper cost cost to account for larger...	11	88.00	1,042	1.00	91,696.01	88,028.17	84.48
5.7	Ventilation systems (VS) (SPONS M&E 2017 - median cost)	11	54.50	1,042	1.00	56,789.00	54,517.44	52.32
5.8	Electrical installations (EI) (SPONS M&E 2017 - median cost)	11	112.50	1,042	1.00	117,225.01	112,536.01	108.00
5.8.5	Local electricity generation systems	11	2,025.00	15	1.00	30,375.00	29,160.00	27.98
5.9	Fuel installations / systems (FI) (SPONS M&E 2017 - median cost)	11	15.50	1,042	1.00	16,151.00	15,504.96	14.88
5.10.1	Lifts and enclosed hoists (SPONS M&E 2017 - 8 person lift)	1	66,000.00	1	1.00	66,000.00	63,360.00	60.81
5.11	Fire and lightning protection (FLP) (SPONS M&E 2017 - median cost)	11	29.00	1,042	1.00	30,218.00	29,009.28	27.84
5.12	Communication, security and cntrol systems (CSC) (SPONS M&E 2017 - median cost)	11	100.50	1,042	1.00	104,721.01	100,532.17	96.48
5.13	Special installations / Systems (SI) (SPONS M&E 2017 - median cost)	11	31.00	1,042	1.00	32,302.00	31,009.92	29.76
2.3.1	Roof (ROO) - additional roof reinforcement for PV only (SPONS A&B 2017 - cost models)	11	20.00	1,042	1.00	20,840.00	20,006.40	19.20
							1,677,627.00	**1,610.01**
	CAPITAL COST						**1,677,627.00**	**1,610.01**

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