Energy and Sustainability Statement

19 Between Towns Road,
Oxford, OX4 3LX

PR7296
Date: 25/01/2021

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19 Between Towns Road – Student Accommodation

Energy & Sustainability Statement

Rev / Issue	Date	Description	Revision Details	Prepared	Checked
A	January 2021	First Issue	-	Nikolaos Filianakis	Mohammed Rehman Khan

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Executive Summary

ERS Consultants Ltd has been appointed to prepare an Energy & Sustainability Statement for 19 Between Towns Road located at Oxford, OX4 3LX.

The proposal is for the development of a 5-storey student accommodation with 195 bedrooms, 12 studios and 29 common rooms.

This energy and sustainability report outlines the key measures to be incorporated in the design, in regards to sustainability, carbon emissions, renewable energy and environmental impact of the considered development in accordance with:

- Oxford Local Plan 2036 (Policy RE1) (June 2020)
- The National Planning Policy Framework (NPPF) March 2019
- The National Planning Practice Guidance (NPPG) March 2012

In line with Oxford Local Plan 2036 policy RE1, the development would need to achieve a 40% reduction in regulated CO_2 emissions against a Building Regulations (Part L 2013) compliant scheme. This reduction is to be secured through on-site renewable energy and other low carbon technologies (this would broadly be equivalent to 25% of all energy used) and/ or energy efficiency measures.

A dynamic energy simulation has been undertaken to establish the energy consumption and carbon emissions of the proposed building.

The methodology used to determine the expected operational CO_2 emissions for the development is in accordance with the Oxford Council's Plan (Policy RE1) and the CO_2 savings achieved for each step are outlined below:

Be Lean – Use Less Energy

The first step addresses reduction in energy demand, through the adoption of passive and active design measures with emphasis on a fabric first approach.

Emphasis will be put on the buildings fabric performance in order to reduce energy consumption, as less heating and cooling will be lost through the high performance fabric hence reducing the demand. A fabric first measures include levels of insulation beyond Building Regulation 2013 requirements which will help in achieving low air tightness levels.

Additional measures to reduce energy will include low energy lighting without comprising the illuminance as well as energy saving controls for space conditioning and lighting. The hot water will be provided by storage cylinders with low hot water storage losses and fueled by the mains ASHPs.

By means of energy efficiency measures alone, regulated CO_2 emissions are shown to reduce by 9.7% (22.577 tonnes per annum).

BE CLEAN – SUPPLY ENERGY EFFICIENTLY

In this building there will be no direct heating networks or CHP incorporated, therefore the Be Clean scenario will not further reduce CO_2 emissions on site.

BE GREEN – USE RENEWABLE ENERGY

The space conditioning at 19 Between Towns Road will consist of high efficiency Air-to-Water Heat Pumps and they will be providing heating throughout the site via underfloor heating. This is a low carbon technology which will be incorporated into the building design as it is an economically viable and reliable option for providing heating where specified.

Additionally, a renewable technologies feasibility study was carried out for the development identifying photovoltaics (29 kWp) as a suitable technology for the development.

The incorporation of renewable/low carbon technologies (Air-to-Water Heat Pumps and PV panels) will further reduce CO_2 emissions on site by a further 31% (72.121 tonnes per annum).

ENERGY & CARBON DEMAND SUMMARY

Table 1 Energy and Carbon Reductions

	Energy Consumption (kWh)	Energy Consumption Savings (%)	CO_2 Emissions (kg/yr)	CO_2 Emissions Savings (%)
Baseline	964,980		233,296	
Be Lean	889,974	-8%	210,719	-9.7%
Be Clean	889,974	-0%	210,719	-0%
Be Green	287,481	62%	135,598	-31%
Total Reduction				**-41%**

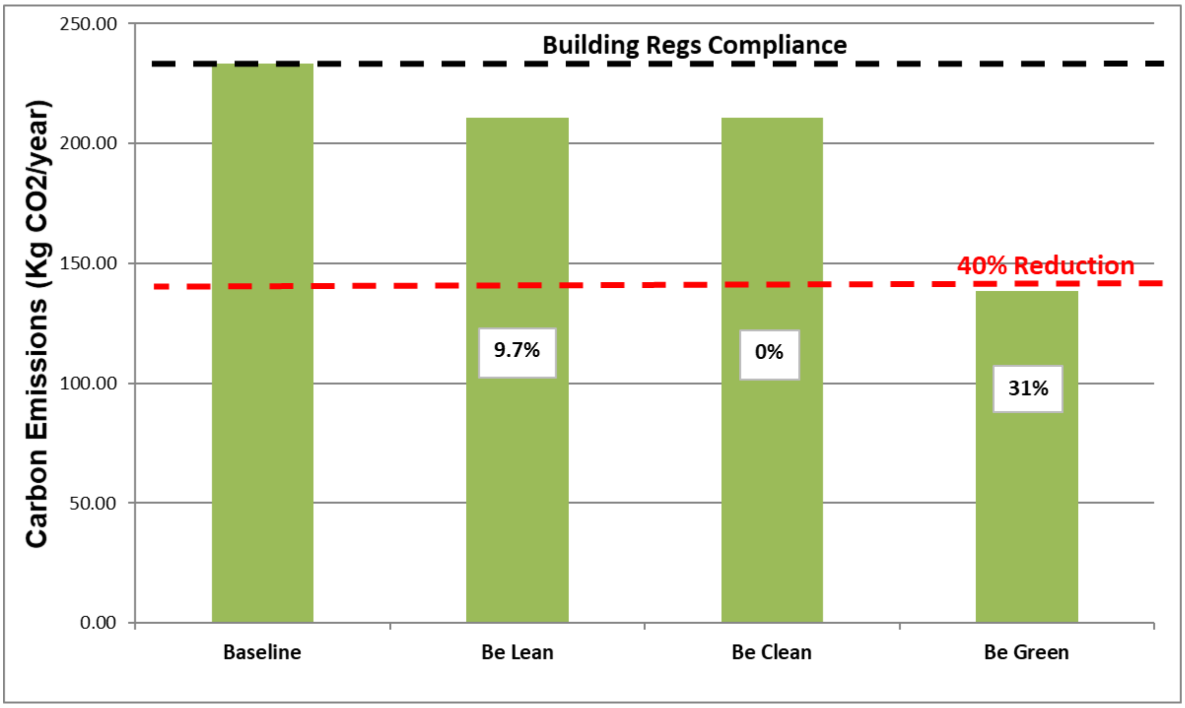

Fig 1. Carbon Emissions Reduction Summary

An SBEM calculation always refers to 'regulated' energy loads, which are those addressed by building regulations, 'unregulated' loads, for example is energy used by white goods.

Table 2. Regulated & Unregulated Energy Loads

	Regulated Energy		Unregulated Energy	
	Energy Consumption (kWh)	CO_2 Emissions (kg/yr)	Energy Consumption (kWh)	CO_2 Emissions (kg/yr)
Baseline	964,980	233,296	2,412,451	233,296
Be Lean	889,974	210,719	2,224,936	210,719
Be Clean	889,974	210,719	2,224,936	210,719
Be Green	287,481	138,598	718,702	138,598

As shown in Table 1, the provisional baseline annual energy consumption of the proposed development has been estimated to be 964,980 KWh/yr and the resulting annual carbon dioxide emissions are 233,296 CO_2Kg/yr.

The incorporation of energy saving measures, low-carbon technologies and renewable energy sources, following Oxford's Local Plan requirements (Policy RE1) would reduce the energy requirement and CO_2 emissions to 287,481 kWh/year and 138,598 kgCO_2/year respectively.

The total reduction with "Be Lean" and "Be Green" measures would result in a total of **41% Carbon Emissions Reduction** which fulfills the required 40% reduction in comparison to the Part L 2013 Building regulations baseline as shown in Figure 1, achieving Oxford's target.

Table 3. Student Accommodation Proposed Specifications

Parameters			
Fabric	U-Value (W/m2K)	Walls	0.18
		Floors	0.18
		Roof	0.18
		Windows	1.10
		Doors	1.20
Air permeability	Q (m3/m2h)		4.50
Systems	Air-to-Water Heat Pumps	COP	3.30
Controls			Local Time and Temperature Zone Control
Lighting Systems	Lighting type		LED Lighting – 100 lm/cW Display Lighting – 50 lumens
Renewables	Photovoltaics Panels		Total 29 kWp

Introduction

Site & Proposal

The site is located at 19 Between Towns Road (Cowley) at the junction with St Luke's Road, in Oxford.

The existing site comprises of a two-storey building which used to be the Cowley Conservative Club and one more two-storey building which part of it was a retail area occupied by Betfred and the rest of it was a residential property (17A-17B). The immediate surrounding areas are characterised by mostly low-rise residential properties, except for the North-East side where a 5-storey student accommodation was recently built.

The site will consist of a 5-storey new build care home 195 bedrooms, 12 studios and 29 common rooms. It will replace the existing 2-storey buildings currently on site. Lounge areas, offices, commercial area and a reception are located on the ground floor.

The approximate site location of the proposed development is shown Figure 2 highlighted in red.

Fig 2. Location of 19 Between Towns Road Student Accommodation, Oxford

Policy Context

This energy and sustainability statement will seek to respond to the energy policies of the Oxford Local Plan 2036 (Policy RE1) – June 2020.

Calculation Methodology

The sections below present the methodology followed in determining carbon emissions reduction savings for the proposed scheme.

The baseline CO_2 emissions are first established, i.e. the emissions of a scheme that is compliant with Part L 2013 of the Building Regulations.

The approved software used to model and calculate the energy performance and carbon emissions is IES VE 2019 3.1.0 using the Apache calculation engine.

The TER which is used as the baseline figure for the carbon reductions for each non-domestic element is multiplied by its floor area to establish the total emissions. Similarly, the BER is calculated in the same method to determine the energy performance and CO_2 emissions of the proposed scheme for each of the steps of the Energy Hierarchy.

BE LEAN

whereby the demand for energy is reduced through a range of passive and active energy efficiency measures.

BE CLEAN

whereby as much of the remaining energy demand is supplied as efficiently as possible using a district energy network or developing a site-wide CHP network.

BE GREEN

whereby renewable technologies are incorporated to offset part of the carbon emissions of the development. The uptake of renewable technologies is based on feasibility and viability considerations, including their compatibility with the energy system determined in the previous step.

The % improvement against the baseline emissions is compared to the relevant targets for each element and in case of a shortfall, savings through off-site measures should be achieved.

The Conclusions section summarises the energy strategy and associated carbon savings for the proposed development.

The carbon emissions factors used in all calculations in this document are those published in Part L2A of the Building Regulations.

Be Lean – Use Less Energy

The proposals incorporate a range of passive and active design measures that will reduce the energy demand for space conditioning, hot water, and lighting.

Measures will also be put in place to reduce the risk of overheating, the regulated carbon saving achieved in this step of the Energy Hierarchy is 9.7% over site wide baseline level.

Passive Design Measures

Building Materials

The key issues to be addressed in the selection of materials and equipment are:

- Use of materials and equipment from sustainable sources
- Minimisation of in-use environmental impacts
- Minimisation of embodied environmental impacts
- Use of materials and equipment with high recycled content

Enhanced U-Values

The heat loss of different building fabric elements is dependent upon their U-value. A building with low U-Values provide better levels of insulation and reduced heating demand during the cooler months.

The proposed development will incorporate high levels of insulation and high-performance glazing beyond Part L 2013 targets and notional building specifications, to reduce the demand for space conditioning (heating and/or cooling).

Table 4 demonstrate the improved performance of the proposed building fabric beyond the Building Regulations requirements.

Table 4. Fabric Specifications

Non-Domestic (U-Values in W/m^{2}k)		
Element	**Part L 2013 Building Regulation**	**Proposed**
Wall	0.35	0.18
Floor	0.25	0.18
Roof	0.25	0.18
Windows	2.20	1.10

Air Tightness Improvement

Heat loss may also occur due to air infiltration. Although this cannot be eliminated altogether, good construction detailing and the use of best practice construction techniques can minimise the amount of air infiltration.

The proposed development will aim to improve upon the Part L 2013 minimum standards for air tightness by targeting air permeability rates of 4.5 m^3/m^2.h at 50Pa.

Reducing The Need For Artificial Lighting

The development has been designed to maximise daylight in all habitable spaces as a way of improving the health and wellbeing of its occupants.

All of the habitable areas will benefit from large areas of glazing to increase the amount of daylight within the internal spaces where possible. This is expected to reduce the need for artificial lighting whilst delivering pleasant, healthy spaces for occupants.

Waste

A site waste management plan that provides details of waste minimisation, sorting, reuse and recycling procedures is required for all levels in the planning guidance. Sustainable waste management should follow the hierarchy described in *BS 5906: Waste management in buildings. Code of practice*. This outlines the following principles in decreasing order of desirability:

- Reduce waste
- Re-use materials and equipment (and facilitate future reuse)
- Recycle waste (and facilitate recycling)
- Compost biodegradable waste
- Recover energy from waste (and facilitate energy recovery from waste)
- Disposal

Active Design Measures

High Efficacy & Low Energy Lighting

Where artificial lighting will be needed it will low energy lighting without compensating for illuminance, and will accommodate LED only.

Heating

Air-to-Water heat pumps with high energy efficiency ratios may be used for heating throughout the building, which will have a positive impact on the total carbon emissions.

Water

Reducing the daily water consumption to 125 litre/person/day is one of the requirements of the Building Regulations, and 105 litre/ person for the CSH. This can be achieved by applying various water efficiency and reclamation / recycling measures.

Water Efficiency Measures

The following measures can be used to reduce the quantity of water demand to satisfy end users:

- Dual or low flush WCs
- Spray or aerating taps
- Water efficient appliances
- Low flow showers

- Smaller size bath

WATER RECLAMATION / RECYCLING MEASURES

- Rainwater collection

Water collected from roofs or hard surfaces such as car parks can be harvested for storage and use for non-potable uses such as watering gardens and WC flushing.

CONTROLS

Advanced lighting and space conditioning controls will be incorporated, specifically:

• For areas of infrequent use, occupant sensors will be fitted for lighting, whereas day lit areas will incorporate daylight sensors where appropriate;

• Heating and cooling systems controls will comprise time and temperature controls locally for each space.

MINIMISING OVERHEATING

OVERHEATING RISK ASSESSMENT

The potential risk of overheating was assessed via the Part L Building Regulation compliance tool Apache. All non-domestic areas have been found to pass Criterion 3 'Limiting Solar Gains' of Part L. The BRUKL output(s) for all non-domestic areas can be found in Appendix A – BRUKL Results.

BE LEAN CO_2 EMISSIONS & SAVINGS

Table 5. Breakdown of energy consumption for the baseline and the proposed schemes after 'Lean' measures are implemented.

	Heating	Cooling	Auxiliary	Lighting	Hot Water	Equipment	Total Energy Consumption
Baseline (kWh/m2)	54.46	0	4.3	9.44	85.67	23.29	153.87
Be Lean (kWh/m2)	36.96	0	5.07	4.7	95.18	23.39	141.91

By means of energy efficiency measures alone, regulated CO_2 emissions are shown to reduce by **9.7% (22,577 tonnes per annum)**.

BE CLEAN – SUPPLY ENERGY EFFICIENTLY

In this building there will be no direct heating networks or CHP incorporated, therefore the Be Clean scenario will not further reduce CO_2 emissions on site.

Be Green – Use Renewable Energy

A low-carbon/renewable technologies feasibility study was carried out for the development identifying photovoltaics and Air-to-Water heat pumps as suitable technologies for the development. The regulated carbon saving achieved in this step of the Energy Hierarchy is 31% over "Be Green" Energy Measures.

Renewable Technologies Feasibility Study

Methods of generating on-site renewable energy (Green) were assessed, once Lean and Clean measures were considered.

This section provides an overview of the technologies considered, a brief assessment of their feasibility, a proposed mixture of suitable technologies.

The proposed development will benefit from an energy efficient building fabric which will reduce the energy consumption of the proposed development in the first instance.

A range of renewable technologies were subsequently considered including:

- Biomass;
- Ground/water source heat pumps;
- Wind energy;
- Photovoltaic panels, and,
- Solar thermal panels.

In determining the appropriate renewable technology for the site, the following factors were considered:

- CO_2 savings achieved;
- Site constraints;
- Financial benefit
- Any potential visual impacts

Demand Profiles

The balance of technologies chosen will depend on the development's energy demand patterns.

Keeping in mind that the space heating energy demand changes according to the season. While hot water energy demand will provide a significant base load throughout the year.

Electrical demand is likely to be moderate throughout the year. Lighting loads will be highest during the evening but will continue at reduced levels throughout the night and during the day.

FEASIBILITY

At this early stage in the design, it is possible only to outline the likely feasibility of specific technologies. Further descriptions of the LZC technologies below are included in Appendix B.

Renewable Technology	Comments	Lifetime (Years)	Maintenance	Impact on External Appearance	Site Feasibility	Adopted for Site
BIOMASS 	Burning of wood pellets releases high NOx emissions and there are limitations for their storage and delivery within an urban location.	20	High	High	3	☐
PV 	PV panels would generate significant carbon savings, whilst having minimal impact on the appearance of the building and no adverse impact on the amenity of neighbouring buildings.	25	Low	Med	9	☑
Solar Thermal 	Solar thermal array mounted on the roof would conflict with the savings made from the CHP unit	25	Low	Med	4	☐
GSHP 	The installation of ground loops requires significant space, additional time at the beginning of the construction process and very high capital costs.	20	Med	Low	5	☐
ASHP 	The installation of ASHPs requires space, additional time at the beginning of the construction process and very high capital costs.	25	Med	Med	10	☑
Wind 	Due to insufficient open area for installation of a stand-alone wind turbine and planning issues this option has not considered in this development.	25	Med	High	3	☐

Detailed Assessment Of Photovoltaic Panels

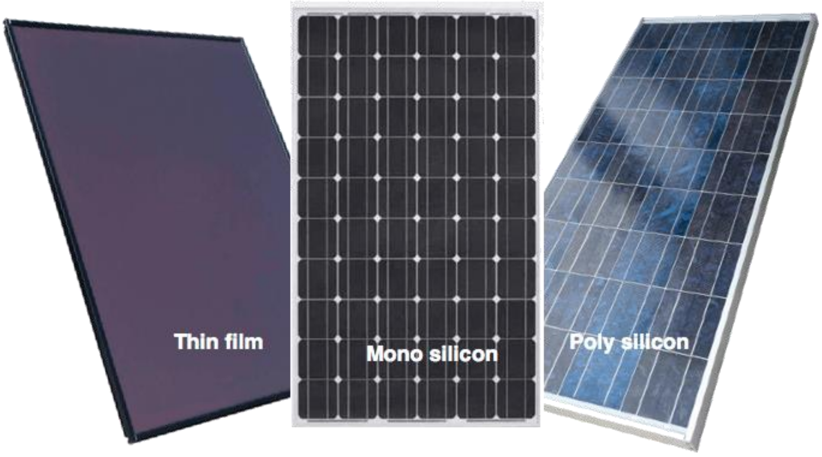

Fig 3. Photovoltaic Panels

Four types of solar cells are available on the market at present and these are mono-crystalline, polycrystalline, thin film and hybrid panels as seen in figure 4. Although mono-crystalline and hybrid cells are the most expensive, they are also the most efficient with an efficiency rate of 12-20%. Poly-crystalline cells are cheaper but they are less efficient (9-15%). Thin film cells are only 5-8% efficient but can be produced as thin and flexible sheets.

1 kWp (Kilo Watt Peak) of PV panels can produce approximately 850 kWh/ year of electricity in this region, reducing the grid energy requirement and CO_2 emissions.

Photovoltaics are considered a suitable technology for this development as the development provides an extent of roof space for the installation of PV panels. In addition to this the PV arrays are relatively easy to install when compared to other renewable systems and provide a significant amount of CO_2 savings.

The PV shall comprise 15kWp (96m^2) of 20° roof mounted arrays and 14kWp (90m^2) of vertical photovoltaics on the South East elevation of the building. Table 6 summarises the technical data for the proposed PV arrays. In total, the PV installation would produce regulated CO_2 savings of 31% for the development.

Table 6. Proposed Photovoltaics Specifications

Photovoltaic Panels	
Module Efficiency	15%
Panel Orientation	South/South-East
Tilt	20°/90°
Array Area	96 m^2/90 m^2
Total power to be installed	15 kWp/14 kWp
Energy Generation	20,131 KWh/yr

ASHPs

Air Source Heat Pumps (ASHPs) system is a low carbon technology rather than a renewable energy technology as ASHPs do not generate any electrical power such as a solar PV or Wind turbine would. The system consumes electrical energy in pumping fluids through the building and the ground and in compressing refrigerant in the heat pumps vapour compression cycle.

ASHPs use the ambient air as the medium from which heat is extracted. In general, ASHPs have a lower SPF than ground source heat pumps (GSHPs) as they are affected by significant variations in the temperature of the ambient air. At peak heating conditions, the ambient air is at its coldest. This leads to more energy input being required from the compressor, reducing the CoP and increasing carbon emissions for the ASHPs system.

As with everything involving moving parts will make some sound, the fans associated with external condensing units may cause noise pollution. However, at this stage it is not possible to know what the noise level associated as no heat pumps have been selected. This issue should be investigated at the detailed design stage

BE GREEN CO_2 EMISSIONS & SAVINGS

The incorporation of low-carbon and renewable technologies will further reduce CO_2 emissions by a further **31% (72.121 tonnes per annum).**

CONCLUSION

Following the implementation of the three-step Energy Hierarchy, the regulated CO_2 savings for the site are estimated at 41% for the proposed development, against a Part L 2013 compliant scheme.

Overall, the proposed development has been designed to meet the energy policy RE1 set out by Oxford's Local Plan 2036, which demonstrates the client and the design team's commitment to enhancing sustainability of the scheme.

Table 7 summarises the implementation of the Energy Hierarchy for the proposed scheme and detail the CO_2 emissions and savings against the baseline scheme for each step of the hierarchy; as well as the savings achieved through carbon offset.

Table 7. CO_2 emissions after each step of the Energy Hierarchy for the proposed development

	CO_2 Emissions (tonnes/yr)	**CO_2 Emissions Savings per Step (%)**
Baseline	**233.296**	
Be Lean	**210.719**	-9.7%
Be Clean	**210.719**	-0%
Be Green	**138.598**	-31%
Total Reduction		**-41%**

Appendix A – SBEM Results

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Student Accommodation - Be Green

As designed

Date: Tue Jan 26 11:24:12 2021

Administrative information

Building Details

Address: 19 Between Towns Rd, Oxford, OX4 3LX

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Iraj Maghounaki

Telephone number: 01865 378885

Address: 27-31 High Street, Kidlington, OX5 2DH

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	30.9
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	30.9
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	22.1
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.18	0.18	GF00000C:Surf[1]
Floor	0.25	0.18	0.18	GF00000C:Surf[0]
Roof	0.25	0.18	0.18	GF00000A:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.1	1.1	GF00000C:Surf[2]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
m³/(h.m²) at 50 Pa	10	4.5

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Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Air-to-Water Heat Pumps - Underfloor Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.3	-	0	0	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.					

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
GF_Bathroom C4	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C5	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C6	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C7	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C8	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C9	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C10	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C1	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C2	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom C3	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom Studio 2	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_DDA WC	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom Studio 1	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A7	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A1	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A2	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A3	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A4	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
GF_Bathroom A5	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom A6	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B3	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B2	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B1	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B10	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B9	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B8	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B7	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B6	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B5	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Bathroom B4	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Communal WCs	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K7	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom H3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom I1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom E3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom E2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom E1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom J6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom E6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom E5	-	-	0.5	-	-	-	-	-	-	-	N/A

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Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1F_Bathroom E4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom F4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom G4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D1	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D2	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D3	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D4	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D5	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D6	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D7	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom D8	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Bathroom K8	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S7	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom P3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom Q1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom M3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom M2	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
2F_Bathroom M1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom R6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom M6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom M5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom M4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom N4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom O4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L1	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L2	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L3	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L4	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L5	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L6	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L7	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom L8	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Bathroom S8	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y7	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y2	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom W6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom W5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom W4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom W3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom W2	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
3F_Bathroom W1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U2	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X2	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom X6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom U4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V2	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom V4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T1	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T2	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T3	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T4	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T5	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T6	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T7	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom T8	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Bathroom Y8	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom BB5	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom AA4	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom AA5	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom AA3	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z4	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z5	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z6	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom BB7	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom AA2	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 2	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 3	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 4			0.5								N/A
4F_Bathroom Studio Room 5	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 6	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom BB3			0.5								N/A

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Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
4F_Bathroom BB2	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom BB1	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z1	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z2	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Z3	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 7	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC1	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC2	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC3	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC4	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC5	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC6	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC7	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom CC8	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom Studio Room 1	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Bathroom BB6	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Common Room BB - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Common Room CC - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Common Room Z - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
4F_Common Room AA - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room W - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room X - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room Y - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room V - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room T - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
3F_Common Room U - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room P - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room Q - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room S - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room R - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room M - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room O - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room N - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
2F_Common Room L - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room G - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room F - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room D - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room E - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room J - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room H - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room I - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
1F_Common Room K - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Common Room C - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
GF_Common Room A - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Common Room B - Kitchen Area	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Kitchen Area Studio1	-	-	0.5	-	-	-	-	-	-	-	N/A
GF_Kitchen Area Studio 2	-	-	0.5	-	-	-	-	-	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
GF_Bedroom C4	-	100	-	41
GF_Bathroom C4	-	100	-	13
GF_Bathroom C5	-	100	-	14
GF_Bedroom C5	-	100	-	42
GF_Bedroom C6	-	100	-	42
GF_Bathroom C6	-	100	-	15
GF_Bedroom C7	-	100	-	42
GF_Bathroom C7	-	100	-	14
GF_Bedroom C8	-	100	-	42
GF_Bathroom C8	-	100	-	15
GF_Bedroom C9	-	100	-	42
GF_Bathroom C9	-	100	-	15
GF_Bathroom C10	-	100	-	14
GF_Bedroom C10	-	100	-	42
GF_Bedroom C1	-	100	-	41
GF_Bathroom C1	-	100	-	14
GF_Bedroom C2	-	100	-	41
GF_Bathroom C2	-	100	-	14
GF_Bedroom C3	-	100	-	40
GF_Bathroom C3	-	100	-	13
GF_Bedroom Studio 2	-	100	-	34
GF_Bathroom Studio 2	-	100	-	15
GF_Exhibition/Function Area	-	100	50	870
GF_Cupd	100	-	-	9
GF_DDA WC	-	100	-	37
GF_Bedroom Studio 1	-	100	-	42
GF_Bathroom Studio 1	-	100	-	14
GF_Bedroom A7	-	100	-	42
GF_Bathroom A7	-	100	-	15
GF_Bedroom A1	-	100	-	42
GF_Bathroom A1	-	100	-	14
GF_Bathroom A2	-	100	-	15
GF_Bedroom A2	-	100	-	42
GF_Bedroom A3	-	100	-	51
GF_Bathroom A3	-	100	-	14

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General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
GF_Bathroom A4	-	100	-	15
GF_Bedroom A4	-	100	-	43
GF_Bedroom A5	-	100	-	43
GF_Bathroom A5	-	100	-	14
GF_Bedroom A6	-	100	-	51
GF_Bathroom A6	-	100	-	15
GF_Laundry Room	-	100	-	88
GF_East Circulation	-	100	-	105
GF_Bedroom B3	-	100	-	40
GF_Bathroom B3	-	100	-	13
GF_Bedroom B2	-	100	-	41
GF_Bathroom B2	-	100	-	14
GF_Bedroom B1	-	100	-	41
GF_Bathroom B1	-	100	-	15
GF_Bedroom B10	-	100	-	42
GF_Bathroom B10	-	100	-	14
GF_Bathroom B9	-	100	-	15
GF_Bedroom B9	-	100	-	42
GF_Bathroom B8	-	100	-	15
GF_Bedroom B8	-	100	-	42
GF_Bedroom B7	-	100	-	42
GF_Bathroom B7	-	100	-	14
GF_Bedroom B6	-	100	-	42
GF_Bathroom B6	-	100	-	14
GF_Bedroom B5	-	100	-	42
GF_Bathroom B5	-	100	-	15
GF_Bathroom B4	-	100	-	13
GF_Bedroom B4	-	100	-	42
GF_East Circulation	-	100	-	118
GF_West Circulation	-	100	-	79
GF_Cupd	100	-	-	10
GF_Reception	-	100	50	58
GF_Management Office	100	-	-	94
GF_Office	100	-	-	82
GF_Post Office	100	-	-	114
GF_Central Hub	-	100	-	1074
GF_Communal WCs	-	100	-	57
GF_South Circulation	-	100	-	118
1F_Bedroom K7	-	100	-	44
1F_Bathroom K7	-	100	-	14
1F_Bedroom K6	-	100	-	37
1F_Bathroom K6	-	100	-	14
1F_Bathroom K5	-	100	-	14

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General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
1F_Bedroom K5	-	100	-	37
1F_Bedroom K4	-	100	-	44
1F_Bathroom K4	-	100	-	14
1F_Bedroom K3	-	100	-	36
1F_Bathroom K3	-	100	-	14
1F_Bathroom K2	-	100	-	14
1F_Bedroom K2	-	100	-	36
1F_Bedroom K1	-	100	-	36
1F_Bathroom K1	-	100	-	14
1F_Bedroom I6	-	100	-	36
1F_Bathroom I6	-	100	-	14
1F_Bathroom I5	-	100	-	14
1F_Bedroom I5	-	100	-	36
1F_Bedroom I4	-	100	-	36
1F_Bathroom I4	-	100	-	14
1F_Bedroom H6	-	100	-	36
1F_Bathroom H6	-	100	-	14
1F_Bathroom H5	-	100	-	14
1F_Bedroom H5	-	100	-	36
1F_Bedroom H4	-	100	-	35
1F_Bathroom H4	-	100	-	13
1F_Bathroom H1	-	100	-	14
1F_Bedroom H1	-	100	-	35
1F_Bedroom H2	-	100	-	35
1F_Bathroom H2	-	100	-	14
1F_Bathroom H3	-	100	-	13
1F_Bedroom H3	-	100	-	34
1F_Bathroom I3	-	100	-	14
1F_Bedroom I3	-	100	-	35
1F_Bedroom I2	-	100	-	35
1F_Bathroom I2	-	100	-	14
1F_Bathroom I1	-	100	-	14
1F_Bedroom I1	-	100	-	35
1F_Bedroom E3	-	100	-	35
1F_Bathroom E3	-	100	-	14
1F_Bathroom E2	-	100	-	14
1F_Bedroom E2	-	100	-	35
1F_Bedroom E1	-	100	-	35
1F_Bathroom E1	-	100	-	14
1F_Bathroom J1	-	100	-	14
1F_Bedroom J1	-	100	-	35
1F_Bedroom J2	-	100	-	35
1F_Bathroom J2	-	100	-	14

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General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
1F_Bathroom J3	-	100	-	14
1F_Bedroom J3	-	100	-	35
1F_Bathroom J4	-	100	-	18
1F_Bedroom J4	-	100	-	37
1F_Bathroom J5	-	100	-	14
1F_Bedroom J5	-	100	-	35
1F_Bedroom J6	-	100	-	35
1F_Bathroom J6	-	100	-	14
1F_Bathroom E6	-	100	-	14
1F_Bedroom E6	-	100	-	35
1F_Bedroom E5	-	100	-	35
1F_Bathroom E5	-	100	-	14
1F_Bedroom E4	-	100	-	37
1F_Bathroom E4	-	100	-	18
1F_Bedroom F1	-	100	-	35
1F_Bathroom F1	-	100	-	14
1F_Bathroom F2	-	100	-	14
1F_Bedroom F2	-	100	-	35
1F_Bedroom F3	-	100	-	35
1F_Bathroom F3	-	100	-	14
1F_Bedroom G1	-	100	-	35
1F_Bathroom G1	-	100	-	14
1F_Bathroom G2	-	100	-	14
1F_Bedroom G2	-	100	-	35
1F_Bedroom G3	-	100	-	34
1F_Bathroom G3	-	100	-	13
1F_Bathroom F6	-	100	-	14
1F_Bedroom F6	-	100	-	36
1F_Bedroom F5	-	100	-	36
1F_Bathroom F5	-	100	-	14
1F_Bathroom F4	-	100	-	14
1F_Bedroom F4	-	100	-	36
1F_Bathroom G6	-	100	-	14
1F_Bedroom G6	-	100	-	36
1F_Bedroom G5	-	100	-	36
1F_Bathroom G5	-	100	-	14
1F_Bathroom G4	-	100	-	13
1F_Bedroom G4	-	100	-	35
1F_Bathroom D1	-	100	-	14
1F_Bedroom D1	-	100	-	36
1F_Bedroom D2	-	100	-	36
1F_Bathroom D2	-	100	-	14
1F_Bathroom D3	-	100	-	14

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
1F_Bedroom D3	-	100	-	36
1F_Bedroom D4	-	100	-	43
1F_Bathroom D4	-	100	-	14
1F_Bathroom D5	-	100	-	14
1F_Bedroom D5	-	100	-	37
1F_Bedroom D6	-	100	-	37
1F_Bathroom D6	-	100	-	14
1F_Bathroom D7	-	100	-	14
1F_Bedroom D7	-	100	-	43
1F_Bedroom D8	-	100	-	36
1F_Bathroom D8	-	100	-	14
1F_Bathroom K8	-	100	-	14
1F_Bedroom K8	-	100	-	36
1F_Circulation	-	100	-	570
2F_Bedroom S7	-	100	-	44
2F_Bathroom S7	-	100	-	14
2F_Bedroom S6	-	100	-	37
2F_Bathroom S6	-	100	-	14
2F_Bathroom S5	-	100	-	14
2F_Bedroom S5	-	100	-	37
2F_Bedroom S4	-	100	-	44
2F_Bathroom S4	-	100	-	14
2F_Bedroom S3	-	100	-	36
2F_Bathroom S3	-	100	-	14
2F_Bathroom S2	-	100	-	14
2F_Bedroom S2	-	100	-	36
2F_Bedroom S1	-	100	-	36
2F_Bathroom S1	-	100	-	14
2F_Bedroom Q6	-	100	-	36
2F_Bathroom Q6	-	100	-	14
2F_Bathroom Q5	-	100	-	14
2F_Bedroom Q5	-	100	-	36
2F_Bedroom Q4	-	100	-	36
2F_Bathroom Q4	-	100	-	14
2F_Bedroom P6	-	100	-	36
2F_Bathroom P6	-	100	-	14
2F_Bathroom P5	-	100	-	14
2F_Bedroom P5	-	100	-	36
2F_Bedroom P4	-	100	-	35
2F_Bathroom P4	-	100	-	13
2F_Bathroom P1	-	100	-	14
2F_Bedroom P1	-	100	-	35
2F_Bedroom P2	-	100	-	35

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
2F_Bathroom P2	-	100	-	14
2F_Bathroom P3	-	100	-	13
2F_Bedroom P3	-	100	-	34
2F_Bathroom Q3	-	100	-	14
2F_Bedroom Q3	-	100	-	35
2F_Bedroom Q2	-	100	-	35
2F_Bathroom Q2	-	100	-	14
2F_Bathroom Q1	-	100	-	14
2F_Bedroom Q1	-	100	-	35
2F_Bedroom M3	-	100	-	35
2F_Bathroom M3	-	100	-	14
2F_Bathroom M2	-	100	-	14
2F_Bedroom M2	-	100	-	35
2F_Bedroom M1	-	100	-	35
2F_Bathroom M1	-	100	-	14
2F_Bathroom R1	-	100	-	14
2F_Bedroom R1	-	100	-	35
2F_Bedroom R2	-	100	-	35
2F_Bathroom R2	-	100	-	14
2F_Bathroom R3	-	100	-	14
2F_Bedroom R3	-	100	-	35
2F_Bathroom R4	-	100	-	18
2F_Bedroom R4	-	100	-	37
2F_Bathroom R5	-	100	-	14
2F_Bedroom R5	-	100	-	35
2F_Bedroom R6	-	100	-	35
2F_Bathroom R6	-	100	-	14
2F_Bathroom M6	-	100	-	14
2F_Bedroom M6	-	100	-	35
2F_Bedroom M5	-	100	-	35
2F_Bathroom M5	-	100	-	14
2F_Bedroom M4	-	100	-	37
2F_Bathroom M4	-	100	-	18
2F_Bedroom N1	-	100	-	35
2F_Bathroom N1	-	100	-	14
2F_Bathroom N2	-	100	-	14
2F_Bedroom N2	-	100	-	35
2F_Bedroom N3	-	100	-	35
2F_Bathroom N3	-	100	-	14
2F_Bedroom O1	-	100	-	35
2F_Bathroom O1	-	100	-	14
2F_Bathroom O2	-	100	-	14
2F_Bedroom O2	-	100	-	35

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General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
2F_Bedroom O3	-	100	-	34
2F_Bathroom O3	-	100	-	13
2F_Bathroom N6	-	100	-	14
2F_Bedroom N6	-	100	-	36
2F_Bedroom N5	-	100	-	36
2F_Bathroom N5	-	100	-	14
2F_Bathroom N4	-	100	-	14
2F_Bedroom N4	-	100	-	36
2F_Bathroom O6	-	100	-	14
2F_Bedroom O6	-	100	-	36
2F_Bedroom O5	-	100	-	36
2F_Bathroom O5	-	100	-	14
2F_Bathroom O4	-	100	-	13
2F_Bedroom O4	-	100	-	35
2F_Bathroom L1	-	100	-	14
2F_Bedroom L1	-	100	-	36
2F_Bedroom L2	-	100	-	36
2F_Bathroom L2	-	100	-	14
2F_Bathroom L3	-	100	-	14
2F_Bedroom L3	-	100	-	36
2F_Bedroom L4	-	100	-	43
2F_Bathroom L4	-	100	-	14
2F_Bathroom L5	-	100	-	14
2F_Bedroom L5	-	100	-	37
2F_Bedroom L6	-	100	-	37
2F_Bathroom L6	-	100	-	14
2F_Bathroom L7	-	100	-	14
2F_Bedroom L7	-	100	-	43
2F_Bedroom L8	-	100	-	36
2F_Bathroom L8	-	100	-	14
2F_Bathroom S8	-	100	-	14
2F_Bedroom S8	-	100	-	36
2F_Circulation	-	100	-	570
3F_Bedroom Y7	-	100	-	44
3F_Bathroom Y7	-	100	-	14
3F_Bedroom Y6	-	100	-	37
3F_Bathroom Y6	-	100	-	14
3F_Bathroom Y5	-	100	-	14
3F_Bedroom Y5	-	100	-	37
3F_Bedroom Y4	-	100	-	44
3F_Bathroom Y4	-	100	-	14
3F_Bedroom Y3	-	100	-	36
3F_Bathroom Y3	-	100	-	14

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
3F_Bathroom Y2	-	100	-	14
3F_Bedroom Y2	-	100	-	36
3F_Bedroom Y1	-	100	-	36
3F_Bathroom Y1	-	100	-	14
3F_Bedroom W6	-	100	-	36
3F_Bathroom W6	-	100	-	14
3F_Bathroom W5	-	100	-	14
3F_Bedroom W5	-	100	-	36
3F_Bedroom W4	-	100	-	36
3F_Bathroom W4	-	100	-	14
3F_Bathroom W3	-	100	-	14
3F_Bedroom W3	-	100	-	35
3F_Bedroom W2	-	100	-	35
3F_Bathroom W2	-	100	-	14
3F_Bathroom W1	-	100	-	14
3F_Bedroom W1	-	100	-	35
3F_Bedroom U3	-	100	-	35
3F_Bathroom U3	-	100	-	14
3F_Bathroom U2	-	100	-	14
3F_Bedroom U2	-	100	-	35
3F_Bedroom U1	-	100	-	35
3F_Bathroom U1	-	100	-	14
3F_Bathroom X1	-	100	-	14
3F_Bedroom X1	-	100	-	35
3F_Bedroom X2	-	100	-	35
3F_Bathroom X2	-	100	-	14
3F_Bathroom X3	-	100	-	14
3F_Bedroom X3	-	100	-	35
3F_Bathroom X4	-	100	-	18
3F_Bedroom X4	-	100	-	37
3F_Bathroom X5	-	100	-	14
3F_Bedroom X5	-	100	-	35
3F_Bedroom X6	-	100	-	35
3F_Bathroom X6	-	100	-	14
3F_Bathroom U6	-	100	-	14
3F_Bedroom U6	-	100	-	35
3F_Bedroom U5	-	100	-	35
3F_Bathroom U5	-	100	-	14
3F_Bedroom U4	-	100	-	37
3F_Bathroom U4	-	100	-	18
3F_Bedroom V1	-	100	-	35
3F_Bathroom V1	-	100	-	14
3F_Bathroom V2	-	100	-	14

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
3F_Bedroom V2	-	100	-	35
3F_Bedroom V3	-	100	-	35
3F_Bathroom V3	-	100	-	14
3F_Bathroom V6	-	100	-	14
3F_Bedroom V6	-	100	-	36
3F_Bedroom V5	-	100	-	36
3F_Bathroom V5	-	100	-	14
3F_Bathroom V4	-	100	-	14
3F_Bedroom V4	-	100	-	36
3F_Bathroom T1	-	100	-	14
3F_Bedroom T1	-	100	-	36
3F_Bedroom T2	-	100	-	36
3F_Bathroom T2	-	100	-	14
3F_Bathroom T3	-	100	-	14
3F_Bedroom T3	-	100	-	36
3F_Bedroom T4	-	100	-	43
3F_Bathroom T4	-	100	-	14
3F_Bathroom T5	-	100	-	14
3F_Bedroom T5	-	100	-	37
3F_Bedroom T6	-	100	-	37
3F_Bathroom T6	-	100	-	14
3F_Bathroom T7	-	100	-	14
3F_Bedroom T7	-	100	-	43
3F_Bedroom T8	-	100	-	36
3F_Bathroom T8	-	100	-	14
3F_Bathroom Y8	-	100	-	14
3F_Bedroom Y8	-	100	-	36
3F_Studio Room 4	-	100	-	55
3F_Studio Room 3	-	100	-	54
3F_Circulation	-	100	-	515
4F_Plant Room 10sqm	100	-	-	44
4F_Bathroom BB5	-	100	-	17
4F_Bedroom BB5	-	100	-	35
4F_Bathroom AA4	-	100	-	12
4F_Bedroom AA4	-	100	-	33
4F_Bedroom AA5	-	100	-	33
4F_Bathroom AA5	-	100	-	12
4F_Bedroom AA3	-	100	-	33
4F_Bathroom AA3	-	100	-	12
4F_Bedroom Z4	-	100	-	35
4F_Bathroom Z4	-	100	-	17
4F_Bedroom Z5	-	100	-	33
4F_Bathroom Z5	-	100	-	12

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
4F_Bathroom Z6	-	100	-	12
4F_Bedroom Z6	-	100	-	33
4F_Bedroom BB7	-	100	-	33
4F_Bathroom BB7	-	100	-	13
4F_Bedroom AA2	-	100	-	35
4F_Bathroom AA2	-	100	-	12
4F_Bathroom Studio Room 2	-	100	-	13
4F_Studio Room 2	-	100	-	44
4F_Bathroom Studio Room 3	-	100	-	13
4F_Studio Room 3	-	100	-	45
4F_Bathroom Studio Room 4	-	100	-	14
4F_Studio Room 4	-	100	-	38
4F_Studio Room 5	-	100	-	40
4F_Bathroom Studio Room 5	-	100	-	13
4F_Studio Room 6	-	100	-	37
4F_Bathroom Studio Room 6	-	100	-	13
4F_Bathroom BB3	-	100	-	12
4F_Bedroom BB3	-	100	-	34
4F_Bedroom BB2	-	100	-	33
4F_Bathroom BB2	-	100	-	12
4F_Bathroom BB1	-	100	-	13
4F_Bedroom BB1	-	100	-	33
4F_Bedroom Z1	-	100	-	33
4F_Bathroom Z1	-	100	-	13
4F_Bathroom Z2	-	100	-	13
4F_Bedroom Z2	-	100	-	33
4F_Bedroom Z3	-	100	-	33
4F_Bathroom Z3	-	100	-	13
4F_Plant Room 15sqm	100	-	-	64
4F_Studio Room 7	-	100	-	40
4F_Bathroom Studio Room 7	-	100	-	13
4F_Bedroom CC1	-	100	-	34
4F_Bathroom CC1	-	100	-	12
4F_Bathroom CC2	-	100	-	13
4F_Bedroom CC2	-	100	-	34
4F_Bedroom CC3	-	100	-	34
4F_Bathroom CC3	-	100	-	13
4F_Bedroom CC4	-	100	-	41
4F_Bathroom CC4	-	100	-	12
4F_Bedroom CC5	-	100	-	36
4F_Bathroom CC5	-	100	-	12
4F_Bathroom CC6	-	100	-	13
4F_Bedroom CC6	-	100	-	36

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
4F_Bedroom CC7	-	100	-	43
4F_Bathroom CC7	-	100	-	12
4F_Bathroom CC8	-	100	-	13
4F_Bedroom CC8	-	100	-	35
4F_Bathroom Studio Room 1		100		12
4F_Studio Room 1	-	100	-	48
4F_Bathroom BB6	-	100	-	12
4F_Bedroom BB6	-	100	-	33
4F_Circulation	-	100	-	416
4F_Common Room BB - Eating Area	-	100	-	53
4F_Common Room BB - Kitchen Area	-	100	-	81
4F_Common Room CC - Eating Area	-	100	-	59
4F_Common Room CC - Kitchen Area	-	100	-	78
4F_Common Room Z - Kitchen Area	-	100	-	80
4F_Common Room Z - Eating Area	-	100	-	53
4F_Common Room AA - Kitchen Area	-	100	-	59
4F_Common Room AA - Eating Area	-	100	-	39
3F_Common Room W - Kitchen Area	-	100	-	78
3F_Common Room W - Eating Area	-	100	-	44
3F_Common Room X - Eating Area	-	100	-	54
3F_Common Room X - Kitchen Area	-	100	-	82
3F_Common Room Y - Kitchen Area	-	100	-	79
3F_Common Room Y - Eating Area	-	100	-	60
3F_Common Room V - Eating Area	-	100	-	43
3F_Common Room V - Kitchen Area	-	100	-	82
3F_Common Room T - Kitchen Area	-	100	-	89
3F_Common Room T - Eating Area	-	100	-	57
3F_Common Room U - Kitchen Area	-	100	-	82
3F_Common Room U - Eating Area	-	100	-	54
2F_Common Room P - Eating Area	-	100	-	47
2F_Common Room P - Kitchen Area	-	100	-	66
2F_Common Room Q - Eating Area	-	100	-	44
2F_Common Room Q - Kitchen Area	-	100	-	78
2F_Common Room S - Kitchen Area	-	100	-	79
2F_Common Room S - Eating Area	-	100	-	60
2F_Common Room R - Eating Area	-	100	-	54
2F_Common Room R - Kitchen Area	-	100	-	82
2F_Common Room M - Eating Area	-	100	-	54
2F_Common Room M - Kitchen Area	-	100	-	82
2F_Common Room O - Kitchen Area	-	100	-	66
2F_Common Room O - Eating Area	-	100	-	46
2F_Common Room N - Eating Area	-	100	-	43
2F_Common Room N - Kitchen Area	-	100	-	82

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
2F_Common Room L - Kitchen Area	-	100	-	89
2F_Common Room L - Eating Area	-	100	-	57
1F_Common Room G - Kitchen Area	-	100	-	66
1F_Common Room G - Eating Area	-	100	-	46
1F_Common Room F - Eating Area	-	100	-	43
1F_Common Room F - Kitchen Area	-	100	-	82
1F_Common Room D - Kitchen Area	-	100	-	89
1F_Common Room D - Eating Area	-	100	-	57
1F_Common Room E - Kitchen Area	-	100	-	82
1F_Common Room E - Eating Area	-	100	-	54
1F_Common Room J - Kitchen Area	-	100	-	82
1F_Common Room J - Eating Area	-	100	-	54
1F_Common Room H - Eating Area	-	100	-	47
1F_Common Room H - Kitchen Area	-	100	-	66
1F_Common Room I - Eating Area	-	100	-	44
1F_Common Room I - Kitchen Area	-	100	-	78
1F_Common Room K - Kitchen Area	-	100	-	79
1F_Common Room K - Eating Area	-	100	-	60
GF_Common Room C - Eating Area	-	100	-	68
GF_Common Room C - Kitchen Area	-	100	-	93
GF_Common Room A - Kitchen Area	-	100	-	95
GF_Common Room A - Eating Area	-	100	-	68
GF_Common Room B - Kitchen Area	-	100	-	94
GF_Common Room B - Eating Area	-	100	-	68
GF_Eating Area Studio1	-	100	-	27
GF_Kitchen Area Studio1	-	100	-	86
GF_Eating Area Studio 2	-	100	-	18
GF_Kitchen Area Studio 2	-	100	-	107

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
GF_Bedroom C4	NO (-81.9%)	NO
GF_Bedroom C5	NO (-59.6%)	NO
GF_Bedroom C6	NO (-59.6%)	NO
GF_Bedroom C7	NO (-59.5%)	NO
GF_Bedroom C8	NO (-59.6%)	NO
GF_Bedroom C9	NO (-59.7%)	NO
GF_Bedroom C10	NO (-59.7%)	NO
GF_Bedroom C1	NO (-67.1%)	NO
GF_Bedroom C2	NO (-67.1%)	NO
GF_Bedroom C3	NO (-84.7%)	NO
GF_Bedroom Studio 2	NO (-59.6%)	NO
GF_Exhibition/Function Area	NO (-38.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
GF_Bedroom Studio 1	NO (-59.4%)	NO
GF_Bedroom A7	NO (-59.6%)	NO
GF_Bedroom A1	NO (-67%)	NO
GF_Bedroom A2	NO (-67.2%)	NO
GF_Bedroom A3	NO (-70.9%)	NO
GF_Bedroom A4	NO (-82.5%)	NO
GF_Bedroom A5	NO (-82.4%)	NO
GF_Bedroom A6	NO (-66.3%)	NO
GF_Bedroom B3	NO (-81.2%)	NO
GF_Bedroom B2	NO (-59.5%)	NO
GF_Bedroom B1	NO (-59.5%)	NO
GF_Bedroom B10	NO (-66.9%)	NO
GF_Bedroom B9	NO (-67.2%)	NO
GF_Bedroom B8	NO (-67.1%)	NO
GF_Bedroom B7	NO (-67%)	NO
GF_Bedroom B6	NO (-66.8%)	NO
GF_Bedroom B5	NO (-67.1%)	NO
GF_Bedroom B4	NO (-85.3%)	NO
GF_Reception	N/A	N/A
GF_Management Office	N/A	N/A
GF_Office	N/A	N/A
GF_Post Office	N/A	N/A
GF_Central Hub	NO (-13.2%)	NO
1F_Bedroom K7	NO (-71.1%)	NO
1F_Bedroom K6	NO (-74.3%)	NO
1F_Bedroom K5	NO (-74.4%)	NO
1F_Bedroom K4	NO (-60.9%)	NO
1F_Bedroom K3	NO (-41.6%)	NO
1F_Bedroom K2	NO (-41.5%)	NO
1F_Bedroom K1	NO (-74.6%)	NO
1F_Bedroom I6	NO (-74.1%)	NO
1F_Bedroom I5	NO (-59.6%)	NO
1F_Bedroom I4	NO (-70.2%)	NO
1F_Bedroom H6	NO (-70.1%)	NO
1F_Bedroom H5	NO (-59.6%)	NO
1F_Bedroom H4	NO (-81.9%)	NO
1F_Bedroom H1	NO (-67%)	NO
1F_Bedroom H2	NO (-67.1%)	NO
1F_Bedroom H3	NO (-84.7%)	NO
1F_Bedroom I3	NO (-67.1%)	NO
1F_Bedroom I2	NO (-67%)	NO
1F_Bedroom I1	NO (-67.2%)	NO
1F_Bedroom E3	NO (-73.9%)	NO
1F_Bedroom E2	NO (-73.2%)	NO
1F_Bedroom E1	NO (-73.1%)	NO
1F_Bedroom J1	NO (-73.2%)	NO
1F_Bedroom J2	NO (-73.3%)	NO
1F_Bedroom J3	NO (-73.7%)	NO
1F_Bedroom J4	NO (-64.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1F_Bedroom J5	NO (-60.4%)	NO
1F_Bedroom J6	NO (-60.5%)	NO
1F_Bedroom E6	NO (-60.5%)	NO
1F_Bedroom E5	NO (-60.6%)	NO
1F_Bedroom E4	NO (-64.5%)	NO
1F_Bedroom F1	NO (-59.6%)	NO
1F_Bedroom F2	NO (-59.8%)	NO
1F_Bedroom F3	NO (-59.5%)	NO
1F_Bedroom G1	NO (-59.8%)	NO
1F_Bedroom G2	NO (-59.5%)	NO
1F_Bedroom G3	NO (-81.2%)	NO
1F_Bedroom F6	NO (-78.9%)	NO
1F_Bedroom F5	NO (-67.1%)	NO
1F_Bedroom F4	NO (-76.7%)	NO
1F_Bedroom G6	NO (-76.7%)	NO
1F_Bedroom G5	NO (-67.1%)	NO
1F_Bedroom G4	NO (-85.3%)	NO
1F_Bedroom D1	NO (-79.3%)	NO
1F_Bedroom D2	NO (-66.9%)	NO
1F_Bedroom D3	NO (-67.2%)	NO
1F_Bedroom D4	NO (-71%)	NO
1F_Bedroom D5	NO (-74.6%)	NO
1F_Bedroom D6	NO (-75.1%)	NO
1F_Bedroom D7	NO (-66.4%)	NO
1F_Bedroom D8	NO (-59.5%)	NO
1F_Bedroom K8	NO (-67.1%)	NO
2F_Bedroom S7	NO (-71.1%)	NO
2F_Bedroom S6	NO (-74.3%)	NO
2F_Bedroom S5	NO (-74.4%)	NO
2F_Bedroom S4	NO (-60.9%)	NO
2F_Bedroom S3	NO (-41.6%)	NO
2F_Bedroom S2	NO (-41.5%)	NO
2F_Bedroom S1	NO (-74.6%)	NO
2F_Bedroom Q6	NO (-74.1%)	NO
2F_Bedroom Q5	NO (-59.6%)	NO
2F_Bedroom Q4	NO (-70.2%)	NO
2F_Bedroom P6	NO (-70.1%)	NO
2F_Bedroom P5	NO (-59.6%)	NO
2F_Bedroom P4	NO (-81.9%)	NO
2F_Bedroom P1	NO (-67%)	NO
2F_Bedroom P2	NO (-67.1%)	NO
2F_Bedroom P3	NO (-84.7%)	NO
2F_Bedroom Q3	NO (-67.1%)	NO
2F_Bedroom Q2	NO (-67%)	NO
2F_Bedroom Q1	NO (-67.2%)	NO
2F_Bedroom M3	NO (-73.9%)	NO
2F_Bedroom M2	NO (-73.2%)	NO
2F_Bedroom M1	NO (-73.1%)	NO
2F_Bedroom R1	NO (-73.2%)	NO

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Zone	Solar gain limit exceeded? (%)	Internal blinds used?
2F_Bedroom R2	NO (-73.3%)	NO
2F_Bedroom R3	NO (-73.7%)	NO
2F_Bedroom R4	NO (-64.2%)	NO
2F_Bedroom R5	NO (-60.4%)	NO
2F_Bedroom R6	NO (-60.5%)	NO
2F_Bedroom M6	NO (-60.5%)	NO
2F_Bedroom M5	NO (-60.6%)	NO
2F_Bedroom M4	NO (-64.5%)	NO
2F_Bedroom N1	NO (-59.6%)	NO
2F_Bedroom N2	NO (-59.8%)	NO
2F_Bedroom N3	NO (-59.5%)	NO
2F_Bedroom O1	NO (-59.8%)	NO
2F_Bedroom O2	NO (-59.5%)	NO
2F_Bedroom O3	NO (-81.2%)	NO
2F_Bedroom N6	NO (-78.9%)	NO
2F_Bedroom N5	NO (-67.1%)	NO
2F_Bedroom N4	NO (-76.7%)	NO
2F_Bedroom O6	NO (-76.7%)	NO
2F_Bedroom O5	NO (-67.1%)	NO
2F_Bedroom O4	NO (-85.3%)	NO
2F_Bedroom L1	NO (-79.3%)	NO
2F_Bedroom L2	NO (-66.9%)	NO
2F_Bedroom L3	NO (-67.2%)	NO
2F_Bedroom L4	NO (-71%)	NO
2F_Bedroom L5	NO (-74.6%)	NO
2F_Bedroom L6	NO (-75.1%)	NO
2F_Bedroom L7	NO (-66.4%)	NO
2F_Bedroom L8	NO (-59.5%)	NO
2F_Bedroom S8	NO (-67.1%)	NO
3F_Bedroom Y7	NO (-71.1%)	NO
3F_Bedroom Y6	NO (-74.3%)	NO
3F_Bedroom Y5	NO (-74.4%)	NO
3F_Bedroom Y4	NO (-60.9%)	NO
3F_Bedroom Y3	NO (-41.6%)	NO
3F_Bedroom Y2	NO (-41.5%)	NO
3F_Bedroom Y1	NO (-74.6%)	NO
3F_Bedroom W6	NO (-74.1%)	NO
3F_Bedroom W5	NO (-59.6%)	NO
3F_Bedroom W4	NO (-70.2%)	NO
3F_Bedroom W3	NO (-67.1%)	NO
3F_Bedroom W2	NO (-67%)	NO
3F_Bedroom W1	NO (-67.2%)	NO
3F_Bedroom U3	NO (-73.9%)	NO
3F_Bedroom U2	NO (-73.2%)	NO
3F_Bedroom U1	NO (-73.1%)	NO
3F_Bedroom X1	NO (-73.2%)	NO
3F_Bedroom X2	NO (-73.3%)	NO
3F_Bedroom X3	NO (-73.7%)	NO
3F_Bedroom X4	NO (-64.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
3F_Bedroom X5	NO (-60.4%)	NO
3F_Bedroom X6	NO (-60.5%)	NO
3F_Bedroom U6	NO (-60.5%)	NO
3F_Bedroom U5	NO (-60.6%)	NO
3F_Bedroom U4	NO (-64.5%)	NO
3F_Bedroom V1	NO (-59.6%)	NO
3F_Bedroom V2	NO (-59.8%)	NO
3F_Bedroom V3	NO (-59.5%)	NO
3F_Bedroom V6	NO (-78.9%)	NO
3F_Bedroom V5	NO (-67.1%)	NO
3F_Bedroom V4	NO (-76.7%)	NO
3F_Bedroom T1	NO (-79.3%)	NO
3F_Bedroom T2	NO (-66.9%)	NO
3F_Bedroom T3	NO (-67.2%)	NO
3F_Bedroom T4	NO (-71%)	NO
3F_Bedroom T5	NO (-74.6%)	NO
3F_Bedroom T6	NO (-75.1%)	NO
3F_Bedroom T7	NO (-66.4%)	NO
3F_Bedroom T8	NO (-59.5%)	NO
3F_Bedroom Y8	NO (-67.1%)	NO
3F_Studio Room 4	NO (77.2%)	NO
3F_Studio Room 3	NO (-81.3%)	NO
4F_Bedroom BB5	NO (-65%)	NO
4F_Bedroom AA4	NO (-59.7%)	NO
4F_Bedroom AA5	NO (-59.4%)	NO
4F_Bedroom AA3	NO (-59.8%)	NO
4F_Bedroom Z4	NO (-64.6%)	NO
4F_Bedroom Z5	NO (-60.5%)	NO
4F_Bedroom Z6	NO (-60.2%)	NO
4F_Bedroom BB7	NO (-60.7%)	NO
4F_Bedroom AA2	NO (-78.2%)	NO
4F_Studio Room 2	NO (-65.7%)	NO
4F_Studio Room 3	NO (-67.1%)	NO
4F_Studio Room 4	NO (-77.6%)	NO
4F_Studio Room 5	NO (-82.5%)	NO
4F_Studio Room 6	NO (-72.5%)	NO
4F_Bedroom BB3	NO (-72.7%)	NO
4F_Bedroom BB2	NO (-73.2%)	NO
4F_Bedroom BB1	NO (-73.2%)	NO
4F_Bedroom Z1	NO (-73.2%)	NO
4F_Bedroom Z2	NO (-73.2%)	NO
4F_Bedroom Z3	NO (-73.2%)	NO
4F_Studio Room 7	NO (-38.2%)	NO
4F_Bedroom CC1	NO (-74.4%)	NO
4F_Bedroom CC2	NO (-41.7%)	NO
4F_Bedroom CC3	NO (-42%)	NO
4F_Bedroom CC4	NO (-60.8%)	NO
4F_Bedroom CC5	NO (-74.9%)	NO
4F_Bedroom CC6	NO (-74.9%)	NO

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Zone	Solar gain limit exceeded? (%)	Internal blinds used?
4F_Bedroom CC7	NO (-71.5%)	NO
4F_Bedroom CC8	NO (-67.1%)	NO
4F_Studio Room 1	NO (-41.6%)	NO
4F_Bedroom BB6	NO (-60.3%)	NO
4F_Common Room BB - Eating Area	NO (-21.8%)	NO
4F_Common Room CC - Eating Area	NO (-58.9%)	NO
4F_Common Room Z - Eating Area	NO (-2.6%)	NO
4F_Common Room AA - Eating Area	NO (-70.3%)	NO
3F_Common Room W - Eating Area	NO (-67.7%)	NO
3F_Common Room X - Eating Area	NO (-21.9%)	NO
3F_Common Room Y - Eating Area	NO (-59.4%)	NO
3F_Common Room V - Eating Area	NO (-74.3%)	NO
3F_Common Room T - Eating Area	NO (-68.1%)	NO
3F_Common Room U - Eating Area	NO (-3.9%)	NO
2F_Common Room P - Eating Area	NO (-55.4%)	NO
2F_Common Room Q - Eating Area	NO (-67.6%)	NO
2F_Common Room S - Eating Area	NO (-59.4%)	NO
2F_Common Room R - Eating Area	NO (-21.9%)	NO
2F_Common Room M - Eating Area	NO (-3.9%)	NO
2F_Common Room O - Eating Area	NO (-63.3%)	NO
2F_Common Room N - Eating Area	NO (-74.3%)	NO
2F_Common Room L - Eating Area	NO (-68.1%)	NO
1F_Common Room G - Eating Area	NO (-63.3%)	NO
1F_Common Room F - Eating Area	NO (-74.3%)	NO
1F_Common Room D - Eating Area	NO (-68.1%)	NO
1F_Common Room E - Eating Area	NO (-3.9%)	NO
1F_Common Room J - Eating Area	NO (-21.9%)	NO
1F_Common Room H - Eating Area	NO (-55.4%)	NO
1F_Common Room I - Eating Area	NO (-67.6%)	NO
1F_Common Room K - Eating Area	NO (-59.4%)	NO
GF_Common Room C - Eating Area	NO (-73.9%)	NO
GF_Common Room A - Eating Area	NO (-79%)	NO
GF_Common Room B - Eating Area	NO (-78.9%)	NO
GF_Eating Area Studio1	NO (-59.8%)	NO
GF_Eating Area Studio 2	NO (-84.9%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	6271.4	6271.4
External area [m²]	6699.4	6699.4
Weather	SWI	SWI
Infiltration [m³/hm²@ 50Pa]	5	3
Average conductance [W/K]	2033.42	3590.85
Average U-value [W/m²K]	0.3	0.54
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
1	**A1/A2 Retail/Financial and Professional services**
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
91	**C2 Residential Institutions: Residential schools**
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
7	**Residential spaces**
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	10.01	18.35
Cooling	0	0
Auxiliary	5.07	4.3
Lighting	5.61	9.44
Hot water	25.15	28.87
Equipment*	23.39	23.39
TOTAL**	**45.84**	**60.97**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	3.21	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	106.11	169.02
Primary energy* [kWh/m²]	140.73	182.5
Total emissions [kg/m²]	22.1	30.9

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: floor heating, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	106.1	0	10	0	5.1	2.94	0	3.3	0
	Notional	169	0	18.4	0	4.3	2.56	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.18	GF00000C:Surf[1]
Floor	0.2	0.18	GF00000C:Surf[0]
Roof	0.15	0.18	GF00000A:Surf[1]
Windows, roof windows, and rooflights	1.5	1.1	GF00000C:Surf[2]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

U_{i-Typ} = Typical individual element U-values [W/(m²K)]

U_{i-Min} = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	4.5

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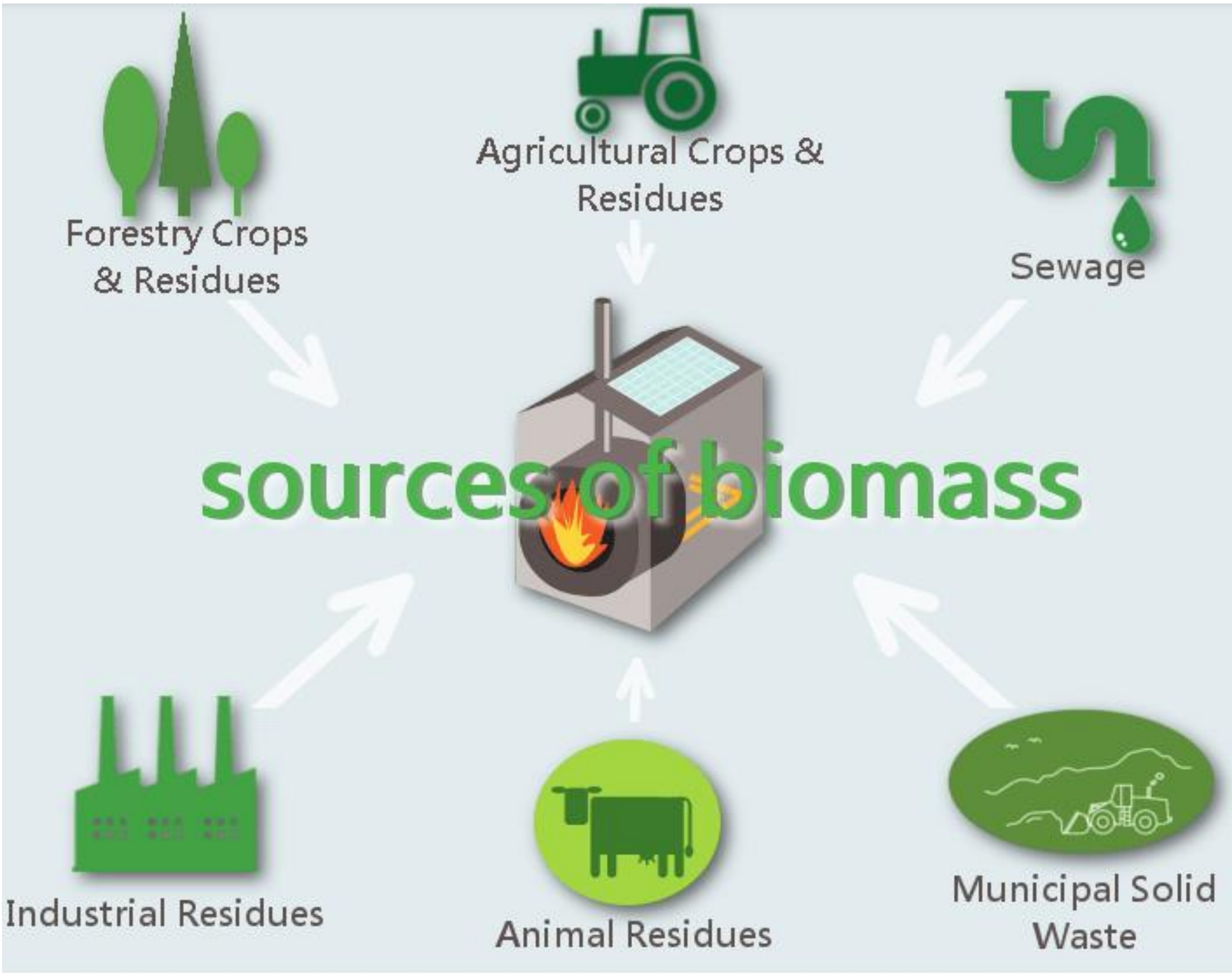
APPENDIX B - LOW OR ZERO CARBON ENERGY SOURCES

BIOMASS AS A FUEL

Biomass is a renewable energy source, generated from burning wood, plants and other organic matter, such as manure or household waste. It releases CO2 when burned, but considerably less than fossil fuels. We consider biomass a renewable energy source, if the plants or other organic materials being burned are replaced.

Biomass is known for its versatility, given it can be used to generate heat, electricity, be used in combined heat and power units and be used as liquid fuel. In domestic settings, it tends to be found in the form of wood-fuelled heating systems.



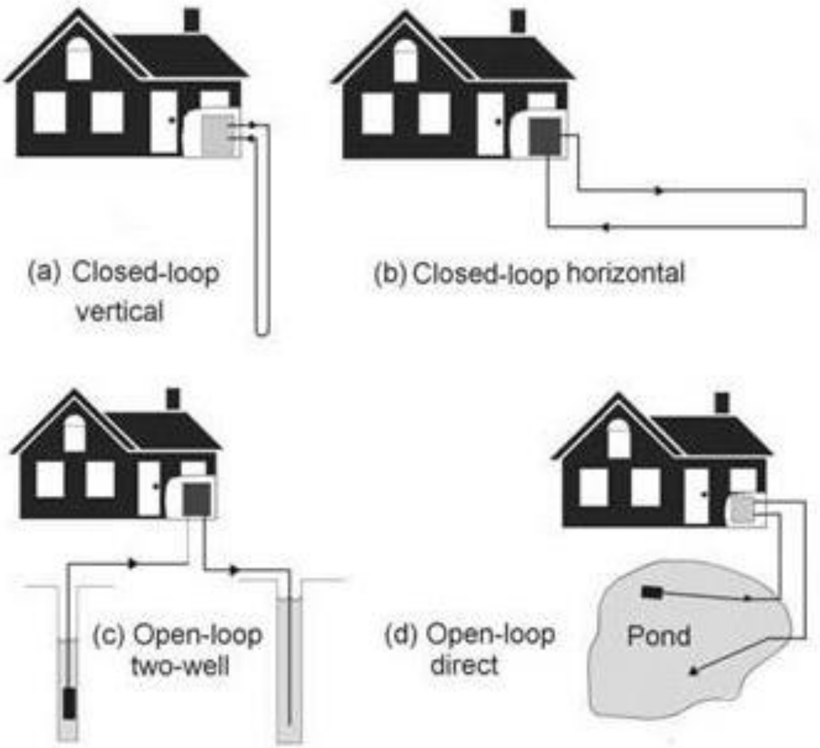
GEOTHERMAL ENERGY:

Geothermal energy technologies use the heat energy stored in ground; either for direct-use applications: such as using the grounds' heat to defrost a driveway or the indirect use with additional equipment such as a geothermal heat pump. Most commercial installations couple a heat pump with the ground to upgrade the low-grade heat from the ground or ground water to a higher grade heat, where it can be used for heating purposes.

The suitability of a ground source system depends heavily on the type of earth coupling heat exchange system used:

Ground source earth coupling options

The right choice of appropriate heat exchanger depends on several factors such as: size of space heating/hot water system, available site area for the heat exchangers, and local ground conditions. Due to the specialist nature of this technology we recommend that a specialist is employed to size the heat exchangers based on a desk-top study of the site's geological conditions – this normally being required in advance of any other contractor appointment.



Vertical Closed Loop System

A frequently used and simple ground source heat exchanger, for a small to medium size project, is a closed loop vertical system. The system comprises of vertically drilled boreholes, usually up to 100 m deep, into which are inserted two polyethylene pipes with a U-shape connector at the base of the hole – effectively providing a flow down to the bottom of the hole and return back up to the surface. All the flow and return loops are connected together across the site - completing the entire heat exchange loop. Water is pumped around the loop and is then circulated around the heat pump to achieve the required heat exchange. The distance between boreholes is dependent on ground conditions but is typically a minimum of a 6mx6m grid, to prevent overlapping of the heat exchange process between loops.

Horizontal Closed Loop System

Horizontal closed loop heat exchangers are usually applied to small projects such as individual houses, which usually require a relatively low heat output. Consisting of horizontal trenches 1.5-2m deep, with either straight pipes or 'slinky' coiled pipes, these require significant excavation work and significant site area to achieve appreciable outputs as such are not normally suited to medium to large projects.

Vertical Open Boreholes System

A further option is a vertical open borehole system. The system involves the abstraction and discharge of natural ground water using boreholes; into which pumps are inserted, connected to collapsible pipework. Each borehole pump abstracts ground water, circulates it around the heat pump and then discharges the water back to the ground via an absorbing well, some distance from the original abstraction borehole. The system is capable of providing very high rates of heat exchange for a relatively small number of boreholes, which makes it very efficient in terms of site area required. However, this depends greatly on the availability of ground water, which in turn varies according to location. A major downside of this system is that the extraction of water from deep boreholes via pumps consumes a lot of energy, as the water has to be physically lifted to the surface by the pump – this in effect reduces the carbon emissions saved by this system as a whole.

Ground source heat exchange options in summary:

Vertical loop system - closed boreholes

- moderate heat capacity
- relatively low installation cost

Vertical open system - open boreholes

- high heat capacity
- high running energy
- high installation cost

Horizontal loop system – straight pipes

- low capacity,
- high installation cost
- extensive ground excavation work

Horizontal coiled loop system – 'slinky' pipes

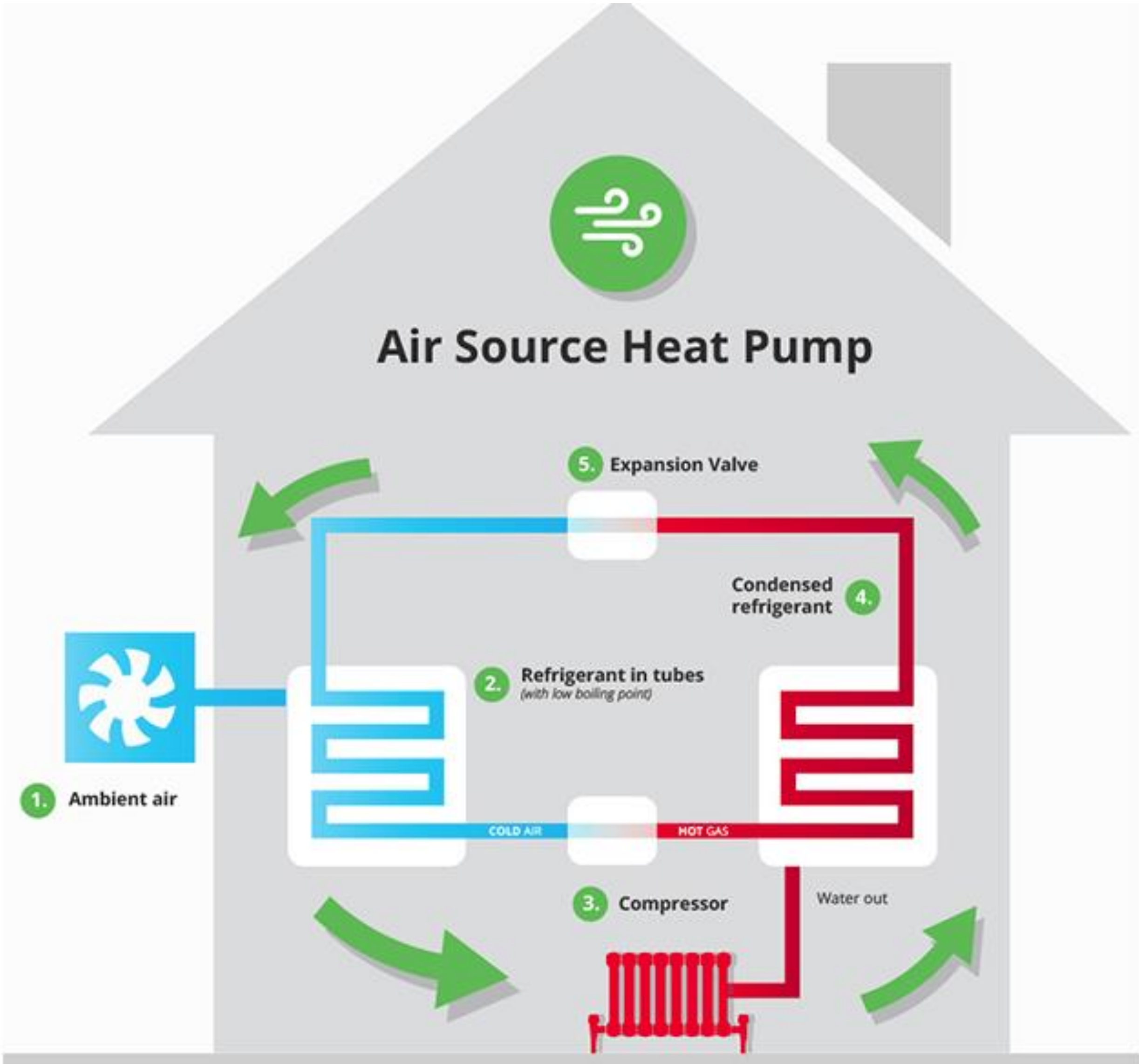
- good capacity
- low installation cost
- extensive ground excavation work

AIR SOURCE HEAT PUMPS

Heat pumps are basically refrigeration units which work in reverse – instead of cooling being produced and heat rejected, the unit produces heat and rejects cooling. Conventional heat pumps use air as the medium to reject this 'coolth' to atmosphere. Ground source units use the ground as a means of improving the unit efficiency because the ground is a constant 11-13 °C at depths of 50m down – this suits the heat pump much better during the coldest weather than the extremes of air temperature. Reversible heat pumps can also be used for cooling, however this is not being considered further for this project.

A heat pump consumes electrical power to drive the compressor and other ancillary elements. The ratio between total energy input and heat energy output of the heat pump is a measure of its efficiency – usually referred to as 'Coefficient of Performance' - COP. A ground source heat pump has a higher COP than an air cooled heat pump – this additional energy effectively being the grounds' natural contribution to the system.

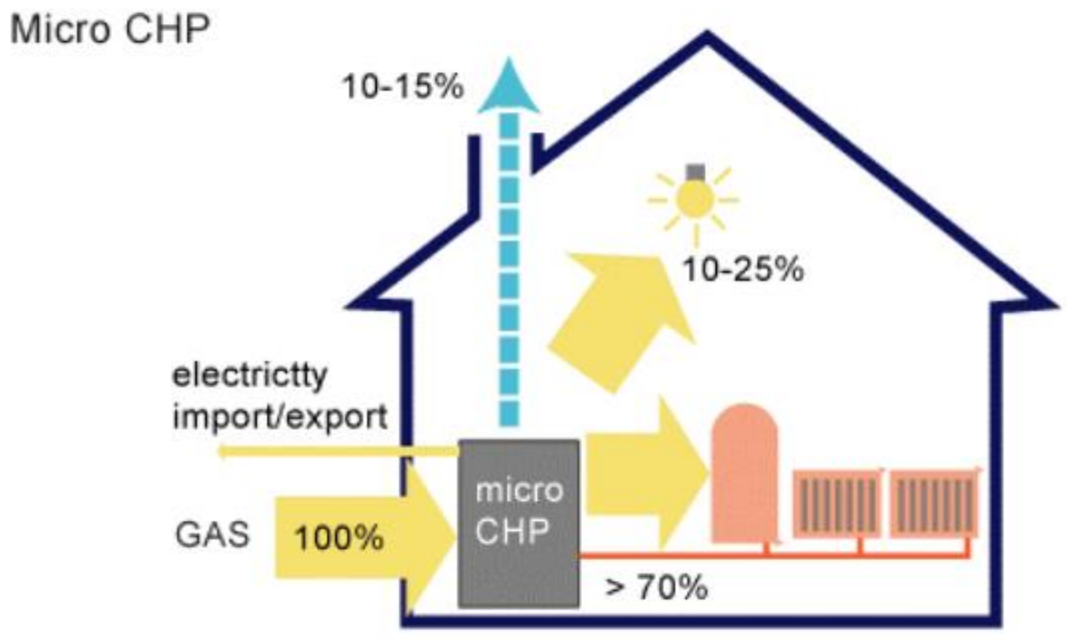
The heat produced by a heat pump is usually used to either provide space heating say to underfloor heating or radiators or the heat is used to generate domestic hot water via a storage vessel.



CHP

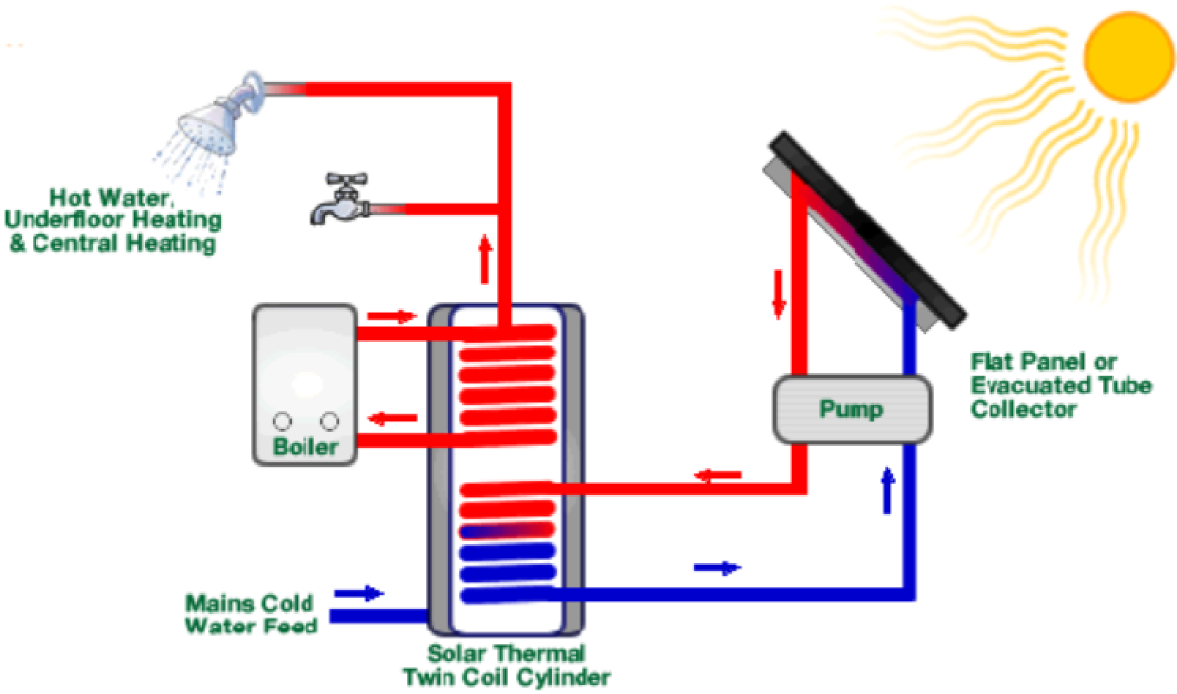
Combined heat and power (CHP) is a process involving simultaneous generation of heat and electricity, where the heat generated in the process in harnessed via heat recovery equipment. CHP at the large commercial size is now fairly common in premises which have a simultaneous demand for heating and electricity for long periods, such as hospitals, recreational centres and hotels. In addition, small CHP systems are now becoming available for individual houses, group residential units and small non-domestic premises. Compared with using centrally generated electricity supplied via the grid, CHP can offer a more efficient and economic method of supplying energy demand, if installed and operated appropriately, owing to the utilisation of heat which is normally rejected to the atmosphere from central generating stations, and by reducing network distribution losses due to local generation and use.

Heat generated will be used for space and water heating, and additional heat storage may be used to lengthen use periods, to assist in warm-up and to improve overall energy efficiency. For overall good energy efficiency, as with all CHP, usage must be heat demand led. Thus, a sophisticated control system is required and users should be made aware of efficient operating practices.



SOLAR THERMAL COLLECTORS

Solar thermal collectors (flat plate or evacuated tubes) convert solar thermal energy into heat for hot water generation. These are usually located on a roof oriented south facing in an ideal slope of 45 degree. Solar collectors properly sized and designed provide approx 50% of annual hot water demand.



PHOTOVOLTAIC

Photovoltaic modules convert sunlight directly into DC electricity and can be integrated into buildings. Photovoltaics (PVs) are distinct from other renewable energy technologies since they have no moving parts to be maintained and are silent. PV systems can be incorporated into buildings in various ways: on sloped roofs and fl at roofs, in façades, atria and shading devices. Modules can be mounted using frames or they can be fully incorporated into the actual building fabric; for example, PV roof tiles are now available which can be fitted in place of standard tiles.

Currently, a PV system will cost between £1500 and £2500 per kWp, and frequently part of this cost can be offset owing to the displacement of a conventional cladding material. Costs have fallen significantly since the first systems were installed (1980s) and are predicted to fall further still.

While single crystal silicon remains the most efficient flat plate technology (15–16% conversion efficiency); it also has the least potential for cost reduction. PV cells made from poly-crystalline silicon have become popular as they are less expensive to produce, although they have a slightly lower efficiency.

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials on a low-cost backing such as glass, stainless steel or plastic. As much less semiconductor material is required as for crystalline silicon cells, material costs are potentially much lower. Efficiencies are much lower, around 4–5%, although this can be boosted to 8–10% by depositing two or three layers of thin film material. Thin film production also requires less handling as the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together. Hence, there is the potential for significant cost reductions with volume production.

Since PVs generate DC output, an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form. The cost of the inverter and these 'Balance Of System' (BOS) components can approach 30% of the total cost of a PV system. Hence, simplification and cost reductions in these components over the coming years will also be necessary to make PV systems affordable.

WIND ENERGY

Wind power is the most successful and fastest spreading renewable energy technology in the UK with a number of individual and group installations of varying size, capacity and location. Traditionally, turbines are installed in non-urban areas with a strong trend for large offshore wind farms. In parallel with the design and development of ever-bigger machines, which are deemed to be more efficient and cost-effective, it is being increasingly recognised that smaller devices installed at the point of use, i.e. urban settings, can play an important role in reducing carbon emissions if they become mainstream.

At present there is a wide range of available off-the-shelf wind products, many manufactured in the UK and EU with proven good performance and durability. The dominant type is horizontal axis wind turbines (HAWT), which are typically ground mounted. Vertical axis wind turbines (VAWT) have limited market presence and there is a trade-off between lower efficiency and potentially higher resistance to extreme conditions. Capacity ranges from 500W to more than 1.5MW, but, for practical purposes and in built-up areas in particular, machines of more than 1kW and below 500kW are likely to be considered.

Wind technology is also currently one of the most cost-effective renewable energy technologies, which is attributable to the large scale of installations reducing the unit output cost. Individual building or community wind projects, although smaller, have the advantage of feeding electricity directly into the building's electricity circuit, thus sparing costly distribution network development and avoiding distribution losses. The downside is the still high capital cost per kW installed for smaller turbines, plus location constraints, such as visual intrusion and noise. The wind regime in urban areas is also a concern owing to higher wind turbulence which reduces the potential electricity output.

In most cases, wind turbines are connected to the electricity grid and all generated energy is used regardless of the building demand fluctuations. The output largely depends on the wind speed and the correlation between the two is a cube function. This means that in short periods of above-average wind speeds the generation increases exponentially. As a result, it is difficult to make precise calculations of the annual output of a turbine, but average figures can provide useful guidance to designers and architects. In reasonably windy areas (average wind speed of 6m/s) the expected output from 1kW installed is about 2500kWh annually.

The cost per kW installed varies considerably by manufacturer and size of machine with an indicative bracket of £2,500–£5,000. With a lifespan of more than 20 years, wind turbines can save money if design and planning are carried out in a robust way.

Building-integrated wind turbines are starting to be a reality in the UK, but potential projects may face difficulties with obtaining planning permission. There are a few examples now of permitted development rights for certain rooftop turbines in some local councils. A number of horizontal axis devices specifically designed for building integration are now available commercially, having design and reliability parameters relevant to the urban context. Building-mounted vertical axis devices are under development.

At present, turbines installed near buildings, as well as community installations for groups of buildings, should be regarded as the larger wind energy source related to buildings, when they contribute to the carbon emissions from these premises using ‘private wire’ networks. However, the contribution of several building-integrated turbines in a development is likely to become significant in the next few years.