THE CONNOLLY QUARTER	HOMAN O'BRIEN *Engineering Excellence.*

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1831	Sustainability and TGD L Report	P1	SB/VY	09-10-2019	SOB

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PROPOSED DEVELOPMENT

The development will consist of;

i. the demolition of 4 no. structures with a combined gross floor area of 3,028sq.m;

ii. the construction of 741 no. Build to Rent (BTR) residential units in 8 no. apartment blocks ranging in height from 4 storeys to 23 storeys with lower height buildings located adjacent to the northeast and east site boundaries, with a cumulative gross floor area of 68,535sq.m comprising;

   a. Block B1 (maximum building height 54.917m, total gross internal floor area 11,260sq.m, Apartment Mix: Studio: 25, 1-bed: 37, 2-bed: 51);
   b. Block B2 (maximum building height 54.917m, total gross internal floor area 10,831sq.m, Apartment Mix: Studio: 20, 1-bed: 35, 2-bed: 51,);
   c. Block B3 (maximum building height 51.767m, total gross internal floor area 9,766sq.m, Apartment Mix: Studio: 22, 1-bed: 60, 2-bed: 27, 3-Bed: 1);
   d. Block C1 (maximum building height 79,450m, total gross internal floor area 12,705sq.m, Apartment Mix: Studio: 84, 1-bed: 40, 2-bed: 41);
   e. Block C2 (maximum building height 39,615 m, total gross internal floor area 4,890 sq.m, Apartment Mix: Studio: 9, 1-bed: 33, 2-bed: 3, 3-Bed: 4);
   f. Block C3 (maximum building height 39,650 m, total gross internal floor area 6,775sq.m, Apartment Mix: Studio: 40, 1-bed: 18, 2-bed: 23);
   g. Block D1 (maximum building height 53,392 m, total gross internal floor area 8,418 sq.m, Apartment Mix: Studio: 10, 1-bed: 25, 2-bed: 44, 3-Bed: 1);
   h. Block D2 (maximum building height 30,950 m, total gross internal floor area 3,890 sq.m, Apartment Mix: Studio: 18, 1-bed: 8, 2-bed: 11);

iii. residential support amenities including 1 no. gyms, a resident's lounge, work areas, meeting rooms, dining rooms, recreational areas with a combined GFA of 1,444 sq.m;

iv. change of use from club house to pedestrian passageway of the existing vault (137sq.m GFA) fronting Seville Place, a Protected Structure (RPS No. 130);

v. a basement of 7,253.4 sq.m with vehicular access from Oriel Street Upper incorporating residents' car parking (58 no. spaces), residents cycle parking (640 no. spaces) 7 no. plant rooms (combined 2,228sq.m), waste management facilities (393 sq.m)

vi. 766 no. covered cycle parking spaces for residents and visitors, concierge office (233 sq.m) and waste management facilities (126 sq.m);

vii. 'other uses' including 10 no. units providing retail, commercial, and community use with a combined GFA of 3,142 sq.m;

viii. A total of 18,562 sq.m of hard and soft landscaping comprising both public, communal and private open space located throughout the development;

ix. A service and emergency vehicle only access ramp from the Oriel Street Upper site entrance to serve CIE's transport needs at Connolly Station;

x. Enabling works of a non-material nature to safeguard the existing vaults (Protected Structures - RPS No. 130) that form part of the subject site fronting Sherriff Street Lower, Oriel Street Upper, and Seville Place during the construction phase;

xi. All associated ancillary development works including drainage, 6 no. electricity substations, pedestrian access; and

xii. Works to the Masonry wall fronting Oriel Street and the Vaults fronting Seville Place (both a Protected Structure) consisting of the creation of a new vehicular and pedestrian entrance.

SECTION 1 BUILDING REGULATIONS & BER

1.1 Compliance Criteria

The residential units will be designed to comply with the new Building Regulations TGD L 2019 – Conservation of Fuel and Energy – Dwellings.

This new version of TGD L includes the requirements for Nearly Zero Energy Building (NZEB).

We have set out our initial calculations based on the public consultation document and will have to verify these calculations once the verification calculation tool is released by S.E.A.I.

The new standard will apply to all dwellings that commence on or after on or after 1st November 2019.

There are a number of options available to demonstrate compliance. The option used will be determined once the standards and calculation methods as well as definitions have been ratified and published by Department of Environment (DOE).

There are five main criteria that this report aims to demonstrate compliance with

- Building Energy Rating
- Energy Performance Coefficient (EPC)
- Carbon Performance Coefficient (CPC)
- Renewable contribution
- Maximum elemental U-Values

Building Energy Rating (BER)
There is no specific BER rating that is required to comply with Part L. However, dwellings compliant with NZEB will usually achieve a BER of A2-A3.

Energy Performance Coefficient (EPC) & Carbon Performance Coefficient (CPC)
The EPC and CPC are the two figures that are used to determine whether the dwelling complies with Part L on an overall basis.

The EPC is the calculated primary energy consumption of the proposed dwelling, divided by that of a reference building of the same size. To comply with Part L and NZEB requirements, the EPC must be better than the Maximum Energy Performance Coefficient (MPEPC) which is 0.30.

The CPC is the calculated carbon dioxide emissions of the proposed dwelling, divided by that of a reference building of the same size. To comply with Part L and NZEB requirements, the CPC must be better than the Maximum Carbon Performance Coefficient (MPCPC) which is 0.35.

Renewable Contribution

To satisfy the new part L, 20% of the building energy must be provided via renewable technologies. This is measured in the form of a renewable energy ratio (RER).

Maximum Elemental U-Values

Technical Guidance Document Part L 2019 sets out maximum U-Values for each construction type:

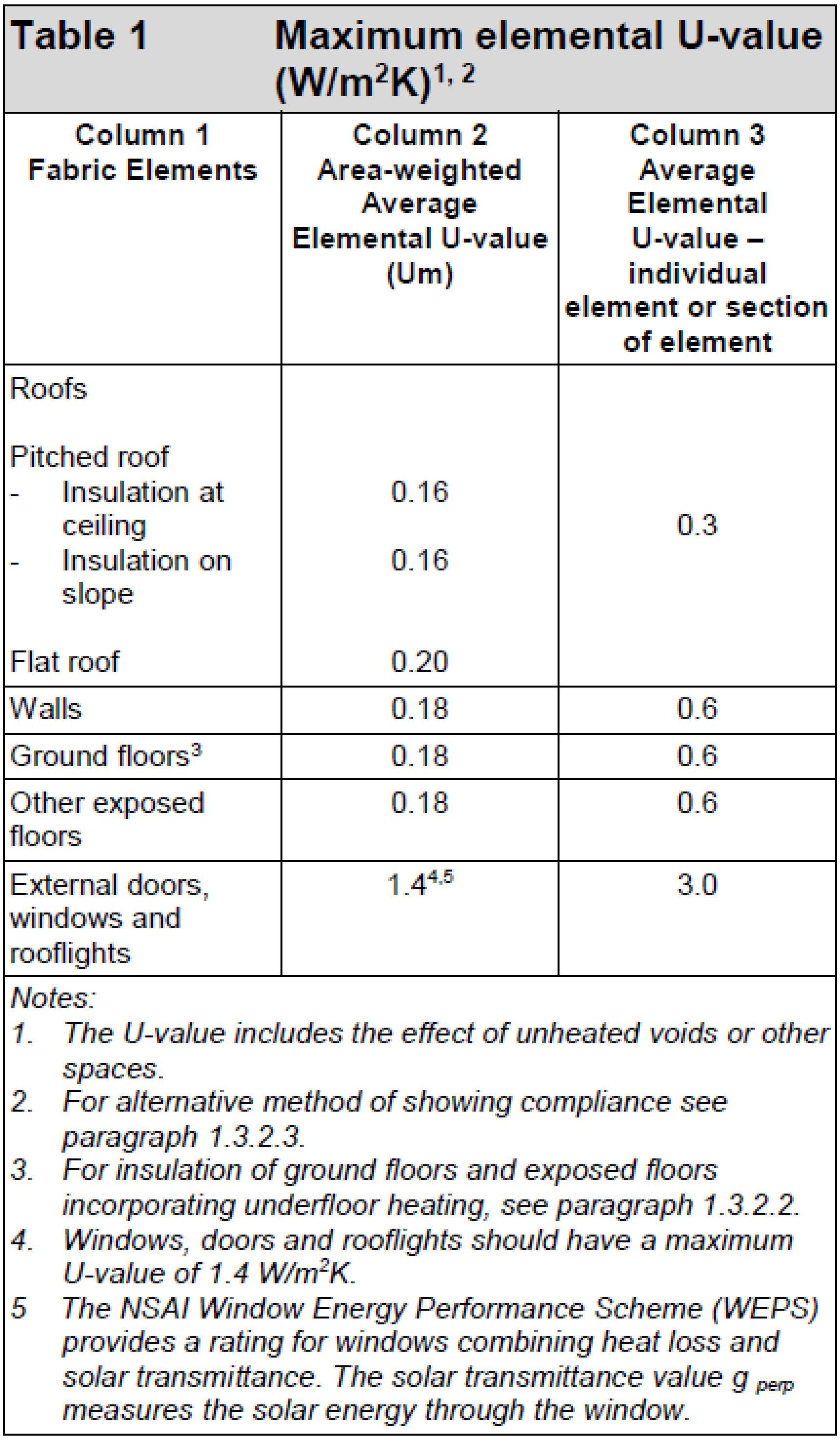


Table 1 **Maximum elemental U-value (W/m^2K)[1, 2]**

Column 1 Fabric Elements	**Column 2 Area-weighted Average Elemental U-value (Um)**	**Column 3 Average Elemental U-value – individual element or section of element**
Roofs		
Pitched roof		
- Insulation at ceiling	0.16	0.3
- Insulation on slope	0.16	
Flat roof	0.20	
Walls	0.18	0.6
Ground floors[3]	0.18	0.6
Other exposed floors	0.18	0.6
External doors, windows and rooflights	1.4[4,5]	3.0

Notes:

1. *The U-value includes the effect of unheated voids or other spaces.*
2. *For alternative method of showing compliance see paragraph 1.3.2.3.*
3. *For insulation of ground floors and exposed floors incorporating underfloor heating, see paragraph 1.3.2.2.*
4. *Windows, doors and rooflights should have a maximum U-value of 1.4 W/m^2K.*
5. *The NSAI Window Energy Performance Scheme (WEPS) provides a rating for windows combining heat loss and solar transmittance. The solar transmittance value g_{perp} measures the solar energy through the window.*

1.2 *Overheating Technical Guidance document Part L 2019*

The only reference in the building regulations in regards to **overheating in dwellings** is contained in the latest revision of Part L Conservation of Fuel and Energy – Dwellings (2019)

Paragraph **1.3.5 Limiting Heat Gains** provides the following guidance.

"1.3.5.1 Guidance is provided in DEAP for carrying out overheating assessment.
Reasonable provision to limit heat gains can be demonstrated by showing through the DEAP calculation that the dwelling does not have a risk of high internal temperatures. (revised DEAP methodology to be published).
Where an overheating risk is indicated in DEAP, further guidance is provided in CIBSE TM 59 to ensure overheating is avoided for normally occupied naturally ventilated spaces."

Upon reviewing the methodology in the latest DEAP manual (draft issue for DEAP version 4.2) the accuracy of the reported results is too broad to provide a meaningful assessment. In addition the reported results don't correlate adequately with the methodology and results of CIBSE TM59. See the below table.

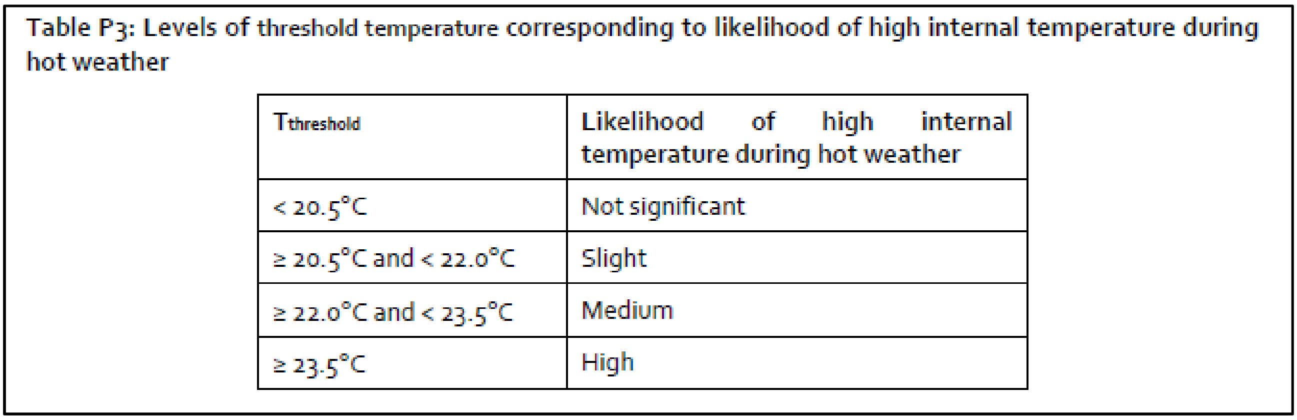


Table P3: Levels of threshold temperature corresponding to likelihood of high internal temperature during hot weather

$T_{threshold}$	Likelihood of high internal temperature during hot weather
< 20.5°C	Not significant
≥ 20.5°C and < 22.0°C	Slight
≥ 22.0°C and < 23.5°C	Medium
≥ 23.5°C	High

Therefore we started with a CIBSE TM 59 assessment to provide a detailed report on the proposed worst case apartment with a room by room breakdown of the main habitable rooms as per the guidance of CIBSE TM 59.

CIBSE TM 59

CIBSE TM 59 is a standardised approach to predicting overheating risk for residential building designs (new-build or major refurbishment) using dynamic thermal analysis. The testing of the methodology has focused on flats, as they tend to represent a higher overheating risk than houses. However, the methodology should also be applicable to houses.

The aim is to produce a test that encourages good design that is comfortable within sensible limits, without being so stringent that it over-promotes the use of mechanical cooling. The test needs to be simple to ensure it is used.

CIBSE Technical Memorandum 59 compliance is based on passing both of the following criteria.

a) "For living rooms, kitchens and bedrooms: the number of hours during which ΔT is greater than or equal to one degree (K) during the period May to September inclusive shall not be more than 3 percent of occupied hours. (CIBSE TM52 Criterion 1: Hours of exceedance).

b) For bedrooms only: to guarantee comfort during the sleeping hours the operative temperature in the bedroom from 10 pm to 7 am shall not exceed 26 °C for more than 1% of annual hours. (Note: 1% of the annual hours between 22:00 and 07:00 for bedrooms is 32 hours, so 33 or more hours above 26 °C will be recorded as a fail)."

"Criteria 2 and 3 of CIBSE TM52 may fail to be met, but both (a) and (b) above must be passed for all relevant rooms."

CIBSE TM 52

As a part of testing to TM 59 the building has also been tested for compliance with CIBSE Technical Memorandum 52, which sets out three criteria for overheating. According to TM 59 only Criteria 1 has to met in domestic purposes.

> "Criteria 1 - This displays the percentage hours when the difference in operative temperature minus the maximum acceptable temperature is greater than or equal to 1 K.
>
> Criteria 2 - This displays the maximum daily degree hours found for the space. This fails if it is greater than 6 K.
>
> Criteria 3 - This displays the maximum ΔT for the space. This space fails if it is greater than or equal to 4 K."

The results for compliance with TM 52 can be found in the results section, these results are based on an air speed of 0.15 m/s, taken from ASHRAE 55:

> "For operative temperatures below 22.5 ºC (72.5 ºF), the limit will be 0.15 m/s (30 ft/min), to avoid local cold discomfort due to draft." – ASHRAE 55 5.2.3.3.2

SECTION 2 INPUT DATA

The DEAP software is used to calculate the BER of the building. Similar to the calculation to demonstrate compliance with Part L. This report and the accompanying calculations are based on the design information and the input data as detailed below.

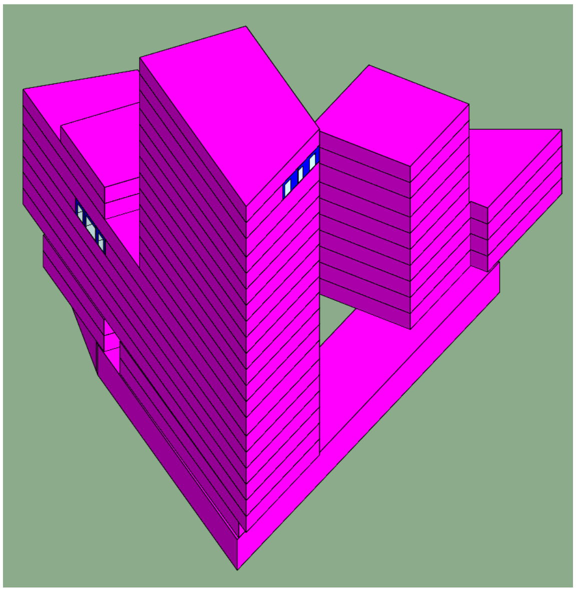
The following input data was applied:

2.1. General Input Data

- Air permeability of 3 $m^3/m^2.h$
- Whole house mechanical ventilation with heat recovery
- SFP of 0.65 W/l/s
- 84% heat recovery efficiency
- Roof U-Value of 0.15 $W/m^2.K$ (on top floor apartments)
- Wall U-Value of 0.18 $W/m^2.K$
- Glazing U-Value of 1.40 $W/m^2.K$
- Thermal bridging factor of 0.08
- 100% of lighting outlets to be low energy (LED)
- Medium thermal mass
- Group heating scheme

2.2 Overheating input data

Two Bedroom apartment on the 20th floor, 7th floor and one studio apartment on 20th floor was selected for the overheating study. The apartment was selected as a worst case representation of the dwellings within the development as it has a greater amount of glazing and is relatively more exposed than other apartments. A 3D model was designed in IES VE 2019 to provide dynamic thermal analysis the internal conditions in the subject spaces.



2.3 Dwelling Layouts

As per section 5.3 of CIBSE TM59 "It is assumed that apartments with the same number of occupants and bedrooms are usually provided with the same appliances, therefore the heat loads given by them should be assumed to be independent of floor area for the purpose of overheating risk assessment. Therefore, the equipment loads are defined in watts (not W/m²).

Notes:

1) Larger or unusual apartments should follow the same principles — assessors should explain the basis of any alternative profile developed for other room types in the compliance report.
2) Single bedrooms are those that cannot accommodate a double bed.
3) Bathrooms and halls do not have to pass the criteria, but should be included in the assessment."

2.4 Windows

In accordance with the methodology of CIBSE TM 59, Windows in each bedroom living room will be open when the internal temperature exceeds 22°C and the room is occupied. In living room window will be open between 9AM to 10PM when the internal temperature exceeds 22°C and the room is occupied. All the windows are top hung and balcony door is sliding/roller door openable. Restrictors are placed in bedroom windows with an angle of opening 30°.

2.5 Lighting

In accordance with the methodology of CIBSE TM 59, lighting energy is assumed to be proportional to floor area, and lighting loads are measured in W/m². From 6 pm to 11 pm, 2 W/m² should be assumed as the default for an efficient new-build home. This assumes that good daylight levels are available (also noting that only May to September is assessed within CIBSE TM52). For existing buildings, or specialist lighting designs, a calculated higher value should be used.

2.6 Profiles

In accordance with the methodology of CIBSE TM 59 the following profiles are set up:

a) Bedrooms are set with a 24-hour occupancy profile, which means that one person is always considered in each bedroom during the daytime, and two people in each double bedroom at night. Refer to Section 2-5 for note on metabolic rate for sleep.

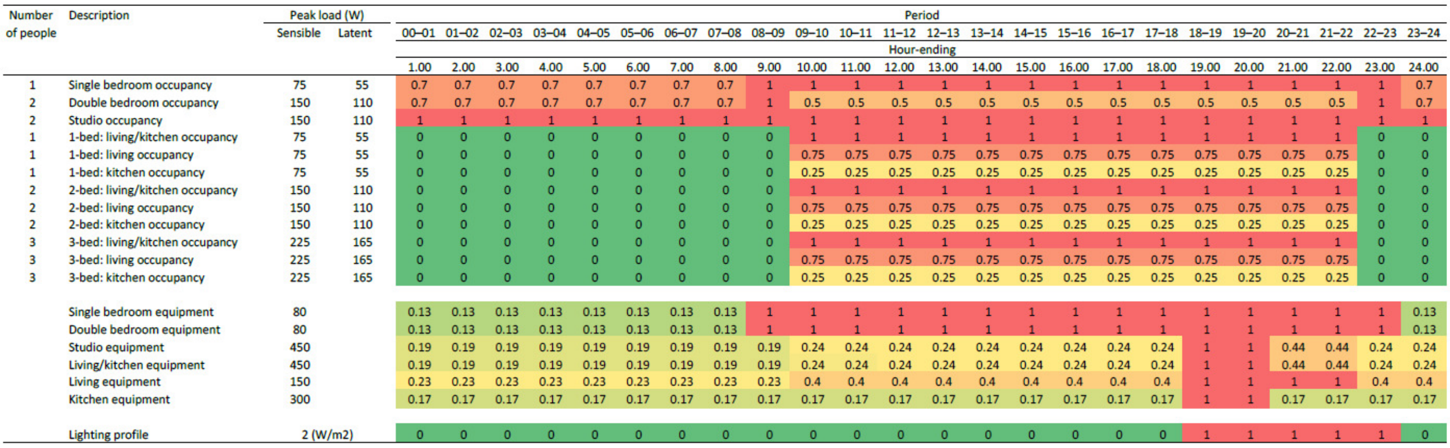
b) Kitchens/living rooms are unoccupied during the sleeping hours and occupied during the rest of the
day. This is the worst-case scenario since the room will be modelled as occupied only during the hottest hours of the day.

c) No differences between weekdays and weekend are considered. Moreover, the overall apartment will be modelled as occupied for 24 hours.

d) Occupied hours should be totalled, as described in CIBSE TM52, as 3672 hours per year for bedrooms (24/7 for the May–September dates covered) and 1989 hours per year for living rooms (13 hours per day for 153 days May–September). This provides a useful check that profiles have been correctly applied.

e) Bedroom windows are modelled as to be open once the internal temperature reaches 22° and the room is occupied as per the above occupancy profile.

f) Living Room windows are modelled as to be open between 9AM to 10PM once the internal temperature reaches 22° and the room is occupied as per the above occupancy profile.



Number of people	Description	Peak load (W)		Period																							
		Sensible	Latent	00–01	01–02	02–03	03–04	04–05	05–06	06–07	07–08	08–09	09–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24
				Hour-ending																							
				1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
1	Single bedroom occupancy	75	55	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.7
2	Double bedroom occupancy	150	110	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.7
2	Studio occupancy	150	110	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1-bed: living/kitchen occupancy	75	55	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
1	1-bed: living occupancy	75	55	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
1	1-bed: kitchen occupancy	75	55	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
2	2-bed: living/kitchen occupancy	150	110	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
2	2-bed: living occupancy	150	110	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
2	2-bed: kitchen occupancy	150	110	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
3	3-bed: living/kitchen occupancy	225	165	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
3	3-bed: living occupancy	225	165	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
3	3-bed: kitchen occupancy	225	165	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
	Single bedroom equipment	80		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.13
	Double bedroom equipment	80		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.13
	Studio equipment	450		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	1	1	0.44	0.44	0.24	0.24
	Living/kitchen equipment	450		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	1	1	0.44	0.44	0.24	0.24
	Living equipment	150		0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1	1	1	1	0.4	0.4
	Kitchen equipment	300		0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	1	1	0.17	0.17	0.17	0.17
	Lighting profile	2 (W/m2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0

2.7 Occupancy

In accordance with the methodology of CIBSE TM 59 and based on CIBSE Guide A (2015a), a maximum sensible heat gain of 75 W/person and a maximum latent heat gain of 55 W/person are assumed in living spaces. An allowance for 30% reduced gain during sleeping is based on Addendum to ANSI/ASHRAE Standard 55-2010: Thermal environmental conditions for human occupancy (ASHRAE, 2013), Table 5.2.1.2 'Metabolic rates for typical tasks'. The occupancy and equipment gain profile developed

Table 2 Occupancy and equipment gain descriptions

Unit/ room type	Occupancy	Equipment load
Studio	2 people at all times	Peak load of 450 W from 6 pm to 8 pm*. 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and 10 pm to 12 pm Base load of 85 W for the rest of the day
1-bedroom apartment: living room/kitchen	1 person from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
1-bedroom apartment: living room	1 person at 75% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
1-bedroom apartment: kitchen	1 person at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm Base load of 50 W for the rest of the day
2-bedroom apartment: living room/kitchen	2 people from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
2-bedroom apartment: living room	2 people at 75% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
2-bedroom apartment: kitchen	2 people at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm Base load of 50 W for the rest of the day
3-bedroom apartment: living room/kitchen	3 people from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
3-bedroom apartment: living room	3 people at 5% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
3-bedroom apartment: kitchen	3 people at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm base load of 50 W for the rest of the day
Double bedroom	2 people at 70% gains from 11 pm to 8 am 2 people at full gains from 8 am to 9 am and from 10 pm to 11 pm 1 person at full gain in the bedroom from 9 am to 10 pm	Peak load of 80 W from 8 am to 11 pm Base load of 10 W during the sleeping hours
Single bedroom (too small to accommodate double bed)	1 person at 70% gains from 11 pm to 8 am 1 person at full gains from 8 am to 11 pm	Peak load of 80 W from 8 am to 11 pm Base load of 10 W during sleeping hours
Communal corridors	Assumed to be zero	Pipework heat loss only; see section 3.1 above

SECTION 3 ENERGY EFFICIENCY & SUSTAINABILITY

3.1 Reducing Energy Consumption – Building Fabric

In order to reduce the energy consumption of the heating and lighting systems, integration between the architects, services engineer and structural engineer is required. This approach ensures the form of the building seeks to minimise heat gains in summer and heat loss in winter and also ensures that the choice of heating and ventilation systems will complement the building design and vice versa.

3.1.1 Elemental U-Values

The U-Value of a building element is a measure of the amount of heat energy that will pass through the constituent element of the building envelope. Increasing the insulation levels in each element will reduce the heat lost during the heating season and this in turn will reduce the consumption of fuel and the associated carbon emissions and operating costs.

It is possible to exceed the requirements of the current building regulations. The current target U-Values are identified below:

Element	**New Buildings & extensions to existing buildings [W/m²k]**	**Proposed for this development [W/m²k]**	**Percentage Improvement**
Walls	0.18	0.18	0%
Floors	0.18	0.15	16.66%
Windows	1.4	1.40	0%
Roofs	0.20	0.15	25%

3.1.2 Air Permeability

A major consideration in reducing the heat losses in a building is the air infiltration. This essentially relates to the ingress of cold outdoor air into the building and the corresponding displacement of the heated internal air. This incoming cold air must be heated if comfort conditions are to be maintained. In a traditionally constructed building, infiltration can account for 30 to 40 percent of the total heat loss; however, construction standards continue to improve in this area.

With good design and strict on-site control of building techniques, infiltration losses can be significantly reduced, resulting in equivalent savings in energy consumption, emissions and running costs.

In order to ensure that a sufficient level of air tightness is achieved, air permeability testing will be specified in tender documents, with the responsibility being placed on the main contractor to carry out testing and achieve the targets identified in the tender documents.

A design air permeability target of **$3\ m^3/m^2/hr$** has been identified

Air testing specification will require testing to be carried out in accordance with:

- BS EN 13829:2001 'Determination of air permeability of buildings, fan pressurisation method'
- CIBSE TM23: 2000 'Testing buildings for air leakage'

3.2 Low Carbon & Renewable Energy Solutions

The building services design on any project is responsible for a large part of how a building will consume energy. The design of heating, ventilation and lighting systems will determine the energy consumption characteristics of the building.

The approach that has been adopted to delivering a development which is both highly efficient and sustainably designed has been to involve all members of the design team from the earliest possible stage in the design process. This integrated design approach will be continued throughout the design process.

This approach ensures that the knowledge and expertise of each member of the design team was available from the outset. The goals for sustainable design were identified at this early stage and each element of the design was progressed accordingly.

Several renewable and low carbon technologies were considered during the preliminary design process.

3.2.1 Combined Heat & Power

The inclusion of combined heat and power plant in any building scheme must be given very careful consideration due to the large capital costs involved and the potential risk of higher running costs than would be incurred if separate heating plant and grid electricity were used.

The most important consideration when designing CHP plant is to carefully assess both the heat load and the electrical load. A CHP installation will typically operate at approximately 80% combined efficiency. Approximately 60% of the useful output will be thermal energy with the remaining 40% being available as electric energy.

E.g. a CHP plant which consumes 100kWhrs of gas will produce approximately 80kWhrs of useful output. 50 kWhrs of this output will be available as thermal energy while the electric energy output will be 30kWhrs.

Following analysis, CHP has not been included in the scheme.

3.2.2 Heat Pump Technology

The general principal of heat pump technology is the use of electrical energy to drive a refrigerant cycle capable of extracting heat energy from one medium at one temperature and delivering this heat energy to a second medium at the desired temperature. The basic thermodynamic cycle involved is reversible which allows the heat pump to be used for heating or cooling.

The efficiency of any heat pump system is measured by its coefficient of performance (CoP). This is a comparison between the electrical energy required to run the heat pump and the useful heat output of the heat pump, e.g. a heat pump requiring 1kW of electrical power in order to deliver 3kW of heat energy has a CoP of 3.0.

This operating principle can be applied to different situations, making use of the
Most readily available heat source on any given site. The most common types are.

- Ground Source
- Water Source
- Air Source

Water source heat pumps generally offer the highest CoP however they can be more expensive to install and must have a source of water from a well, lake or river.

Air-source heat pump technology has been included.

3.2.3 Bio-Mass Boilers

The use of bio-fuel in the form of wood chip or wood pellet can provide a realistic alternative to conventional fuels such as oil or gas. In terms of heat output, biomass boilers operate in exactly the same manner as conventional oil or gas fired boilers. There are, however, important differences to be considered.

The major drawback of a biomass heating system is the inconvenience associated with supply and storage of fuel, the increased maintenance of the boiler plant when compared to gas or oil-fired systems and the increased capital costs. The advantage of the system, however, is the practically zero net carbon emissions associated with the combustion of wood products and the marginal cost savings which can be achieved.

When natural gas is available as a potential fuel source it is always very difficult to make a sound financial argument for the inclusion of biomass heating systems. The unit cost of wood pellet or indeed wood chip (although slightly cheaper than pellet) is generally only marginally less than the unit of cost of natural gas (less than 10%).

This marginal saving is typically offset by the increase in maintenance costs and is never sufficient to offset the increase in capital costs associated with this installation of the biomass systems.

Biomass technology will not be included in the development.

3.2.4 Solar Water Heating

Solar thermal collection uses of the sun's energy and transfers the heat generated to the building's domestic hot water supply. Two distinct types of collection panel are available. The evacuated tube array and the flat panel collector. The evacuated tube array is the more effective of the two as it is capable of generating approximately twice as much hot water from the same surface area of flat panel.

Solar thermal collection can deliver up to 50% of the total annual hot water load of a Building.

Solar thermal technology will not be included in the development.

3.2.5 Photovoltaic (PV) Panels

PV Panels are capable of generating direct current electricity from the sun's energy, which can then be converted to alternating current and used within the building. They are generally a "maintenance free" technology as there are no moving parts. They also typically have a 20-year manufacturer's guarantee on electrical output and can be expected to operate effectively for 30 years or more.

Capital costs have also reduced significantly in recent years due to worldwide increase in production levels, particular from China. They are adaptable and scalable in that the amount installed can be selected to suit the budget available.

PV panels are not included.

3.2.6 Wind Turbines.

Due to the urban nature of the site wind energy has not been considered.

SECTION 4 PROPOSED HEATING STRATEGY

The building services strategy for The Connolly Quarter is to utilize as many sustainable design options and energy efficient systems that are technically, environmentally and economically feasible for the project to achieve low energy and environmentally friendly buildings, while also providing quality accommodation maximizing user health and wellbeing.

The design team also recognizes the need for the development to be designed to maximize reliability and maintainability of the installations to efficiently operate the development in a sustainable manner.

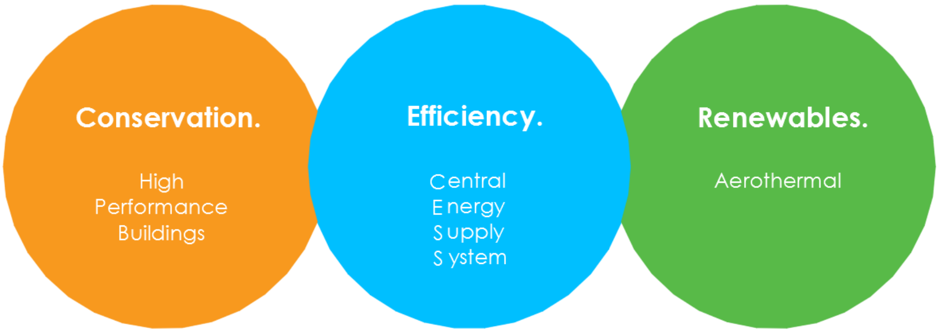
The preferred Heating Strategy taking cognizance of the above is a centralized low temperature heating scheme incorporating Air Source Heat Pumps, High Efficiency Condensing Gas Boilers, Thermal Storage, coupled to Heat Interface Units within each apartment to provide space heating and instantaneous domestic hot water heating.

As there is a common Basement under the development, a Central Heat Generation Plant with horizontal piped distribution throughout the development can be considered.

It is proposed that a centralized heating system to serve The Connolly Quarter would be designed to the following current best practice guidelines:

- Heat Networks Code of Practice" CP1 2017 as published by CIBSE and Association for Decentralized Energy (ADE).
- A Technical Guide to District Heating FB 72 2014.
- CIBSE AM 12 Combined Heat and Power for Buildings.
- CIBSE AM 14 Non-Domestic Hot Water Heating Systems.
- BSRIA BG 62/2015 Heat interface units.

The implementation of a low temperature centralized distribution approach is a key component to providing the framework for integration of sustainable renewable energy technologies such as Air Source Heat Pumps, reducing heat distribution losses and at the same time reducing specific building energy consumption in a cost-effective manner considering economy of scale. This will require a lean approach in relation to the whole system design.



High performance buildings will reduce the energy demand on site by passive means.

Deliver Energy Efficiently with a Central Energy Supply System.

Incorporate renewables as the primary source of thermal energy.

District heating systems generate heat in a centralized location and distribute it amongst multiple different buildings for space heating and domestic hot water heating. District heating has evolved where 1st generation systems typically distributed steam at high temperatures which resulted in high heat losses and operated at low efficiency to more recently 3rd generation systems which operated at lower temperatures of approximately 80°C flow temperature, 60-70°C return temperatures.

The system considered for The Connolly Quarter is the natural progression to the previous iterations which is a Next Generation Low Temperature system operating at lower flow and return temperatures of 65°C Flow - 35°C return.

The central plant proposed incorporates Air Source Heat Pumps coupled with thermal storage as the primary Heat Source capable of offsetting 90% of the annual thermal demand. High Efficiency Condensing Gas Boilers will cover the remaining 10% of the annual peak thermal demand.

The Heat Pump units considered will operate at an SCOP of 3.8 - e.g. each unit requires 1kW of electrical power in order to deliver 3.8 kW of heat energy.

The unit's efficiency would be optimized by minimizing the leaving water temperature as low as practicable but taking cognizance of the minimum temperatures required to generate domestic hot water (DHW) to an adequate temperature to prevent legionella colonizing domestic hot water installations. The units would be selected to generate low temperature hot water at a flow temperature of 65°C for space heating and DHW production.

The units shall be equipped robust screw compressors, capable of variable capacity & variable refrigerant control for capacity modulation.

Thermal Storage (TES)

It is beneficial to close couple Heat Pumps with a Thermal Storage System (TES) for a number of purposes.

TES could enable the proposed units to operate at low night time electricity tariffs to generate low temperature hot water for heating and DHW at night which will be drawn off during the day to offset a proportion of the heating load. TES may also decrease peak electrical infrastructure required on site.

TES also serves the purpose of extending the life of plant by preventing On / Off short cycling of plant which occur at times of low heat demand when the plant will produce heat at a faster rate than can be used by the system. The low temperature heat storage tanks shall act as a store to absorb part of the heat pump output when the system load is below the minimum operating output of the plant. This stored heat is then used at the start of the heating period each day when the buffer will discharge in a controlled manner to satisfy part or all of the initial peak heat demand while the central plant heats up to satisfy the peak instantaneous DHW demand.

SECTION 5 RESULTS

5.1 Energy Results

The following table shows the energy performance criteria, carbon performance criteria and renewable energy ratio of the current proposed strategy.

The BER achieved is also given, although this is not a requirement for NZEB compliance.

		Compliant
Proposed BER Rating	A2 / A3	Yes
EPC	0.28	Yes
CPC	0.27	Yes
Renewable Energy Ratio	32%	Yes
NZEB Compliant	Yes	

NOTE:

The optimum solution will be finalized and decided upon once the associated finalized ratified calculation tool associated with TGD L 2019 is formally published by Department of Environment (DOE).

The DOE have not yet confirmed if PRS Schemes are covered by TGD L Domestic or Non-Domestic.

We have the ability to adjust the design to suit the requirements of Domestic or Non-Domestic in compliance with TGD L once determined by the DOE.

5.2. Overheating Results

Criteria A (All Rooms)

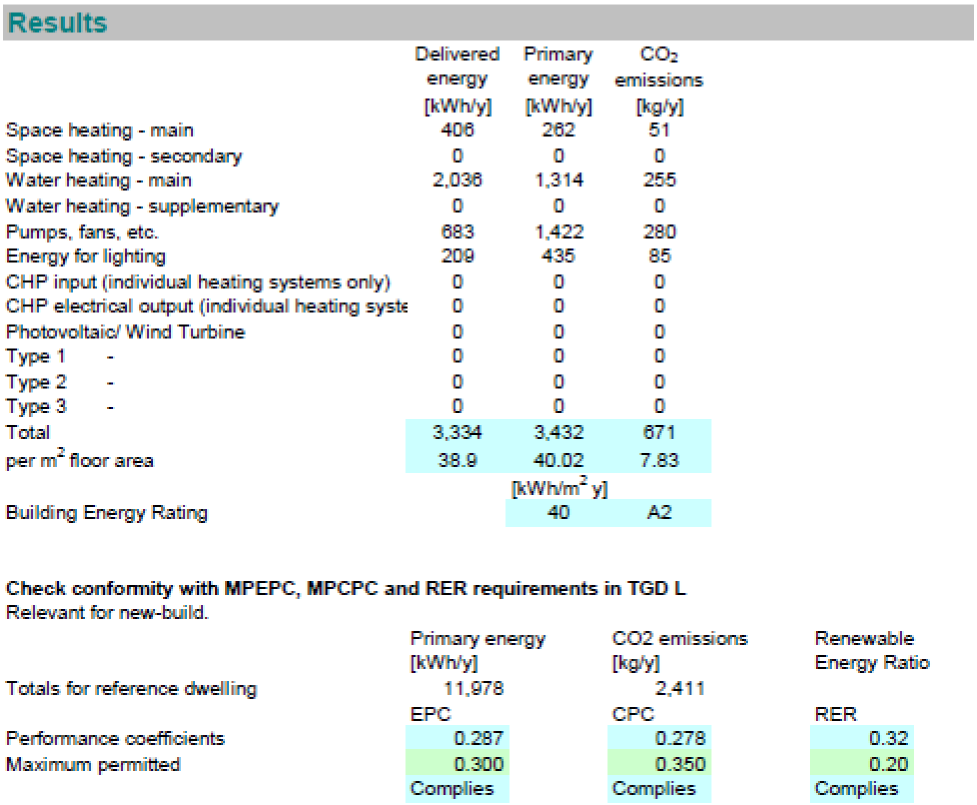
Room Name	Criteria 1 (%Hrs Top-Tmax>=1K)	Limit %	Result
L07 - Bedroom 1	0.1	3	Pass
L07 - Kitchen	0	3	Pass
L07 - Bedroom 2	0.1	3	Pass
L20 - Bedroom 1 (Apt. 1)	0	3	Pass
L20 - Bedroom 2 (Apt. 1)	0.1	3	Pass
L20 - Kitchen (Apt 1)	0	3	Pass
L20 - Bedroom 1 (Apt. 2)	0.1	3	Pass

Criteria B (Bedrooms only)

Room Name	Percentage of annual hours at 26°	Limit %	Result
L07 - Bedroom 1	0	1	Pass
L07 - Kitchen	0	1	Pass
L07 - Bedroom 2	0	1	Pass
L20 - Bedroom 1 (Apt. 1)	0	1	Pass
L20 - Bedroom 2 (Apt. 1)	0	1	Pass
L20 - Kitchen (Apt 1)	0.1	1	Pass
L20 - Bedroom 1 (Apt. 2)	0	1	Pass
Total hours (% of sum)	0	1	Pass

It can be seen from the above table of results that the apartments tested comfortably comply in full with TM59 as required.

APPENDIX A TYPICAL APARTMENT DEAP OUTPUT



Results

	Delivered energy [kWh/y]	Primary energy [kWh/y]	CO_2 emissions [kg/y]
Space heating - main	406	262	51
Space heating - secondary	0	0	0
Water heating - main	2,036	1,314	255
Water heating - supplementary	0	0	0
Pumps, fans, etc.	683	1,422	280
Energy for lighting	209	435	85
CHP input (individual heating systems only)	0	0	0
CHP electrical output (individual heating syste	0	0	0
Photovoltaic/ Wind Turbine	0	0	0
Type 1 -	0	0	0
Type 2 -	0	0	0
Type 3 -	0	0	0
Total	3,334	3,432	671
per m^2 floor area	38.9	40.02	7.83
		[kWh/m^2 y]	
Building Energy Rating		40	A2

Check conformity with MPEPC, MPCPC and RER requirements in TGD L
Relevant for new-build.

	Primary energy [kWh/y]	CO2 emissions [kg/y]	Renewable Energy Ratio
Totals for reference dwelling	11,978	2,411	
	EPC	CPC	RER
Performance coefficients	0.287	0.278	0.32
Maximum permitted	0.300	0.350	0.20
	Complies	Complies	Complies