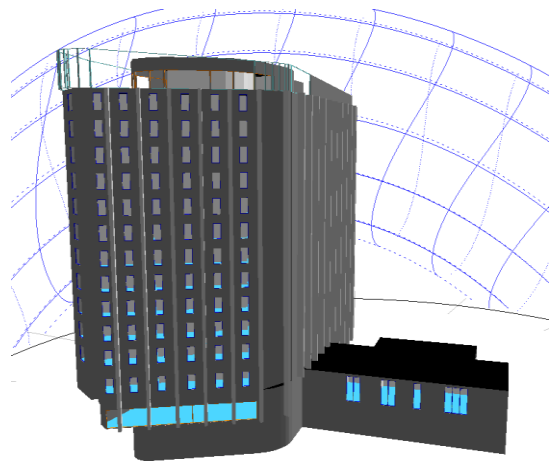


**Energy Strategy Report
For**



**Proposed T2 Hotel Development
Terminal 2
London Heathrow Airport
for**

**GROVE
DEVELOPMENTS**

**on
07/09/2017
REV: 05**

Overview

The proposed T2 Hotel development is subject to London Mayor's Sustainable Design and Construction Supplementary planning guidance. Planning requirements for the T2 Hotel stipulates the hotel must ensure at least a 35% reduction in carbon emissions below 2015 Part L Building Regulations Benchmark.

This report outlines the strategy employed for the development to ensure compliance with the planning requirement. Three different options were assessed in stages against the Part L Benchmark as to illustrate their effect on the overall reduction of carbon emissions.

The proposed hotel development includes connection to the Heathrow Airport Limited (HAL) District Heating and it has been confirmed that planned modifications at Heathrow Energy Centre are scheduled for summer 2018, which will see decarbonation of this system; with further improvements potentially realised once T3 and T4 are connected (envisaged for 2022), therefore this report assess the EPC performance based on three district heating system timeframes (and their associated carbon factors): current 2017 and envisaged 2018/2022 scenarios.

It has been confirmed by HAL (correspondence dated 23rd July 2017) that modifications at Heathrow Energy Centre would see significant decarbonisation of the existing district heating system. As these ameliorates are scheduled to occur in summer 2018, this would result in the T2 Hotel utilising district heating for domestic hot water (the buildings primary energy use within the EPC methodology) at a considerable reduced carbon intensity at the time of handover, then currently delivered by the system.

It has been determined that this schedule upgrade to the HAL Energy Centre associated decarbonisation would result in T2 hotel considerably exceeding the London Plan target (35%), with carbon reduction of 45% below Part L Benchmark.

It is anticipated that further decarbonisation of the HAL District Heating may be achieved in the future once other terminal Energy Centres are connected. This is envisaged (T3 and T4) to occur circa 2022 and was determined to result in projected carbon reductions against Part L Benchmark to future increase to 52%.

The report identifies how a carbon emission reduction of 28.2% on the 2015 Building Regulations benchmark was determined to be achieved based on current District Heating system performance. Although this is 6.8% below the required target for the London plan, there are a number of site-related restrictions and constraints which make this 35% reduction considerably difficult to achieve.

A range of renewable energy generation options have been considered and assessed in the context of this development, but due to unavailability of installation space, unfeasible renewable resources and various other site-related restrictions, a renewable energy installation is not feasible at this site. These constraints are discussed in further detail within this report. For example, it was determined that a notional CHP connection (not viable due to restriction of gas on site) would achieve target.

A level 5 dynamic simulation was completed for the development to confirm the predicted carbon reduction from the benchmark and to confirm the predicted Part L results. The analysis was based on construction drawings received from Grove Developments. The assessment was carried out using approved software by our in-house accredited UK Part L and EPC assessor.

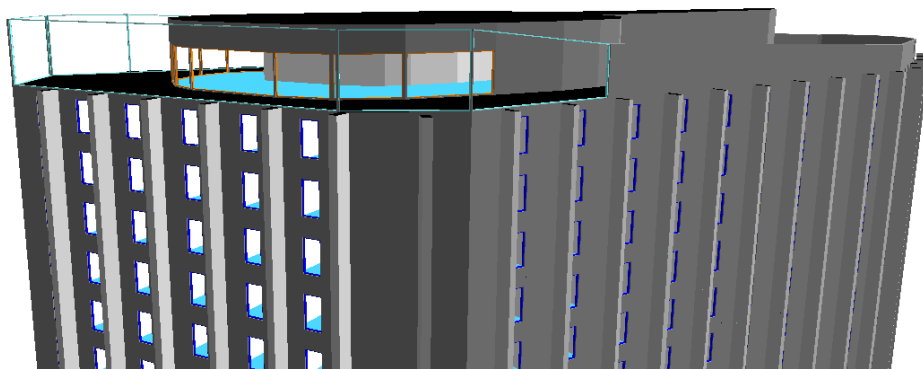
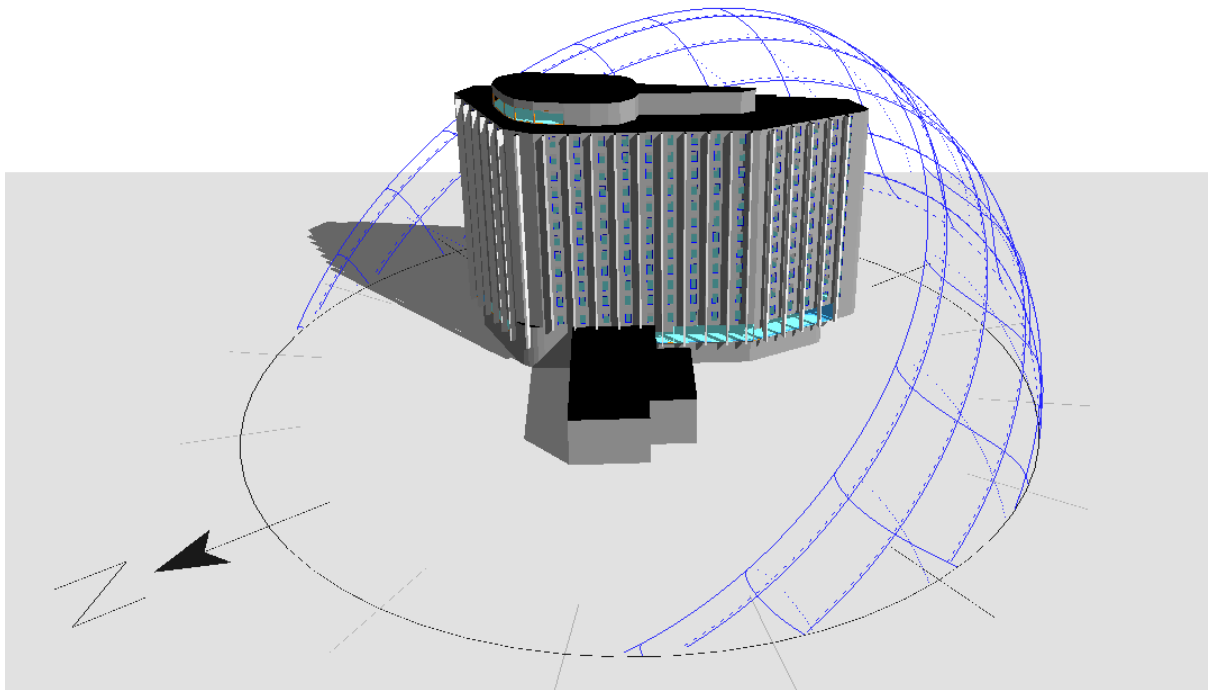


Figure 1: 3D Model for T2 hotel

1.0 Reduction in CO₂ Emission

As part of the planning application, requirements from the Mayor's Sustainable Design and Construction planning guidance, the Hotel is required to ensure a 35% reduction in carbon emissions over the 2015 Building Regulations.

The benchmark is determined by the Part L methodology and is shown below.

OPTION	Energy Type	Building Energy Consumption (kWh/m ²)						Carbon Emissions		
		HTG	HWS	CLG	AUX	LTG	CHPe	Total REG. kgCO ₂ /m ²	Tonnes of Carbon	Improvement on Benchmark
Part L Benchmark	HTG: GB HWS: GB CLG: FC	2.54	191.42	9.41	21.55	13.11		64.19	993	NA

The table below illustrates the 35% reduction in CO₂ from the benchmark.

Energy Type	Total kgCO ₂ /m ²	Tonnes of Carbon	Improvement on Benchmark
Part L Benchmark Notional	64.19	993	NA
Required Reduction	42.00	649	35%

In order to determine if reduction was being achieved, the following options were assessed:

A) Benchmark – Fan Coil Units

This iteration represents the building's carbon emissions associated with a compliant Part L design.

As per the methodology, the air conditioning to the bedrooms was assumed to be fan coil units, served from centralised gas-fired boiler and air-cooled chiller plant. This iteration provided the benchmark carbon emissions.

Part L Benchmark has been updated due to changes in the building envelope, addition of spaces such as offices and the changes of areas in spaces.

B) District Heating, Air Source Heat Pumps, Electric Heaters and VRF

This option represents the proposed design for T2 Hotel. Each option was done in stages as to illustrate how the change of plant affected the overall result.

A range of renewable energy options were assessed in order to determine their respective viability for this particular development, in the interests of increasing the energy and carbon performance of the building. The below summarises the viability analysis performed and the outcome of each:

- **CHP:** There is no existing natural gas infrastructure at the site and as such combined heat and power (CHP) cannot be utilised to satisfy electrical and thermal loads.
- **Solar Thermal & PV:** A Solar Thermal or PV installation is not possible at this site due to a lack of available installation space at roof level due to the extent of mechanical plant layout. Furthermore, the roof footprint to gross floor area ratio is ineffective in terms of solar generation.

- **Wind Energy:** Wind energy would not be economically feasible at low levels due to low wind speeds and high levels of turbulence. At higher elevations, the wind resource available is more economically feasible, but as per above, the required space at roof level for turbine mounting is not available. Furthermore, the height of turbine required to considerably impact the environmental performance of the building would be impractical in the context of an airport site.
- **Biomass Energy:** A Biomass energy installation would not be feasible due to the considerable storage space required and the logistical issues with site delivery. Also, the flue emissions from this installation would be significant and would have a considerable impact on the site air quality.
- **Geothermal Energy:** A geothermal energy system or ground source heat pump installation has been considered; however, the high temperatures required for domestic hot water generation (i.e.: $>60^{\circ}\text{C}$) in order to reduce legionella risk are not compatible with these systems as the coefficient of performance (COP) and associated system efficiency is poor at these higher temperatures. This is even more significant for a hotel development where there is generally a significant demand for domestic hot water. Additionally, the extent of existing below-ground site services would be restrictive for this type of installation.

Due to the relevant site restrictions listed above and the infeasibility of assessed renewable energy options, all electrical loads within the building will be satisfied by means of grid-imported electricity, while domestic hot water generation are to be served from the existing on-site LTHW district heating network.

The improvement in carbon emissions from the benchmark building is due to the utilisation of district Air Source Heat Pumps and Variable Refrigerant Flow (VRF) systems in combination with an energy efficient design for lighting, fans and pumps. Electric Heaters will be utilised in Ground B

As a gas supply is not available at the site for the use of either gas boiler or CHP (due to the HAL's gas supply security strategy which seeks to remove gas supplies from CTA), T2 Hotel will avail of the local district heating infrastructure for domestic hot water. The carbon factor for district heating $0.189 \text{ kgCO}_2/\text{kWh}$.

Further scheduled improvements are envisaged connections to the District Heating have been confirmed to reduce this carbon factor to $0.126 \text{ kgCO}_2/\text{kWh}$ and $0.10 \text{ kgCO}_2/\text{kWh}$ during 2018 and 2022 (estimated) respectively.

Variable Refrigerant Flow (VRF) heat pumps were also utilised with local units in each guest rooms. The grid supplied electricity is used to operate the heat pumps has a carbon factor of $0.519 \text{ kgCO}_2/\text{kWh}$.

Air Source Heat Pumps and Electric Heaters were utilised as a source of heating to specified areas. These heating systems utilise the grid supplied electricity to operate.

2.0 Technical Data / Assumptions

Building Fabric

External Wall: Panel 003, U-Value 0.2W/m²K:

Building Construction			
Building Fabric	U-value (Part L)	General Fabric Details	
Walls	0.20 W/m ² /k	Air Tightness:	5 m ³ /hr/m ²
Roof Flat	0.16 W/m ² /k	Glazing (g) Value	0.5
Ground	0.20W/m ² /k		
Windows	1.10 W/m ² /k		

CO₂ factor

- District Heating: 0.189 kg/kWh
- Grid Supplied Electricity: 0.519 kg/kWh
- Natural Gas: 0.216 kg/kWh

Heating

- Air Source Heat Pump.
- VRF to Guest bedrooms and Office spaces.
- Electric Heaters to Ground Back of House (BOH) etc.

Domestic Hot water

- District Heating

Ventilation

- Heat Recovery Units (HRU) to all guest rooms. SFP of 1.6 W/(l/s).
- Air Handling Units (AHU) to Restaurant, SFP of 1.6 W/(l/s).
- Air Handling Units (AHU) to Lobby/ Reception, SFP of 1.6 W/(l/s).
- Air Handling Units (AHU) to Kitchen, SFP of 1.6 W/(l/s).
- Air Handling Units (AHU) to Bar, SFP of 1.6 W/(l/s).
- Air Handling Units (AHU) to Back of House, SFP of 1.5 W/(l/s).
- Air Handling Units (AHU) to WC, SFP of 1.5 W/(l/s).
- Air Handling Units (AHU) to Meeting Rooms, SFP of 1.6 W/(l/s).
- Supply and Extract fans to circulation spaces, SFP of 0.6 W/(l/s) and 0.5 W/(l/s) respectively.
- All SFP to comply with UK Building Regulations

Cooling

- Variable Refrigerant Flow (VRF); unit SEER = 5.5

Lighting

- 100 lumens/circuit watt.
- Presence detection PIR control Auto On/Off to Bedroom Spaces.
- Absence detection to Office Spaces, meeting rooms and consultation rooms.
- Photocell Daylight Control in Office Spaces where average daylight factor exceeds 2%.

3.0 Results

3.1 Options

Five different options have been assessed for against the Part L Bench Mark. The following table lists the different plant systems used for each of the option.

OPTIONS	Plant Breakdown For Each Option		
	HTG	HWS	CLG
Part L Benchmark	Gas Boiler (GB)	Gas Boiler (GB)	Fancoil Units (FC)
1	District Heating (DH) 2017 + Variable refrigerant flow (VRF)	District Heating (DH) 2017	Variable refrigerant flow (VRF)
2	Combined Heat & Power (CHP) + Variable refrigerant flow (VRF)	Combined Heat & Power (CHP)	Variable refrigerant flow (VRF)
3	AIR Source Heat Pumps (ASHP) + Variable refrigerant flow (VRF) + Electric Heaters (EH)	District Heating (DH) 2017	Variable refrigerant flow (VRF)
4	AIR Source Heat Pumps (ASHP) + Variable refrigerant flow (VRF) + Electric Heaters (EH)	District Heating (DH) 2018	Variable refrigerant flow (VRF)
5	AIR Source Heat Pumps (ASHP) + Variable refrigerant flow (VRF) + Electric Heaters (EH)	District Heating (DH) 2022	Variable refrigerant flow (VRF)

Part L Benchmark: Under the requirements of the building regulations, the Part L Benchmark utilises a gas boiler for its heating and hot water demand. Fancoils are used to meet the cooling demand for the hotel. This benchmark building is then compared to that of the proposed plant installation.

Option 1: utilises District Heating (DH) for heating and hot water. Variable Refrigerant Flow (VRF) units to be installed in the guest rooms and office spaces as well as any other specified areas. This option was assessed as to current district heating carbon factors of 0.189kg/CO₂/kWh.

Option 2: is assessed as a comparison between the current district heating system and the installation of a Combined Heat and Power (CHP). The CHP provides for the heating and hot water demand.

Option 3: This option is the Value Engineering option. Air Source Heat Pumps (ASHP), Electric Heaters (EH) and VRF units are utilised for the heating system. District heating is utilised for the hot water demand only. VRF are used for the cooling.

Option 4: This option assesses the scheduled 2018 decarbonisation of the HAL District Heating System. The Carbon Factor of the District Heating system is set to drop from 0.189kgCO₂/kWh to 0.126kgCO₂/kWh by 2018.

Option 5: The Carbon intensity of the District Heating system is envisaged further reduce to 0.100kgCO₂/kWh by 2022. This option assesses the Hotel performance for further decarbonisation.

3.2 Results

The table below compares the energy breakdown and the resulting carbon emissions for the Part L Benchmark building against the proposed building option.

OPTION	Energy Type	Building Energy Consumption (kWh/m ²)						Carbon Emissions		
		HTG	HWS	CLG	AUX	LTG	CHPe	Total REG. kgCO ₂ /m ²	Tonnes of Carbon	Improvement on Benchmark
Part L Benchmark	HTG: GB HWS: GB CLG: FC	2.54	191.42	9.41	21.55	13.11		64.19	993	NA
1	HTG: DH, VRF HWS: DH 2017 CLG: VRF	1.49	174.18	2.64	13.80	8.35		46.07	712	28.2%
2	HTG: CHP, VRF HWS: CHP CLG: VRF	1.68	286.13	2.64	13.80	8.35	68.95	39.24	607	38.9%
3	HTG: ASHP, VRF, EH HWS: DH 2017 CLG: VRF	0.87	174.18	2.64	13.80	8.35		46.10	713	28.2%
4	HTG: ASHP, VRF, EH HWS: DH 2018 CLG: VRF	0.87	174.18	2.64	13.80	8.35		35.13	543	45.3%
5	HTG: ASHP, VRF, EH HWS: DH 2022 CLG: VRF	0.87	174.18	2.64	13.80	8.35		30.60	473	52.3%

The results illustrate how the potential reduction in Carbon emissions of 28.2% was determined. This would be achieved based on the proposed installations in each of the options based on current 2017 carbon factor values for district heating system.

The theoretical introduction of the CHP was predicted to enable a reduction of 39% on Carbon emissions. The CHP option is predicted to have a greater energy consumption for hot water production, due to its thermal efficiency, but this would be offset by the displaced electricity produced by the CHP, reducing its overall carbon emission value.

The Value Engineering options for the heating systems was predicted to have a negligible impact on the EPC performance, as heating energy was determined to constitute a minor part of the overall carbon intensity.

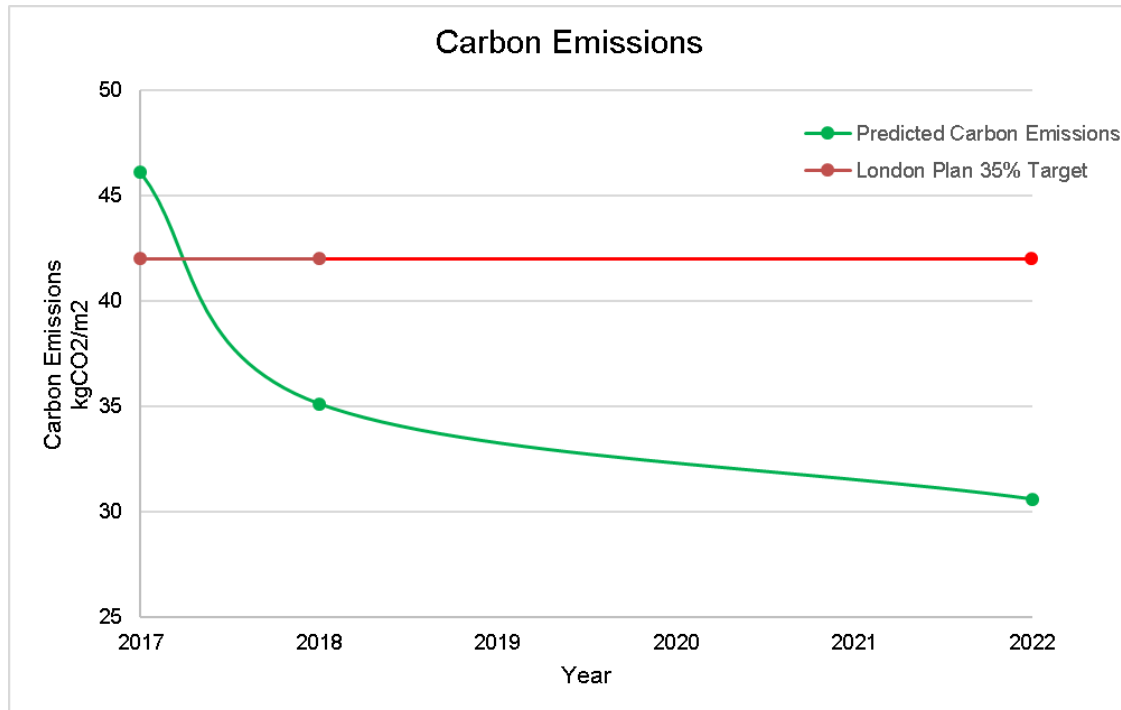
Conversely Domestic Hot water equates to approximately 70% of the building's carbon intensity. Savings in this regulated energy could yield the greatest reductions in carbon emissions. As this energy is delivered by the district heating system, future decarbonisation of this will significantly reduce carbon emissions. Carbon factors are scheduled to be reduced in the years 2018 and 2022 as follows:

- Carbon Factor 2017 (current): 0.189kgCO₂/kWh
- Carbon Factor 2018: 0.126kgCO₂/kWh
- Carbon Factor 2022: 0.100kgCO₂/kWh

Option 4 demonstrate that it was determined that from 2018 onwards, the decarbonised HAL District Heating would considerably exceed London's Plan Target, with 45% reduction against Part L Benchmark.

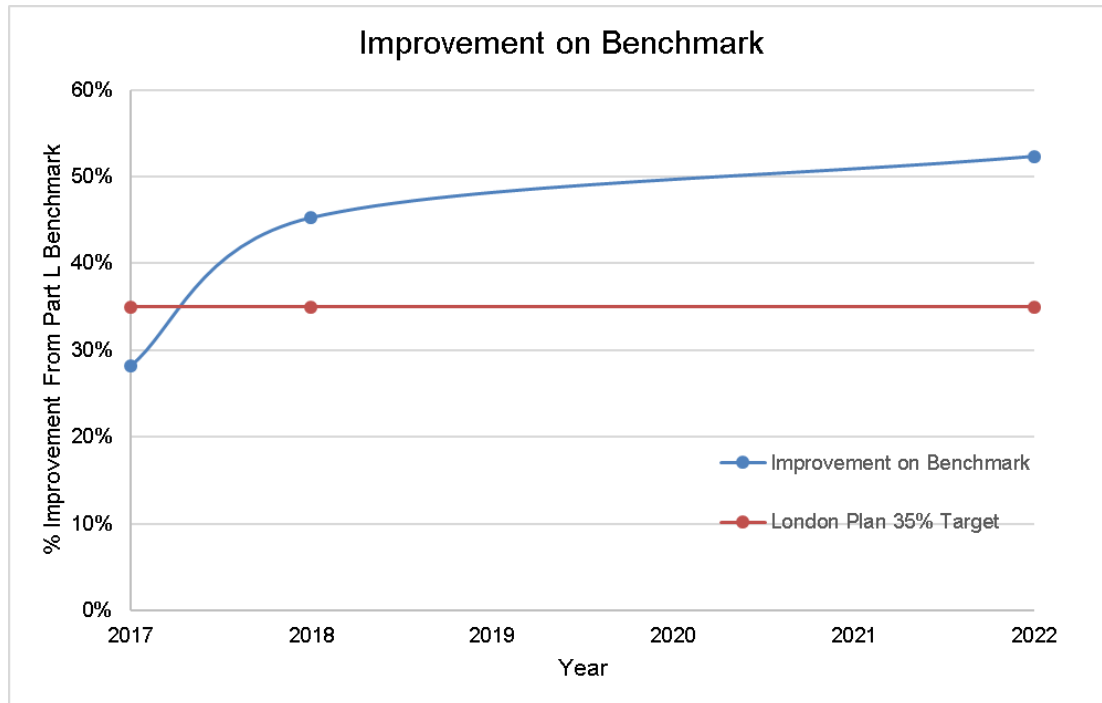
This would further improve allowing envisaged further decarbonisation in 2022, with a 52% reduction.

3.2 Results (Cont'd)



A graphical example to how the improving carbon factor for the HAL District Heating was determined to reduce carbon emissions is illustrated above. Current values based on existing district heating carbon intensity are predicted to release 46kgCO₂/m², this value is expected to drop to 35kgCO₂/m² by 2018. At this value, this would be below the 35% required benchmark value of 42kgCO₂/m². This value has been determined to further reduce to 30kgCO₂/m² by 2022.

3.2 Results (Cont'd)



The percentage improvement on the Part L Benchmark per year as the carbon factor improvements are realised can be seen above. It was determined the 28% reduction based on current 2017 carbon intensity value will not meet the required 35% reduction. At the time of handover, 2018, the decarbonisation of HAL District Heating would result in improvements of 45% against Part L Benchmark; considerably exceeding London Plan requirement. A further improvement of 52% improvement on Part L Benchmark would be envisaged with the envisaged connection with other energy centre terminals.

4.0 BRUKL Output

4.1 Benchmark

Fan Coil Units & Gas Boilers

BRUKL Output Document



HM Government

Compliance with England Building Regulations Part L 2013

Project name

T2 Hotel

As designed

Date: Tue Sep 05 18:02:24 2017

Administrative information

Building Details

Address: Terminal 2 Hotel, Heathrow Airport, London,
Postcode

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.4.1"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.4.1

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Address, City, Postcode

Certifier details

Name: William O Donnell

Telephone number: +353 1 4960900

Address: Unit B Mount Pleasant Business Park, Dublin, D6

Criterion 1: The calculated CO₂ emission rate for the building should not exceed the target

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	63.3
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	63.3
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	61.3
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 the building services should achieve reasonable overall standards of energy efficiency

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

Building fabric

Element	U _o -Limit	U _o -Calc	U _i -Calc	Surface where the maximum value occurs ¹
Wall**	0.35	0.2	0.2	External Wall
Floor	0.25	0.18	0.2	Ground Floor
Roof	0.25	0.16	0.16	Roof
Windows***, roof windows, and rooflights	2.2	1.34	1.37	Bedroom
Personnel doors	2.2	-	-	No personal doors in project
Vehicle access & similar large doors	1.5	-	-	No vehicle doors in project
High usage entrance doors	3.5	-	-	No high usage entrance doors in project

U_o-Limit = Limiting area-weighted average U-values [W/(m²K)]

U_o-Calc = Calculated area-weighted average U-values [W/(m²K)]

U_i-Calc = Calculated maximum individual element U-values [W/(m²K)]

¹ 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
m ³ /(h.m ²) at 50 Pa	10	5

4.0 BRUKL Output

4.2 Proposed Value Engineering Option

Air Source Heat Pumps, Electric Heaters, Variable Refrigerant Flow and District Heating.
2017

BRUKL Output Document



HM Government

Compliance with England Building Regulations Part L 2013

Project name

T2 Hotel

As designed

Date: Wed Sep 06 14:40:28 2017

Administrative information

Building Details

Address: Terminal 2 Hotel, Heathrow Airport, London,
Postcode

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.4.1"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.4.1

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Address, City, Postcode

Certifier details

Name: William O Donnell

Telephone number: +353 1 4960900

Address: Unit B Mount Pleasant Business Park, Dublin, D6

Criterion 1: The calculated CO₂ emission rate for the building should not exceed the target

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	51.1
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	51.1
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	46.1
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 the building services should achieve reasonable overall standards of energy efficiency

Values not achieving 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 ¹
Wall**	0.35	0.2	0.2	External Wall
Floor	0.25	0.18	0.2	Ground Floor
Roof	0.25	0.16	0.16	Roof
Windows***, roof windows, and rooflights	2.2	1.34	1.37	Bedroom
Personnel doors	2.2	-	-	No personal doors in project
Vehicle access & similar large doors	1.5	-	-	No vehicle doors in project
High usage entrance doors	3.5	-	-	No high usage entrance doors in project

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)]

¹ 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
m ³ /(h.m ²) at 50 Pa	10	5