

McDonald's Restaurants, Dearne Valley

Ene04: LZC Feasibility Report

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revision: -

Summary

This report sets out the scope and results of the LZC feasibility assessment undertaken in accordance with BREEEAM 2018 Ene04.

ZED Ltd has undertaken a LZC feasibility assessment for the proposed McDonalds restaurant at Dearne Valley at Stage 2.

Works have been undertaken by a CIBSE registered Energy Assessor and Low Carbon Consultant (LCEA206041). Predicted energy consumption and CO_2 emissions have been calculated in accordance with CIBSE AM11. Baseline building performance has been calculated using the Part L2a approach with room templates taken from the NCM (National Calculation Methodology) database.

Regulatory CO_2 emissions factors will be updated shortly to reflect the change in energy mix on a national level, i.e. the phasing-out of coal and increased capacity of photovoltaics and wind turbines. The proposed future carbon factors are compared to the current ones below:

Fuel	CO_2 Emissions Factor (kg.CO_2/kWh)		
	Current	Future	
Grid electricity	0.519	0.233	(-55%)
Natural gas	0.216	0.210	(-3%)

Table 1. CO_2 emission factors

For resilience, assessment of the feasibility and impact of LZC technology has been undertaken in the context of both current and future emissions factors.

This assessment shows that the following LZC technologies are feasible for integration into this development, resulting in a total CO_2 reduction of 5.9 tonnes CO_2/yr against current factors and 2.65 tonnes CO_2/yr against future factors:

- Solar PV
- DHW with combined ASHP & direct-electric heater

Payback calculations are based upon all- inclusive unit rates of 18.6p/kWh, for electricity, and 5.1p/kWh, for Natural Gas.

The Development

The development site is located off the Dearne Valley Parkway (A6195) in Birdwell, Barnsley at Rockingham Services.

The development compromises the construction of a two storey fast food restaurant in Birdwell in the Dearne Valley. The restaurant will provide 100 covers and include all associated food storage, food preparation, staff and welfare facilities.

A fabric-first approach to design has been taken, comprising of low thermal U-values to reduce heat loss in winter and solar-control glazing to reduce heat gain in summer. High efficiency LED luminaires and low Specific Fan Powers (SFPs) will minimise energy consumption associated with the fixed building services.

The feasibility for incorporating recognised LZC technologies has been undertaken in two stages. An initial high level desktop appraisal has been carried out to establish whether a technology is technically viable considering the site opportunities and constraints in context with building use. The second stage then considers each of the remaining technologies against the scope described in 2018 BREEAM guidance, including; payback period, the feasibility of energy export and any available grants.



Figure 1. Site location

Initial Review

Prior to detailed analysis, a high-level appraisal has been undertaken to determine broad potential.

Technology	Justification summary	Consider
Building-mounted wind turbine	The BERR wind speed database shows an average wind speed of 4.8m/s at 10m above ground level for the site region, therefore below the recommended threshold of 6m/s for economic operation. Maximum turbine height must be no more than 3m above the top of the building of 15m above the ground risking a clash with rooftop plant and plant access routes.	✗
Pole-mounted wind turbine	The BERR wind speed database shows an average wind speed of 4.8m/s at 10m above ground level for the site region, therefore below the recommended threshold of 6m/s for economic operation. As maximum turbine height must be no more than 11.1m above the ground, average wind speed is anticipated to be further impeded by shelter from the building and associated landscaping.	✗
Solar thermal water	The development site has excellent solar access and a notable demand for domestic hot water. However, as hot water is likely to be drawn off at a relatively steady rate over the course of sunlight hours, a 'recovery period' doesn't exist when solar thermal energy could be harnessed and accumulated to make a meaningful contribution.	✗
Solar Photovoltaics (PV)	The development site has excellent solar access and a relatively high and continuous demand for electricity. Although space for roof-mounted PV panels is limited, all generated electricity would be consumed within the building.	✓
Tidal/hydro	The are no significant water courses within the vicinity of the development site.	✗
Ground source heat pumps	Due to the size of the development site, the source for ground-coupled heat pumps would be limited to vertical bore holes. Ground investigation and the required drilling to satisfy the building load is expected to make this technology economically unfeasible.	✗
Air source heat pumps	Low-grade heat from an air source heat pump could be used to provide pre-heating of domestic hot water. Outdoor units could be installed onto the rooftop plant deck.	✓

Table 2.1 Initial LZC technology review

Initial Review

Technology	Justification summary	Consider
Biomass heating	Due to the level of hard landscaping and customer movement around the perimeter building, there is inadequate space for bulk fuel storage. In addition, burning biomass/biofuel may cause a negative impact upon local air quality for nearby residents.	✕
Combined Heat and Power (CHP)	A small, commercially-available CHP unit (12kWth) operating at minimum turn-down would operate for 3100 hours per annum to meet the total DHW demand, therefore below the recommended 4500-5000 hours to be economically viable.	✕
District heating	There are no known existing heat networks within the vicinity of the development.	✕

Table 2.2 Initial LZC technology review

Thermal Model

Thermal modelling has been carried out using IES-VE v2019.1 dynamic simulation software.

The thermal model has been constructed from the drawings by Elliott UK. Building envelope performance has been taken from Elliott UK also. The simulation has been carried out against the nearest, appropriate, CIBSE Test Reference Year (TRY) weather file.

Element	U-value (W/m².K)	Notes
Ground/exposed floor	0.16	50mm Screed, 2mm Steel, 160mm Mineral Fibre insulation, Polyurethane board
External walls	0.23 0.27	Brick Trespa cladding
Roof	0.20	Rigid insulation and waterproof membrane over plywood deck, with 500mm ceiling void and 20mm Ceiling tile
Windows/glazed curtain wall	1.20	Solar g-value = 0.37, visible light transmittance = 0.70
Personnel doors	1.20	Glazed door photometric performance same as windows.
Internal partitions	1.59	15mm Plasterboard, 50mm Cavity, 15mm Plasterboard
Internal floors	1.16	50mm Screed, 2mm Steel, 500mm ceiling void, 20mm Ceiling tile

Air permeability	APR (m³/h.m² @ 50Pa)	Notes
Entire building	10.0	To be tested.

Table 3. Building envelope specification

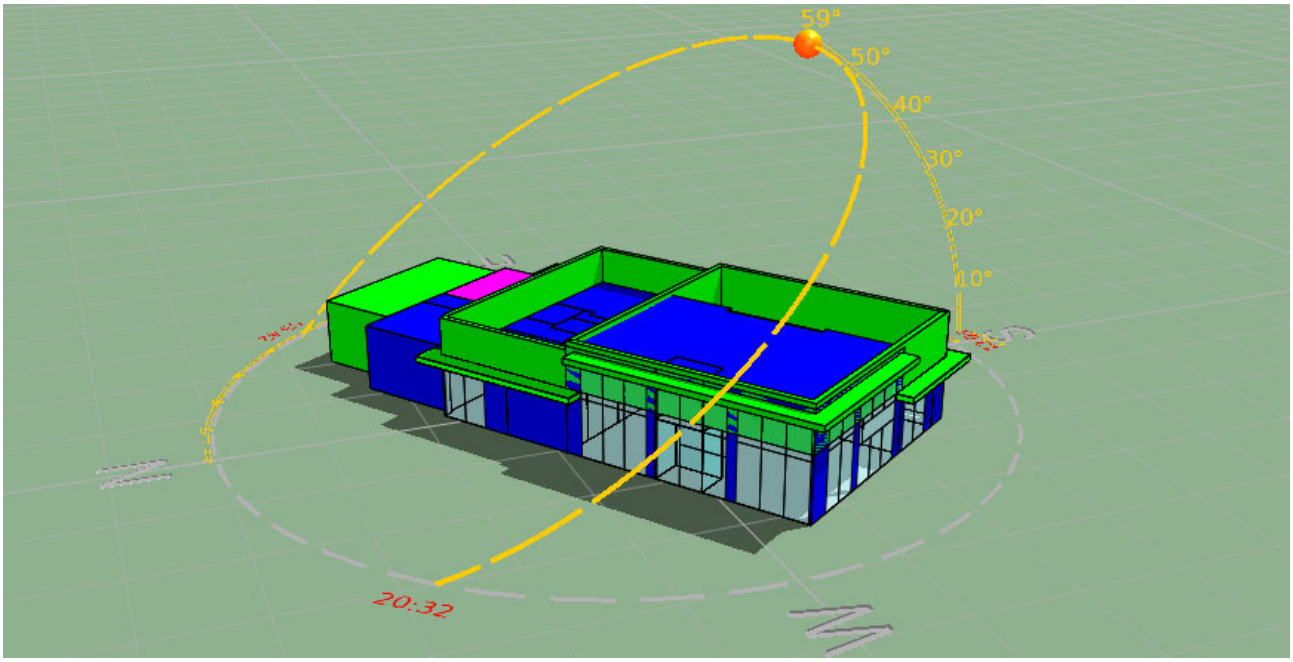


Figure 2. IES-VE thermal model geometry

Thermal Model

The energy strategy and building services performance has been taken from Stage 2 design information by Silcock Leedham Consulting Engineers

Space conditioning

Building area	System	Efficiency	Ventilation	Notes
Kitchen and Cash Booth	AHU S1 (DX150 + ZRP250)	SCOP 3.75, EER 2.73, SEER 5.40	SFP 0.80W/l/s Extract SFP 0.5W/l/s (toilets and changing only) 0.6W/l/s (Kitchen only) Casing – L2 Duct – Class A	
Dining, toilets and changing	AHU S2 (DX120 + ZRP200)	SCOP 3.68, EER 2.84, SEER 5.52	SFP 0.8W/l/s Casing- L2 Duct- Class A	
Office	A/C PKA-M35HA R32	SCOP 4.00, EER 4.14, SEER 6.30	SFP 0.8W/l/s Casing- L2 Duct- Class A	
Crew Room	A/C PKA-M50HA R32	SCOP 4.10, EER 3.71, SEER 6.40	SFP 0.6W/l/s Casing – L2 Duct – Class A	

Table 4.1. M&E specification

Domestic hot water

Building area	Source	Storage	Distribution	Notes
All areas	Instantaneous electric heater	No storage	No secondary circulation	η=95%

Internal lighting

Building area	Input method	Performance	Automatic control	Notes
All areas	Lighting efficacy supplied by LAUK	Lighting efficacies applied on a room-by-room basis from SLCE drawings.	Auto-On-Off applied to all areas but Kitchen, Dining, Cash Booth, McDelivery and Entrance Lobby.	

Table 4.2. M&E specification

Energy Demand

The building energy profile has been derived from initial Part L modelling undertaken at Stage 2.

The chart below shows the predicted energy and CO_2 for the baseline model. Results show energy attributable to pumps/fans and DHW to be dominant, while heating and cooling demand been significantly lower partly due to the incorporation of energy-efficient VRF and packaged heat pump AHU technology.

Predicted CO_2 emissions follow the same pattern with most emissions attributable to pumps/fans and DHW, with internal lighting been also significant. Conversely, CO_2 emissions attributable to heating and cooling remain low due to the reduced electricity demand.

Total regulated energy consumption = 58.9 MWh/yr
Total emissions (current factors) = 30.6 tonnes.CO_2/yr
Total emissions (future factors) = 13.7 tonnes.CO_2/yr

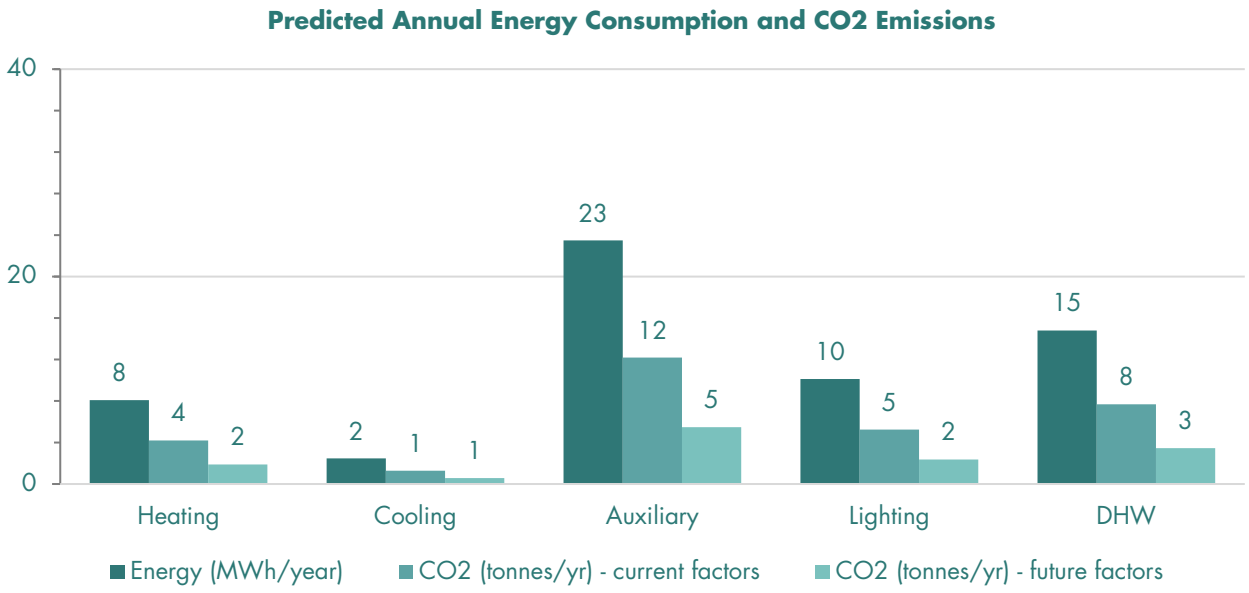


Figure 3. Predicted baseline energy consumption and CO_2 emissions (current and future factors)

Feasibility

Desktop feasibility has been based upon a combination of industry guidance and dynamic simulation modelling.

Further to the initial review, the feasibility of the following LZC technologies are considered:

- Solar Photovoltaics (PV)
- DHW with combined heat pump (ASHP) and direct-electric system

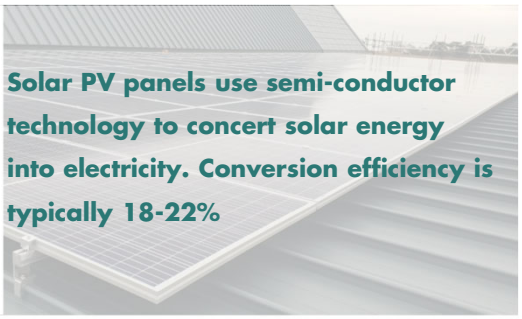
Estimated plant and fuels costs are based upon a combination of Government data, industry guidance and supplier quotations.

Fuel costs are based upon published non-domestic price records for Q1 of 2020, taken to be:

- Electricity = 18.6p/kWh, inclusive of VAT and CCL
- Gas = 5.0p/kWh, inclusive of VAT and CCL

Fuel price inflation is based on a Consumer Prices Index of 1.8%.

Solar PV



Solar PV panels use semi-conductor technology to concert solar energy into electricity. Conversion efficiency is typically 18-22%

Year	Yield (kWh/yr)	Saving (£/yr)	FiT (£/yr)	Cumulative Benefit (£)
1	2,244	£ 418	£ -	£ 418
2	2,222	£ 421	£ -	£ 838
3	2,200	£ 424	£ -	£ 1,263
4	2,178	£ 427	£ -	£ 1,690
5	2,156	£ 431	£ -	£ 2,121
6	2,134	£ 434	£ -	£ 2,555
7	2,113	£ 438	£ -	£ 2,993
8	2,092	£ 441	£ -	£ 3,434
9	2,071	£ 444	£ -	£ 3,878
10	2,050	£ 448	£ -	£ 4,326
11	2,030	£ 451	£ -	£ 4,777
12	2,009	£ 455	£ -	£ 5,232
13	1,989	£ 459	£ -	£ 5,691
14	1,969	£ 462	£ -	£ 6,153
15	1,950	£ 466	£ -	£ 6,619
16	1,930	£ 469	£ -	£ 7,088
17	1,911	£ 473	£ -	£ 7,561
18	1,892	£ 477	£ -	£ 8,038
19	1,873	£ 480	£ -	£ 8,518
20	1,854	£ 484	£ -	£ 9,002
21	1,836	£ 488	£ -	£ 9,490
22	1,817	£ 492	£ -	£ 9,982
23	1,799	£ 496	£ -	£ 10,478
24	1,781	£ 500	£ -	£ 10,977
25	1,763	£ 503	£ -	£ 11,481

Table 5. Projected benefit - Solar PV

Capacity

A 2 kilo-Watt peak array comprising 8no. 250Watt panel could be installed to roof-mounted framework pitched 30° and rotated to face due-south.

Energy Generation

In the first year, Part L simulation shows that a total yield of 2,244kWh would be expected, equivalent to 3.8% of the total regulated predicted electricity demand.

A panel degradation rate of approx.1% per annum is typical.

CO_2 Reduction

Using the current regulatory emissions factor of 0.519kg.CO_2/kWh, annual generation would abate 1.2 tonnes CO_2, equivalent to 3.8% of the total predicted regulated CO_2 emissions.

It should be noted that where the future CO_2 factors are applied, the abatement would be 0.5 tonnes CO_2 but still an equivalent of 3.8%.

Life Cycle Cost

Assuming mean installed costs of £2,025/kWp and 1no. programmed inverter at a rate of £60/panel, the total estimated cost is £4,530.

On the basis that the payback is achieved exclusively through offsetting demand from the grid, and an electricity unit cost of 18.6p/kWh, simple payback would be achieved within 11 years. Although panel performance degrades over time, the useful lifespan is expected to be over 20 years and therefore exceeding the payback period.

Local Planning Criteria

There are no known local policies that restrict the installation of small scale, building-mounted solar PV.

Solar PV systems and installations should be Microgeneration Certification Scheme (MCS) accredited and adhere to the requirements of the District Network Operator (DNO).

Solar PV



Energy storage

Battery systems are available to enable energy storage for times when supply exceeds demand. However, the baseload electrical demand is anticipated to be greater than the peak output at all times.

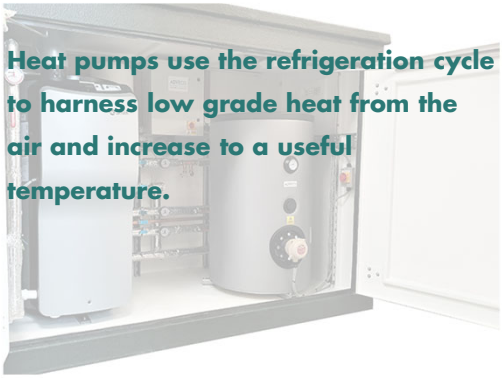
Grants

The Governments Smart Export Guarantee (SEG) has replaced the Feed-in-Tariff (FIT) scheme. Subject to an MCS installation and approved energy meter, a tariff will be payable by the energy provider for any electricity exported to grid. It is expected however that given the continuous demand for electricity on site, all electricity generated by a 2kWp PV array will be consumed.

Conclusion

Solar PV technology is considered technically and economically feasible for this development. It is therefore recommended that it be installed.

Air Source Heat Pumps: DHW



Heat pumps use the refrigeration cycle to harness low grade heat from the air and increase to a useful temperature.

Year	Cost – Baseline (£)	Cost – ASHP-DHW (£)	RHI	Cumulative Benefit (£)
1	2,754	1,331	£ -	£ 1,424
2	2,804	1,355	£ -	£ 2,873
3	2,855	1,379	£ -	£ 4,348
4	2,906	1,404	£ -	£ 5,850
5	2,958	1,429	£ -	£ 7,379
6	3,011	1,455	£ -	£ 8,936
7	3,066	1,481	£ -	£ 10,521
8	3,121	1,508	£ -	£ 12,134
9	3,177	1,535	£ -	£ 13,776
10	3,234	1,563	£ -	£ 15,447
11	3,292	1,591	£ -	£ 17,149
12	3,352	1,619	£ -	£ 18,882
13	3,412	1,648	£ -	£ 20,645
14	3,473	1,678	£ -	£ 22,441
15	3,536	1,708	£ -	£ 24,268
16	3,600	1,739	£ -	£ 26,129
17	3,664	1,770	£ -	£ 28,023
18	3,730	1,802	£ -	£ 29,951
19	3,798	1,835	£ -	£ 31,914
20	3,866	1,868	£ -	£ 33,912

Table 6. Projected benefit – ASHP: DHW

Capacity

Calculations by current hot water system provider (Adveco/AO Smith) show that a combined heat pump and direct-electric system is a feasible option instead of the baseline direct-electric water heater. This packaged system would meet the entire DHW demand.

Energy Generation

Part L simulation shows that the annual DHW demand is reduced 7,652kWh, equivalent to a reduction of 13.0% of the total regulated predicted electricity demand.

CO_2 Reduction

Using the current regulatory emissions factor of 0.519kg.CO_2/kWh, annual generation would abate 4.73 tonnes CO_2, equivalent to 15.5% of the total predicted regulated CO_2 emissions.

When the future CO_2 factor of 0.233kg.CO_2/kWh for electricity is applied, the potential abatement is equivalent to 2.12 tonnes but with the same equivalent 15.5% total reduction.

Life Cycle Cost

Calculations by the design team at concept stage show the uplift to be £8,000 moving from a direct electric water heater to a combined heat pump and direct-electric system.

Simulation results show a reduction in annual fuel cost of £1,424 in the first year, therefore, simple payback will be achieved within 6 years.

Over a 15 year plant service life, the cumulative fuel savings are calculated to be above £24k.

Air Source Heat Pumps: DHW



Local Planning Criteria

There is no known planning policy that would affect the installation of air source heat pumps. Noise assessments will be undertaken to demonstrate compliance with boundary condition stipulations & units will be selected appropriately.

Export Feasibility

There are no current opportunities to export heat from the system.

Energy storage

Pre-heated water from the air-to-water heat pump would be stored within a dedicated indirect cylinder. An additional immersion electric cylinder would be used to heat the preheat.

Grants

There are no known grants available for this technology. It has been assumed that the non-domestic RHI is unavailable.

Conclusion

Integration of heat pump technology will result in a significant reduction in annual CO2 emissions and would enable the building to operate exclusively by electricity. This would omit the expense of introducing a connection and align with the Governments plan to reduce the consumption and reliance upon fossil fuels.

Conclusion

Results show the potential impact from the inclusion of:

- **Solar Photovoltaic (PV)**
- **Air source heat pumps (ASHP) for pre-heating DHW**

Considering that all electricity generated by the proposed 2kWp PV array will be consumed on site and none exported to grid, the solar PV system does represent a technical and economic solution with a relatively short financial payback within 11 years.

Higher energy and CO_2 savings would be achieved with a combined ASHP and direct-electric water heater system to meet the entire DHW demand.

	Current CO_2 Factors		Future CO_2 Factors	
	Energy (kWh/yr)	CO_2 Emissions (kg.CO_2/yr)	Energy (kWh/yr)	CO_2 Emissions (kg.CO_2/yr)
Baseline	58,961	30,598	58,961	13,736
Solar PV	-2,244	-1,165	-2,244	-523
ASHP - DHW	-7,652	-4,730	-7,652	-2,123
Total	49,065	24,703	49,065	11,090
Saving	9,896	5,895	9,896	2,646
	16.8%	19.3%	16.8%	19.3%

Table 7. Calculated energy and CO_2 savings (current and future factors)

Appendix

BRUKL - Baseline

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	326.2	326.2
External area [m^2]	979.6	979.6
Weather	LEE	LEE
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	310.05	379.6
Average U-value [W/m^2K]	0.32	0.39
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
100	**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
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	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/m^2]

	Actual	Notional
Heating	24.8	9.69
Cooling	7.55	14.69
Auxiliary	71.98	67.68
Lighting	31.03	49.37
Hot water	45.39	47.38
Equipment*	123.51	123.51
TOTAL**	**180.75**	**188.8**

* 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/m^2]

	Actual	Notional
Photovoltaic systems	0	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/m^2]	436.35	289.54
Primary energy* [kWh/m^2]	631.06	504.43
Total emissions [kg/m^2]	93.8	86.7

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

BRUKL – LZC

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	326.2	326.2
External area [m^2]	979.6	979.6
Weather	LEE	LEE
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	310.05	379.6
Average U-value [W/m^2K]	0.32	0.39
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
100	**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
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	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/m^2]

	Actual	Notional
Heating	24.8	9.69
Cooling	7.55	14.69
Auxiliary	71.98	67.68
Lighting	31.03	49.37
Hot water	21.93	23.82
Equipment*	123.51	123.51
TOTAL**	**157.29**	**165.24**

* 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/m^2]

	Actual	Notional
Photovoltaic systems	6.88	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/m^2]	436.35	289.54
Primary energy* [kWh/m^2]	626.34	598.58
Total emissions [kg/m^2]	75.7	81.2

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

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