Centre for Integrative Semiconductor Materials

Low and Zero Carbon Technologies Feasibility Study

Swansea University

08 August 2019

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This document has 18 pages including the cover.

Document history

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Client signoff

Client	Swansea University
Project	Centre for Integrative Semiconductor Materials
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Contents

Executive Summary

This report has been structured in accordance with the requirements of BREEAM 2018 UK New Construction Credit ENE 04. The targeted credits under BREEAM ENE 04 will assist in achieving the overall targeted building rating of ‘Excellent’. Photovoltaic (PV) electricity generation has been established at the most appropriate LZC technology, based on the building energy use, site constraints and payback time.

Other LZC technologies that were considered, but ultimately ruled out, are detailed below.

- Solar Hot Water (STH)
- Biomass Boilers
- Combined Heat and Power (CHP)
- Ground Source Heat Pumps (GSHP)
- Air Source Heat Pumps (ASHP)
- Wind turbines

Wind turbines have been ruled out due to site constraints. As the building will be located on an existing, built up, university campus, there is little available space to locate wind turbines.

Of the six renewable technologies initially investigated, the only technology to offer a significant reduction in CO_2 emissions was PV. In addition, the only technology with a predicted payback time less than 20 years is PV, with an estimated 11 years.

STH, Biomass, CHP, GSHP and ASHP are technologies that generate thermal energy and therefore reduce the natural gas demand of a building. Due to the nature of the CISM building, the natural gas demand is approximately 1% of the total energy demand.

CISM is also seeking to comply with ENE 01 – Reduction of energy use and carbon emissions, aiming to achieve a minimum of 4 credits. This is equivalent to approximately a 30% reduction over the TER. Therefore, to achieve a significant reduction in energy, the LZC technology must provide a reduction of electrical energy rather than thermal. Due to this, STH, Biomass, CHP, GSHP and ASHP have been deemed unsuitable for the application.

1. Introduction

1.1. Project Background

The Centre for Integrative Semiconductor Materials (CISM) will be located at the heart of Swansea University Bay Campus within the existing engineering quarter. This location will allow for collaboration and shared facilities with the existing surrounding engineering buildings.

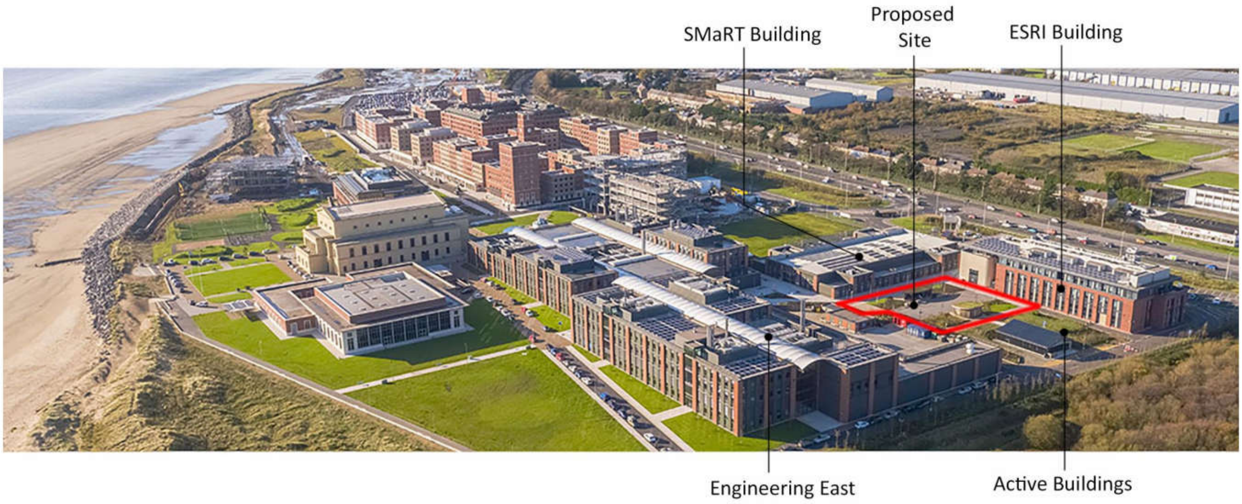
The proposed building will be three stories, covering 4,100m^2 of clean room, research and office facilities. The building proposes to use sustainable, energy efficient building techniques and a renewable technology, informed by this feasibility study. The project aims to achieve a BREEAM ‘Excellent’ rating.

1.2. Purpose of Report

The purpose of the report is to explore the most appropriate LZC Technology for the site given the local constraints, operational characteristics of the facility and the potential payback periods. This report is produced prior to detailed design stages, to inform the selection and development of appropriate LZC technologies. The report compares the feasibility of each of PV against baseline carbon data derived from an Integrated Environmental Solutions (IES) Virtual Environment (VE) Thermal Model. The IES model is based on Architectural information provided at RIBA Stage 2. Due to the developing nature of design, the figures established are subject to change.

1.3. Description of Site

The proposed site for CISM is on the Swansea University Bay Campus, located between Fabian Way and Jersey Marine Beach.



1.4. Compliance with BREEAM 2018 UK New Construction

This report has been structured appropriately to provide evidence to support the third credit of ENE 04, Low and Zero Carbon Technologies, within BREEAM 2018 UK New Construction guidance. To achieve this credit, and to support an informed decision on the application of LZC technologies at CISM Swansea University, the report aligns with the assessment criteria defined within the BREEAM 2018 UK New Construction Technical Manual, outlined below.

1.4.1. ENE 04 Low Carbon Design – LZC Technologies

An energy specialist completes a feasibility study by the end of Concept Design. The study should establish the most appropriate recognised local LZC energy sources for the building or development. Specify local LZC technologies for the building or development in line with the feasibility study recommendations. Quantify the regulated carbon dioxide emissions resulting from the feasibility study.

The LZC carbon feasibility study should cover as a minimum:

1. Energy generated from LZC energy source per year
2. Carbon dioxide savings from LZC energy source per year
3. Life cycle cost of the potential specification, accounting for payback
4. Local planning criteria, including land use and noise
5. Feasibility of exporting heat/electricity from the system
6. Any available grants
7. All technologies appropriate to the site and energy demand of the development.
8. Reasons for excluding other technologies
9. If appropriate:
    a. The building is connected to an existing local community CHP system or
    b. The building is connected to an existing source of waste heat or power or
    c. A building or site CHP system is specified with the potential to export excess heat or power via a local community energy scheme
    d. A source of waste heat or power is specified with the potential to export excess heat or power via a local community energy scheme

1.4.2. ENE 01 Reduction of Energy Use and Carbon Emissions

Reduce operational energy consumption and associated carbon emissions. Promote energy performance beyond regulatory requirements including recognition of net zero carbon solutions in line with World Green Building Council policy. Encourage consideration of operational aspects in determining optimal energy strategy. Provide a route to verification of building performance post occupation. Help reducing the performance gap between predicted and actual performance. The thermal energy model can be used to provide energy use data and explore energy savings.

1.5. Compliance with Local Planning Policies

No local planning policies have been identified for this project, however Swansea University requires all new buildings to meet BREEAM Excellent. Therefore CISM must achieve a reduction of CO_2 emissions equivalent to 4 credits under ENE 01 – Reduction of energy use and carbon emissions.

2. Building Energy Data – Baseline Calculations

2.1. IES Virtual Environment Results

The total energy demand for CISM has been calculated using an IES Thermal Model/Carbon Emissions simulation. The analysis has been completed in IES VE (v2018.0.1.0) which computes a dynamic simulation of the building, producing estimates of inherent building, and building services, energy use and the subsequent CO_2 emissions in accordance with Approved Document Part L2A for Wales (2014).

All input information is based on the National Calculation Methodology (NCM) templates as defined with the Standard Building Energy Model (SBEM) compliance tool. In the IES VE software the Apache-Sim compliance tool is being used, rather than SBEM, to enable more accurate editing of auxiliary energy values.

The Energy Analysis is based on “As Designed Stage” for the current building services.

The NCM building type has been defined as ‘B2:B7: General Industrial and Special Industrial Groups’

Weather tape: Cardiff TRY05

Location: Swansea, United Kingdom

The notional building simulation produces a Target Emission Rate (TER) of 19.8kg.CO_2/m². annum.

To achieve compliance with ENE01 Reduction of energy use and carbon emissions, CISM must achieve a minimum of 4 credits. This is equivalent to approximately a 30% reduction over the TER.

3. Low and Zero Carbon Technologies

3.1. Technologies reviewed and excluded

STH, Biomass, CHP, GSHP and ASHP were initially considered as part of this feasibility, but ultimately ruled out as CISM is also seeking compliance with ENE 01. For BREEAM Excellent, 4 credits must be achieved for ENE 01, which is equivalent to approximately a 30% reduction from the Target Emission Rate (TER). The overall natural gas demand of the building is 1% of the total energy demand. Therefore, as sources of thermal energy, these technologies do not offer a significant contribution to the overall reduction in energy.

3.2. Selected Technology: Photovoltaic Cells (PV)

3.2.1. Background Information

Photovoltaic (PV) systems convert energy from the sun into electricity using semi-conductor cells, connected together and mounted into modules. Modules are connected to an inverter that converts direct current (DC) into alternating current (AC), which is then usable in buildings. PV systems can either supply electricity to the buildings to which they are attached or, when the building demand is insufficient, they can export the surplus electricity to the grid to generate financial revenue.

There are three principal types of photovoltaic cell - polycrystalline, monocrystalline and thin film. A fourth variety, hybrid, utilises both thin film and polycrystalline silicon to combine the improved efficiencies of thin film in overcast conditions with the greater conversion efficiencies of polycrystalline to improve performance.

3.2.2. PV Energy Production Calculation

Notes on Sizing of technology

The maximum gross area of south-facing inclined solar arrays that could be installed on the roof of the proposed building is approximately 820m^2. Approximately 490m^2 of net PV panel area is required to meet the 30% reduction from the TER, required for ENE 01, therefore this figure shall be used for the PV energy saving calculation.

Based on a typical monocrystalline PV system and an average annual energy generation of 850 kWh per kWp, a 490m^2 PV installation at CISM is expected to generate 83.3 MWh per annum of electricity and save circa 43.5 tonnes of CO_2 per annum.

Photovoltaic Production Overall Annual Conditions

Description of Calculation	Numerical Value
Annual Electrical Demand as identified within Base Load Thermal Model Simulation	561,524 kWh / Annum
Gross area of PV array installation	490 m^2
Average area of monocrystalline PV panel to generate 1 kWp electricity	5 m^2
Rated output (Gross Area / kWp Yield Area)	97 kWp
Mean average energy generated per kWp:	850 kWh
Annual output of proposed system	**83,300kWh / annum**

3.2.3. Life Cycle Costs

Cost Saving Per Annum

Description of Calculation	Numerical Value
Annual Energy Saving (through reduction of Grid Supplied Electricity) at 13p per kWh	£10,830

Photovoltaic Panel Simple Payback

Description of Calculation	Numerical Value
Typical Capital Cost of PV Installation per m^2 of panel area	£220
Total System Capital Cost (+10% Contingency)	£18,600
Simple Payback - on Energy Saving	**11 years**

3.2.4. Site Constraints

PV panels rely on consistent solar radiation to generate energy. The proposed location and height of the building is such that the panels would not be obstructed by high-rise buildings or other significant obstructions. Therefore, there is low risk shading of potential proposed PV panels.

3.2.5. Local Planning Requirements

No local planning constraints have been identified that would prohibit the use of a PV system within the proposed development. It is advisable that Neath Port Talbot Council be contacted to advise prior to undertaking any detailed design work.

3.2.6. Noise

The only noise issue to consider with this technology is the possible disruption to building occupants during the installation and maintenance of the arrays; however, this is not likely to pose any significant impact. The actual operation of the technology is silent and, if required, installation can take place whilst the building is unoccupied.

3.2.7. Feasibility of Export of Energy

Due to the high energy demand of this building throughout the year, it is not anticipated there will be a period in which an excess of electrical energy is produced that can be exported.

3.2.8. Available Grants

The government Feed-In Tariff programme is closed to new applicants from April 2019, therefore there are no available grants to support exporting energy.

Appendices

Appendix A.

A.1. Internal Space Volumes and occupancies

Space Name (Notional)	Volume (m^3) (Notional)	Floor Area (m^2) (Notional)	Lighting Power Consumption (W/m^2) (Notional)	Lighting Power Consumption (W) (Notional)	Occupancy Density (m^2/person) (Notional)	Occupancy (People) (Notional)	Misc Power Consumption (W/m^2) (Notional)	Misc Power Consumption (W) (Notional)	Air Infiltration (ac/hr) (Notional)
Level 0									
L0_Circulation	133.92	49.6	7.027	807.013	20	6	5	574	0.043
L0_Plant Equipment store	122.76	30.69	8.53	177.168	20	1	5	104	0.043
L0_Plant Chemical store	122.76	30.69	7.269	452.945	20	3	5	312	0.043
L0_Primary riser	30.144	7.536	7.517	312.236	20	2	5	208	0.043
L0_Lift	43.52	10.88	7.517	312.236	20	2	5	208	0.043
L0_Stair	45.56	11.39	2.88	142.86	8	6	2.24	111	0.043
L0_Circulation core 02	73.343	26.194	2.451	132.215	8	7	2.24	121	0.043
L0_Plant room	2335.52	583.88	1.438	44.123	8	4	0	0	0.043
L0_Lift	17.64	4.41	1.438	44.123	8	4	0	0	0.043
L0_W.C. 01	4.185	1.55	3.401	38.742	8	1	2.24	26	0.043
L0_W.C. 01	3.976	1.472	2.856	74.815	8	3	2.24	59	0.043
L0_W.C. 01	4.185	1.55	4.592	2681.169	9	64	50	29194	0.043
L0_W.C. 01	21.519	7.97	6.924	1275.067	20	9	5	921	0.043
L0_W.C. 02	4.394	1.628	7.725	474.179	20	3	5	307	0.043
L0_W.C. 02	3.976	1.472	13.895	21.537	8	0	5.59	9	0.043
L0_W.C. 02	4.185	1.55	13.895	20.46	8	0	5.59	8	0.043
L0_W.C. 02	21.931	8.123	13.895	21.537	8	0	5.59	9	0.043

L0_Circulation core 01	90.549	33.536	6.942	55.331	8	1	5.59	45	0.043
L0_Stair	61.124	15.281	13.895	22.614	8	0	5.59	9	0.043

Space Name (Notional)	Volume (m³) (Notional)	Floor Area (m²) (Notional)	Lighting Power Consumption (W/m²) (Notional)	Lighting Power Consumption (W) (Notional)	Occupancy Density (m²/person) (Notional)	Occupancy (People) (Notional)	Misc Power Consumption (W/m²) (Notional)	Misc Power Consumption (W) (Notional)	Air Infiltration (ac/hr) (Notional)
L0_Disc W.C. 01	10.246	3.795	13.895	20.46	8	0	5.59	8	0.043
L0_Lab MOCVD	344.52	114.84	13.895	21.537	8	0	5.59	9	0.043
L0_Lab w/ fume cupboard	62.31	20.77	6.891	55.973	8	1	5.59	45	0.043
L0_Lab Nano probe AFM	186.93	62.31	2.806	94.103	8	4	2.24	75	0.043
L0_Lab SEM	124.62	41.54	3.128	47.804	8	2	2.24	34	0.043
L0_Lab Sample prep -	124.62	41.54	9.154	34.739	8	0	5.59	21	0.043
L0_Circulation	161.82	53.94			-	-	-	-	-
L0_Lab Opto-electronics lab	552.42	184.14			-	-	-	-	-
L0_Plant Workshop	245.52	61.38			-	-	-	-	-
Level 1									
L1_LAB Laboratory	271.44	90.48	7.095	641.925	20	5	5	452	0.043
L1_Lift	36.603	0	13.895	21.537	8	0	5.59	9	-
L1_W.C. 01	4.185	1.55	13.895	20.46	8	0	5.59	8	0.043
L1_W.C. 01	3.976	1.472	13.895	21.537	8	0	5.59	9	0.043
L1_W.C. 01	4.185	1.55	6.942	55.331	8	1	5.59	45	0.043
L1_W.C. 01	21.519	7.97	13.895	22.614	8	0	5.59	9	0.043
L1_W.C. 02	4.394	1.628	13.895	20.46	8	0	5.59	8	0.043
L1_W.C. 02	3.976	1.472	13.895	21.537	8	0	5.59	9	0.043
L1_W.C. 02	4.185	1.55	6.891	55.973	8	1	5.59	45	0.043
L1_W.C. 02	21.931	8.123	6.948	106.165	8	2	2.24	34	0.043

L1_Stair	126.832	15.281	9.154	34.739	8	0	5.59	21	0.043
L1_Disc W.C. 01	10.246	3.795	6.948	232.995	8	4	2.24	75	0.043
Space Name (Notional)	Volume (m^3) (Notional)	Floor Area (m^2) (Notional)	Lighting Power Consumption (W/m^2) (Notional)	Lighting Power Consumption (W) (Notional)	Occupancy Density (m^2/person) (Notional)	Occupancy (People) (Notional)	Misc Power Consumption (W/m^2) (Notional)	Misc Power Consumption (W) (Notional)	Air Infiltration (ac/hr) (Notional)
L1_Riser	6.163	0.742	2.395	147.026	8	8	2.24	137	-
L1_Circulation core 01	278.353	33.536	5.087	148.239	8	4	2.24	65	0.043
L1_Support Change	165.726	61.38	7.185	596.967	20	4	5	415	0.043
L1_Support Change	241.862	29.14	7.185	596.967	20	4	5	415	0.043
L1_Lab ISO 6 (Dry) Customer	249.24	83.08	7.185	596.967	20	4	5	415	0.043
L1_Lab ISO 6 Customer Bay	249.24	83.08	6.926	575.39	20	4	5	415	0.043
L1_Lab ISO 6 Customer Bay	249.24	83.08	6.768	562.274	20	4	5	415	0.043
L1_Lab ISO 7 Organics	249.24	83.08	6.768	562.274	20	4	5	415	0.043
L1_Lab ISO 6 Dep	249.24	83.08	6.768	562.274	20	4	5	415	0.043
L1_Lab ISO 6 Metal Dep	249.24	83.08	6.813	565.999	20	4	5	415	0.043
L1_Lab ISO 6 Dry Etch	249.24	83.08	7.113	305.851	20	2	5	215	0.043
L1_Lab ISO 6 Wet Etch	249.24	83.08	6.949	1042.859	20	8	5	750	0.043
L1_Lab ISO 6 Wet Etch	129	43	6.948	79.132	8	1	2.24	26	0.043
L1_Lab ISO 5 Photo	450.24	150.08	2.958	77.477	8	3	2.24	59	0.043
L1_Primary riser	62.549	7.536	7.515	745.508	20	5	5	496	-
L1_Lift	90.304	0	2.822	387.682	8	17	2.24	308	-
L1_Stair	94.537	11.39	-	-	-	-	-	-	0.043
L1_Circulation core 02	70.724	26.194	-	-	-	-	-	-	0.043
L1_Clean Circulation	267.84	99.2	-	-	-	-	-	-	0.043
L1_Circulation	370.98	137.4	-	-	-	-	-	-	0.043

Space Name (Notional)	Volume (m^3) (Notional)	Floor Area (m^2) (Notional)	Lighting Power Consumption (W/m^2) (Notional)	Lighting Power Consumption (W) (Notional)	Occupancy Density (m^2/person) (Notional)	Occupancy (People) (Notional)	Misc Power Consumption (W/m^2) (Notional)	Misc Power Consumption (W) (Notional)	Air Infiltration (ac/hr) (Notional)
Level 2									
L2_Room 1	34.648	12.833	11.794	151.348	9	1	13.91	179	0.043
L2_Room 2	34.648	12.833	11.794	151.348	9	1	13.91	179	0.043
L2_Office_Operations and	221.981	82.215	9.404	773.138	9	9	13.91	1144	0.043
L2_Office_Open plan office	436.914	161.82	9.223	1492.396	9	17	13.91	2251	0.043
L2_Office_Open plan office	373.383	138.29	9.266	1281.454	9	15	13.91	1924	0.043
L2_Kitchen	240.497	89.073	11.796	1050.71	5	19	49.5	4409	0.043
L2_Lift	43.52	0	3.401	38.742	8	1	2.24	26	-
L2_Circulation Core 02	45.56	11.39	2.666	88.206	8	4	2.24	74	0.043
L2_Primary riser	30.144	7.536	2.799	273.594	8	12	2.24	219	-
L2_Circulation Core 02	89.346	33.091	2.883	139.516	8	6	2.24	108	0.043
L2_Circulation	263.898	97.74	2.904	120.64	8	5	2.24	93	0.043
L2_Circulation	130.68	48.4	9.263	1137.173	9	13	13.91	1708	0.043
L2_Circulation	112.149	41.536	9.263	1137.173	9	13	13.91	1708	0.043
L2_Office_Open plan office	331.452	122.76	9.753	492.405	9	5	13.91	702	0.043
L2_Office_Open plan office	331.452	122.76	9.753	492.405	9	5	13.91	702	0.043
L2_Office_Meeting room 01	136.323	50.49	3.492	53.355	8	2	2.24	34	0.043
L2_Office_Meeting room 02	136.323	50.49	27.79	105.463	9	0	13.91	53	0.043
L2_Circulation	61.124	15.281	13.895	21.537	8	0	5.59	9	0.043
L2_Lift	17.64	0	13.895	20.46	8	0	5.59	8	-

L2_Riser	2.97	0.742	13.895	21.537	8	0	5.59	9	-
L2_Room 3	15.18	3.795	6.942	55.331	8	1	5.59	45	0.043
L2_W.C. 01	4.185	1.55	13.895	22.614	8	0	5.59	9	0.043
L2_W.C. 01	3.976	1.472	13.895	20.46	8	0	5.59	8	0.043
L2_W.C. 01	4.185	1.55	13.895	21.537	8	0	5.59	9	0.043
L2_W.C. 01	21.519	7.97	6.891	55.973	8	1	5.59	45	0.043
L2_W.C. 02	4.394	1.628	13.036	759.755	9	6	13.91	811	0.043
L2_W.C. 02	3.976	1.472	5.138	1091.501	9	23	50	10622	0.043
L2_W.C. 02	4.185	1.55	-	-	-	-	-	-	0.043
L2_W.C. 02	21.931	8.123	-	-	-	-	-	-	0.043
L2_Seminar room	402.132	58.28	-	-	-	-	-	-	0.043
L2_Plant room	1465.836	212.44	-	-	-	-	-	-	0.043

A.2. Baseline Energy Use and Carbon Emissions

	Ap Sys boilers DHW energy (MWh)	Ap Sys boilers space cond'g energy (MWh)	Ap Sys boilers energy (MWh)	Total nat. gas (MWh)
Date	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps
Jan 01-31	1.0574	1.4289	2.4862	2.4862
Feb 01-28	0.955	1.5931	2.5481	2.5481
Mar 01-31	1.0574	1.0783	2.1356	2.1356
Apr 01-30	1.0233	0.4379	1.4611	1.4611
May 01-31	1.0574	0.0504	1.1078	1.1078
Jun 01-30	1.0233	0.0103	1.0336	1.0336
Jul 01-31	1.0574	0.0021	1.0594	1.0594
Aug 01-31	1.0574	0.0036	1.061	1.061
Sep 01-30	1.0233	0.0238	1.0471	1.0471
Oct 01-31	1.0574	0.1151	1.1725	1.1725
Nov 01-30	1.0233	0.5427	1.566	1.566
Dec 01-31	1.0574	1.0756	2.1329	2.1329
Summed total	12.4495	6.3618	18.8113	18.8113

	Ap Sys aux + DHW/solar pumps energy (MWh)	Ap Sys chillers energy (MWh)	Ap Sys heat rej fans/pumps energy (MWh)
Date	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps
Jan 01-31	3.7597	0.1295	0
Feb 01-28	3.3959	0.2904	0
Mar 01-31	3.7597	0.9793	0
Apr 01-30	3.6385	2.013	0
May 01-31	3.7597	4.1804	0
Jun 01-30	3.6385	5.0463	0
Jul 01-31	3.7597	6.5696	0
Aug 01-31	3.7597	6.6608	0
Sep 01-30	3.6385	4.9037	0
Oct 01-31	3.7597	3.2252	0
Nov 01-30	3.6385	1.7049	0
Dec 01-31	3.7597	0.9201	0
Summed total	44.2679	36.6231	0

	Equip electricity (MWh)	Lights electricity (MWh)	System electricity (MWh)	Total electricity (MWh)
Date	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps	n_(Part L2 2014)_CISM_Swansea University_Part L.aps
Jan 01-31	32.2283	9.2161	0.1295	45.3337
Feb 01-28	29.1094	8.0304	0.2904	40.8263
Mar 01-31	32.2283	8.5592	0.9793	45.5266
Apr 01-30	31.1887	8.0128	2.013	44.853
May 01-31	32.2283	8.1663	4.1804	48.3349
Jun 01-30	31.1887	7.865	5.0463	47.7385
Jul 01-31	32.2283	8.1305	6.5696	50.6883
Aug 01-31	32.2283	8.1928	6.6608	50.8418
Sep 01-30	31.1887	8.1362	4.9037	47.8672
Oct 01-31	32.2283	8.7507	3.2252	47.964
Nov 01-30	31.1887	8.797	1.7049	45.3291
Dec 01-31	32.2283	9.3128	0.9201	46.2211
Summed total	379.4619	101.1696	36.6231	561.5245

	Total energy (MWh)
Date	n_(Part L2 2014)_CISM_Swansea University_Part L.aps
Jan 01-31	45.5661
Feb 01-28	41.3387
Mar 01-31	45.4083
Apr 01-30	44.133
May 01-31	47.1888
Jun 01-30	46.591
Jul 01-31	49.4939
Aug 01-31	49.649
Sep 01-30	46.7331
Oct 01-31	46.8826
Nov 01-30	44.714
Dec 01-31	46.1002
Summed total	553.7987

	Natural Gas Carbon Emissions (kg/CO2 per Annum)	Electricity Carbon Emissions (kg/CO2 per Annum)	Total Carbon Emissions
Date			
Jan 01-31	527.0744	23664.1914	24191.2658
Feb 01-28	540.1972	21311.3286	21851.5258
Mar 01-31	452.7472	23764.8852	24217.6324
Apr 01-30	309.7532	23413.266	23723.0192
May 01-31	234.8536	25230.8178	25465.6714
Jun 01-30	219.1232	24919.497	25138.6202
Jul 01-31	224.5928	26459.2926	26683.8854
Aug 01-31	224.932	26539.4196	26764.3516
Sep 01-30	221.9852	24986.6784	25208.6636
Oct 01-31	248.57	25037.208	25285.778
Nov 01-30	331.992	23661.7902	23993.7822
Dec 01-31	452.1748	24127.4142	24579.589
Summed total	3987.9956	293115.789	297103.7846

Total building energy consumption: 553,799 kWh/Annum

Total building CO_2 emissions: 297,104 $kgCO_2$/Annum

Atkins
Atkins Limited
The Hub
500 Park Avenue
Aztec West
Bristol
BS32 4RZ