University of Essex

LCMB Building Performance Specialists

UNIVERSITY OF ESSEX

THE ROAD TO NET ZERO

April 2021

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EXECUTIVE SUMMARY

The University of Essex declared a Climate Emergency on 9th December 2020 and pledged to produce a Climate Action Plan including a target date for achieving net zero emissions.

This report is in response to the University of Essex's request for LCMB to scope how carbon emissions are produced based on an understanding of current infrastructure and produce an action plan to achieve net zero by 2030, 2040 and 2050.

This report reviews the energy consumption, quantifies Scope 1 and 2 emissions and details the potential opportunities for energy improvements at the University's three campuses.

It was decided that the calendar year 2019 should be used as a baseline as the University was operational as normal, whereas the Coronavirus pandemic affected consumption from March 2020

Total electrical energy consumption for the calendar year 2019 was 23,538,867 kWh, equating to £3,017,683 at the current rate excluding CCL, standing charges and VAT and is summarised in the table below. The gas consumption for the same period was 34,277,466 kWh at £826,087. 2.13% of the university's electricity was generated by solar panels amounting to 503,378 kWh.

ENERGY CONSUMPTION

Utility	Energy Consumption		Cost		CO_2	
	KWh/year	%	£/year	%	tonne	%
Electricity	23,538,867	40.36%	3,017,683	78.51	6,017	48.84
Gas	34,277,466	58.78%	826,087	21.49	6,302	51.16
Solar Generation	503,378	0.86%	0	-		
Total Energy	**58,319,711**	**100**	**3,843,770**	**100**	**12,318**	**100**

Table 1 Energy consumption 2019

CARBON EMISSIONS

Utility	CO_2 emissions	
	tonne	**%**
Electricity	6,017	48.08%
Gas	6,302	50.36%
Fugitive Refrigerant	139	1.11%
Fugitive - Generators	3	0.02%
Transport	52	0.42%
Solar Generation	0	0.00%
Total Energy	**12,513**	**100%**

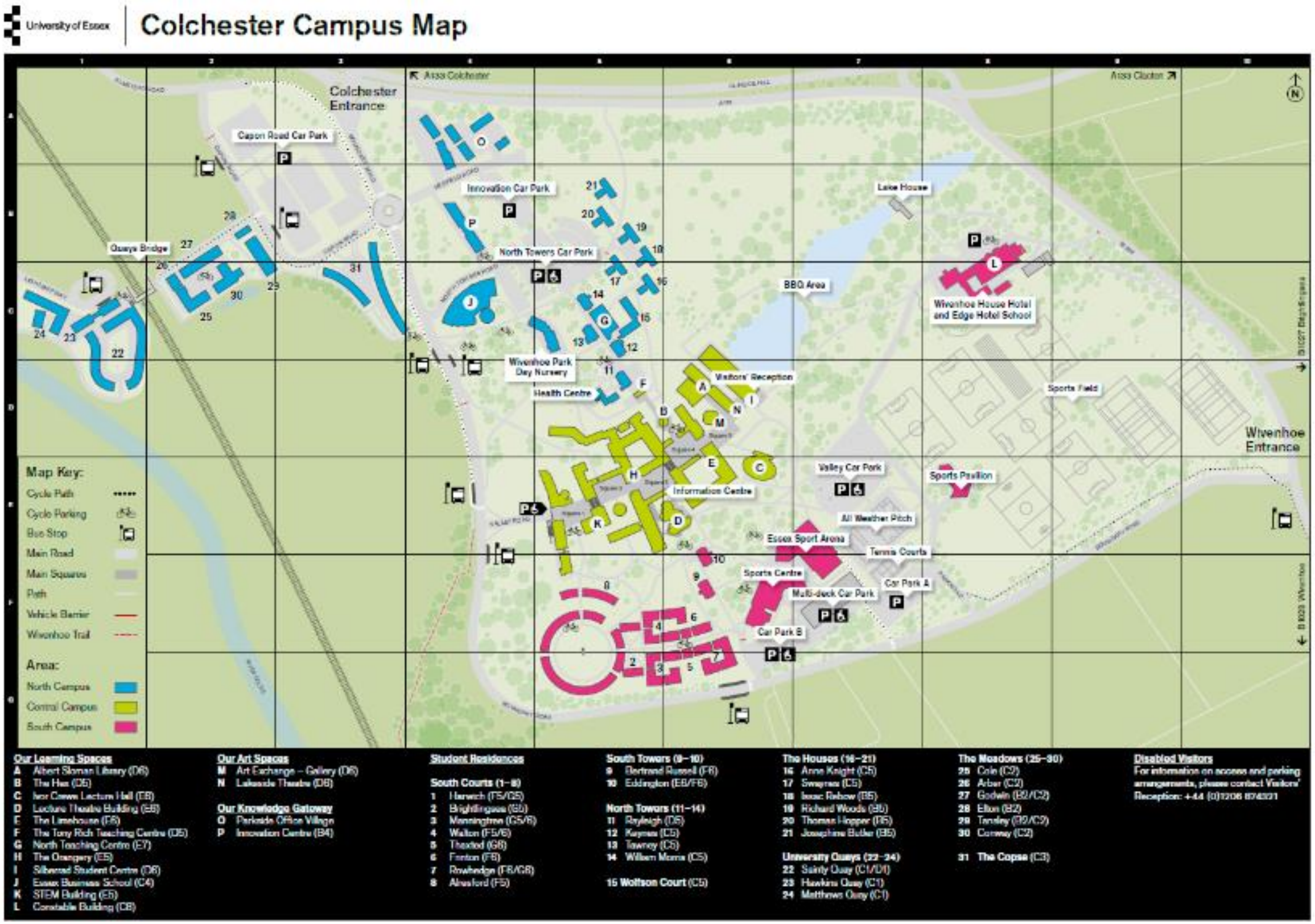
Table 2 Carbon Emissions 2019

In addition to the Scope 2 electricity carbon emissions and the Scope 1 gas carbon emissions, the fugitive emissions and emissions from owned transport have been included in the table above giving a total Scope 1 and 2 carbon footprint of 12,513 tonnes.

The consumption data has been provided by the University, but half-hourly data was only available from October 2019.

A summary of an Energy Reduction Action Plan is presented in the table on page 13. If the measures are implemented, there is the opportunity to reduce energy consumption at the sites as detailed in the plan. The estimated savings could be considered to be conservative and may prove to be higher.

All costs and savings stated in this report are based on the data available at the time and can only be taken as indications at this stage. We recommend that further investigation and feasibility studies are undertaken to develop this information in greater depth before any financial or commercial commitment is made. These savings are mutually exclusive and not cumulative but an indication of the potential savings for each measure.


University of Essex
Colchester Campus Map
Colchester Entrance
Wivenhoe Entrance
A133 Colchester
A133 Clacton
Capon Road Car Park
Innovation Car Park
North Towers Car Park
Quays Bridge
Lake House
BBQ Area
Wivenhoe House Hotel and Edge Hotel School
Wivenhoe Park Day Nursery
Health Centre
Visitors' Reception
Information Centre
Valley Car Park
Sports Pavilion
Sports Field
All Weather Pitch
Essex Sport Arena
Tennis Courts
Sports Centre
Car Park A
Multi-deck Car Park
Car Park B
Map Key:
Cycle Path
Cycle Parking
Bus Stop
Main Road
Main Squares
Path
Vehicle Barrier
Wivenhoe Trail
Area:
North Campus
Central Campus
South Campus
Our Learning Spaces
A Albert Sloman Library (D6)
B The Hex (D5)
C Ivor Crewe Lecture Hall (E8)
D Lecture Theatre Building (E6)
E The Limehouse (F6)
F The Tony Rich Teaching Centre (D5)
G North Teaching Centre (E7)
H The Orangery (E5)
I Silberrad Student Centre (D6)
J Essex Business School (C4)
K STEM Building (E5)
L Constable Building (C8)
Our Art Spaces
M Art Exchange – Gallery (D6)
N Lakeside Theatre (D6)
Our Knowledge Gateway
O Parkside Office Village
P Innovation Centre (B4)
Student Residences
South Courts (1–8)
1 Harwich (F5/G5)
2 Brightlingsea (G5)
3 Manningtree (G5/6)
4 Walton (F5/6)
5 Thaxted (G6)
6 Fenton (F6)
7 Rowhedge (F6/G6)
8 Alresford (F5)
South Towers (9–10)
9 Bertrand Russell (F6)
10 Eddington (E6/F6)
North Towers (11–14)
11 Rayleigh (D5)
12 Keynes (C5)
13 Tawney (C5)
14 William Morris (C5)
15 Wolfson Court (C5)
The Houses (16–21)
16 Anne Knight (C5)
17 Swaynes (C5)
18 Isaac Rebow (B5)
19 Richard Woods (B5)
20 Thomas Hopper (B5)
21 Josephine Butler (B5)
University Quays (22–24)
22 Sainty Quay (C1/D1)
23 Hawkins Quay (C1)
24 Matthews Quay (C1)
The Meadows (25–30)
25 Cole (C2)
26 Arber (C2)
27 Godwin (B2/C2)
28 Elton (B2)
29 Tansley (B2/C2)
30 Conway (C2)
31 The Copse (C3)
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INTRODUCTION

The University of Essex is a plate glass university that was established in 1963. It has three campuses in Colchester, Southend and Loughton.

The largest campus in Colchester accounts for 87% of the university's energy consumption. It is located two miles from the town centre and is a self-contained 'village' campus which has student accommodation, teaching space, offices, sports facilities, restaurants and even a cinema all in the one place.

By contrast, the Southend campus is based in the seaside town and provides accommodation, teaching space, a theatre, offices and a Student's Union. The Loughton campus is the home of the E15 Acting School and has studios and a theatre as well as teaching and office space.

The campuses are a mix of suburban parkland and town centre settings. The gross internal area (GIA) covers over 280,000 square metres. Buildings are a mix of academic/teaching spaces and offices as well as accommodation, ranging from 1960s brutalist architecture and converted 18th Century manors, as well as more modern constructions: including a low-carbon Business School.

The university declared a Climate Emergency on 9th December 2020 and pledged to produce a Climate Action Plan including a target date for achieving net zero emissions.

This report will provide recommendations on the university's road to net-zero.

At present, there are no technological solutions that allow an individual, organisation, county or country to operate at zero carbon without significant change to lifestyle, behaviour and the adoption of carbon offsetting schemes.

Adopting climate change initiatives, using proven technology or practice, will typically reduce operational costs and improve service quality. Achieving net zero carbon emissions at the University will require significant planning, resource and investment across the whole organisation.

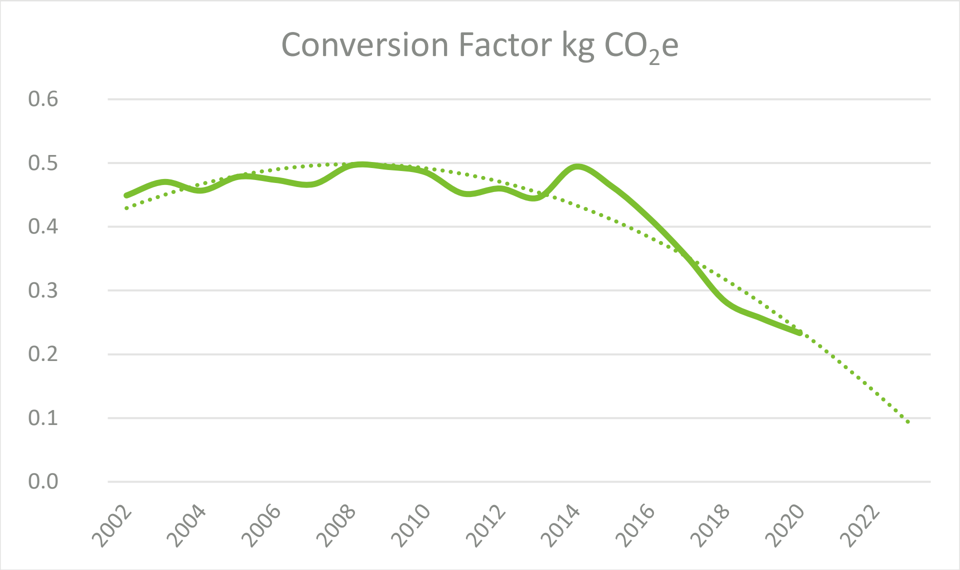
We believe that it is in the University's, short-, medium- and longer-term interest to engage the support of staff and students in delivering a change programme to improve the organisation's sustainable performance and to reduce its' climate change impact in line with the 2050 net zero target.

NET ZERO CARBON EMISSIONS

The University of Essex is currently setting a target date as to when they should reach net zero for Scope 1 and 2 carbon emissions.

This report has examined various options to address the existing carbon emissions which are roughly 50 / 50 between scope 1 and scope 2 at 6,496 and 6,017 tonnes of CO_2 respectively.

There is a move towards the decarbonisation of heat and electrification of heating. Decarbonising heating through electricity seems more likely to be realised in practice. As things stand, electricity has a slightly higher carbon content than gas, when used for heating. But that is decreasing all the time. Emissions from grid electricity have reduced by nearly half over the last 20 years, principally as a result of retiring coal power stations and a massive surge in solar PV and offshore wind turbines. That trend is likely to continue. According to predictions from the Department of Business, Energy and Industrial Strategy (BEIS), electricity will become greener than oil, LPG and even natural gas per kWh of heat within five years.



The UK electricity factor is prone to fluctuate from year to year as the fuel mix consumed in UK power stations (and auto-generators) and the proportion of net imported electricity changes.

These annual changes can be large as the factor depends very heavily on the relative prices of coal and natural gas as well as fluctuations in peak demand and renewables.

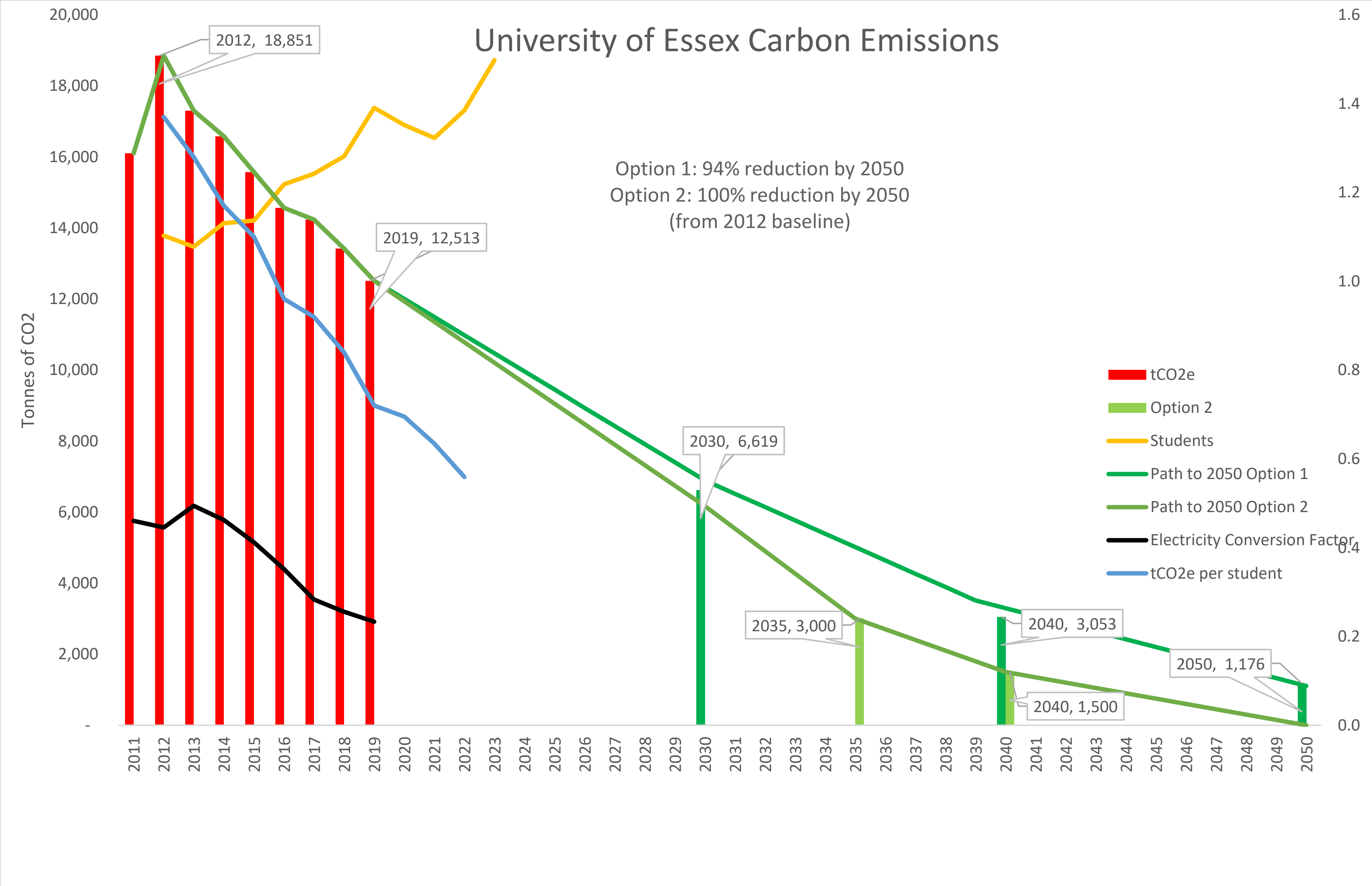
In the 2020 GHG Conversion Factors, there was a 9% decrease in the UK electricity CO_2e factor compared to the previous year because there was a decrease in coal generation and an increase in gas and renewables generation. Since 2016 they have fallen by 11%, 15%, 19% and 10% each year.

Natural gas is used mainly for heating buildings and water. 90% of homes have gas-fired boilers and the majority of the university's buildings are reliant on gas. New builds have seen a move towards electric heating, but gas is still responsible for 50% of the university's carbon emissions.

However, to move away completely from gas would be cost-prohibitive especially when new gas boilers have been installed refurbishments like the Towers and the Nursery. Hence why, to begin with, there is a recommendation to blend hydrogen into the Colchester site gas supply, which will reduce the carbon emissions by 630 tonnes. It would be too expensive to manufacture hydrogen on-site, therefore it would be necessary to transport hydrogen filled cylinders to a site close to the main gas incomers serving the University. The hydrogen would be injected into the existing distribution service line downstream of the gas governors at the main incoming site meters.

It is impossible to predict what the heating profile will look like in 30 years. The government is currently writing a hydrogen strategy which is expected to be published in late 2021. Hydrogen is firmly embedded in the Government's Ten Point Plan who are committed to driving the growth of low carbon hydrogen. There is little point in the University investing in their own hydrogen production and network along with all the appliance and infrastructure upgrades when it may be 'on tap' after 2030.

The chart below shows the proposed route to net zero carbon emissions up to 2030, 2040 and 2050. This equates to a 94% reduction by 2050 from the University's 2012 baseline.


University of Essex Carbon Emissions
Option 1: 94% reduction by 2050
Option 2: 100% reduction by 2050
(from 2012 baseline)
Tonnes of CO2
2012, 18,851
2019, 12,513
2030, 6,619
2035, 3,000
2040, 3,053
2040, 1,500
2050, 1,176
tCO2e
Option 2
Students
Path to 2050 Option 1
Path to 2050 Option 2
Electricity Conversion Factor
tCO2e per student

ENERGY REDUCTION ACTION PLAN

Priority	Recommendation	Estimated annual savings			Estimated cost (£)	Payback period (years)	Timescale	Recommended Funding Route
		£	CO_2 (Tonnes)	kWh				
1	Hydrogen Fuel Blending	-£44,775	630	8,569,367	£244,775	-5.47	2030	Capital
2	0.75 MW Solary PV Array	£91,343	182	712,500	£705,000	7.72	2030	Salix Loan
3	4MW Solar PV Array	£487,160	971	3,800,000	£3,008,000	6.17	2030	PPA
4	2MW Solar PV Array	£243,580	486	1,900,000	£1,504,000	6.17	2030	PPA
5	Battery Storage - VTG	£25,693	51	200,410	£250,000	9.73	2030	PPA
6	Behavioural Change Campaign	£76,875	616	1,156,327	£50,000	0.65	2030	Capital
7	Electrification of Heating	£117,717	898	4,884,539	£1,224,236	10.40	2030	PSDS
8	Heating Distribution Upgrades	£6,694	51	277,751	£217,000	32.42	2030	PSDS
9	Air Source Heat Pumps - Electrical Energy 1	£0	0	-1,221,135	£0	0.00	2030	n/a
10	Replace Hand Dryers	£56,921	113	444,000	£120,000	2.11	2030	Salix Loan
11	Building Fabric Insulation	£58,509	446	2,427,772	£800,000	13.67	2030	PSDS
12	Glazing Upgrade	£82,609	630	3,427,747	£1,500,000	18.16	2030	PSDS
13	Replace Physical Servers with Virtual Host Servers	£75,000	500	1,956,182	£300,000	4.00	2030	Capital
14	SMART LED Lighting upgrade	£63,551	127	495,718	£250,000	3.93	2030	Salix Loan
15	BMS Controls	£32,050	64	250,000	£150,000	4.68	2030	Capital
16	AHU upgrades	£64,100	128	500,000	£700,000	10.92	2030	Salix Loan
TOTAL		**1,437,026**	**5,894**	**29,781,175**	**11,023,011**	**7.83**		

Note: the above details the type of projects that could be undertaken through to 2030 and the possible funding routes. They exclude the additional University programme and project costs for concept design, resourcing, and communications at £4.7m up to 2030 to define, scope and deliver the net zero projects. These are likely to be revenue costs for the University of £0.5m per annum, however it may be possible to capitalise some of these costs based on the nature of the spend (see page 34 for further detail). Funding options show a spread of optionality and a light touch approach to the use of University capital. However, the greater the level of University capital used for projects, the greater the level of utility bill savings that can be realised.

[1] Whilst heat pumps offer a saving on gas consumption, there is an element of electrical consumption for the energy to run the heat pumps.

Abbreviation Key:
PPA – Power Purchase Agreement
PSDS – Public Sector Decarbonisation Scheme

ENERGY AUDIT METHODOLOGY

The BS EN 16247 series methodology has been used to conduct the energy audits for the sites.

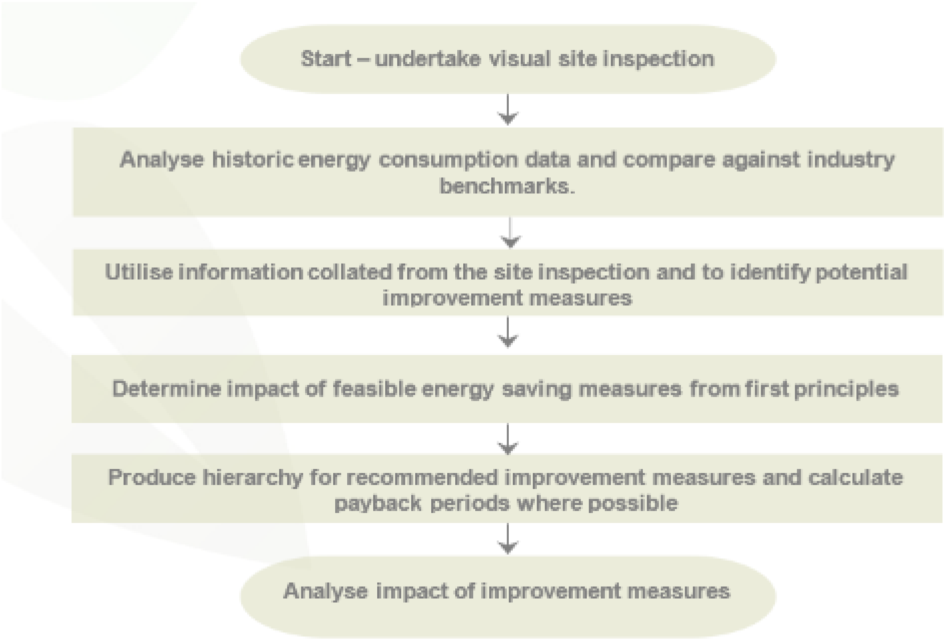


Figure 3. Audit process

Definition of Energy Consumption

Energy consumption includes the consumption of all forms of energy products, combustible fuels, heat, renewable energy, electricity, or any other form of energy. The reference period in this report is 1st January 2019 to 31st December 2019 as it was thought that the pandemic would have an adverse effect on a later period which is not representative of 'normal' operations. Half hourly electricity data was provided three months of the year and gave an indication of 'business as usual'.

Description & Basic Data of Audited Objects

This section provides a description of the sites, buildings and systems that have been part of the energy audit, and the basic data associated with them.

Buildings

Visual site inspections have been undertaken across all three sites by Michael Kenny of LCMB in 2018, 2019 and most recently in March 2021. All accessible building areas were inspected during the audit to ascertain usage type, the building services strategy and level of control. The key objectives were to collate sufficient information to identify the potential for energy savings.

SITE INFORMATION

Client: University of Essex

The Albert Sloman Library, Colchester Campus

The Tony Rich Teaching Centre, Colchester Campus

The Towers, Colchester Campus

The Gateway Building, Southend Campus

University Square, Southend Campus


Hatfield House, Loughton Campus

The Corbett Theatre, Loughton Campus

ENERGY USE AND CO_2 EMISSIONS

SCOPE 1 EMISSIONS are the greenhouse gases produced directly from sources that are owned or controlled by your organisation – for example, from the combustion of fuel in vehicles, boilers and generators. The fugitive emissions from refrigerant losses have also been accounted for.

SCOPE 2 EMISSIONS are the indirect greenhouse gases resulting from the generation of electricity, heating and cooling, and steam off site but purchased by the university. The electricity consumed on site from renewable sources is carbon free and excluded from the calculation.

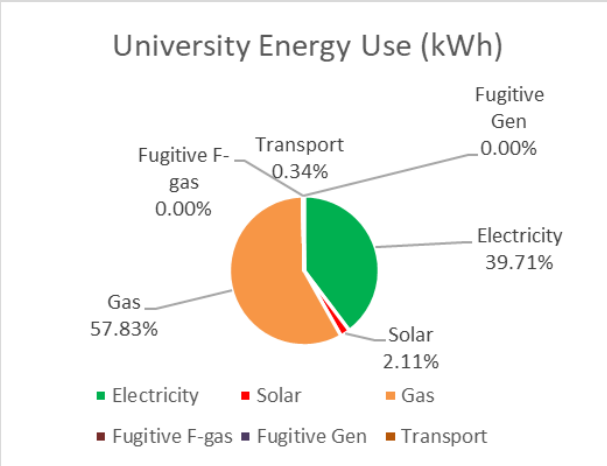
Scope 3 includes all other indirect emissions that occur in an organisations value chain and are beyond the scope of this report.

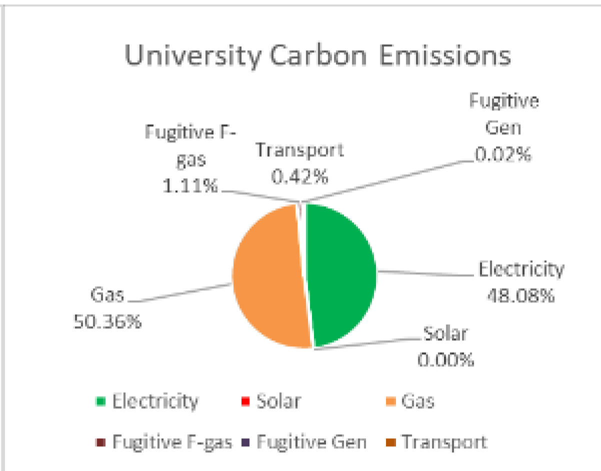
The government conversion factors for greenhouse gas reporting have been used to calculate these emissions and can be found here:

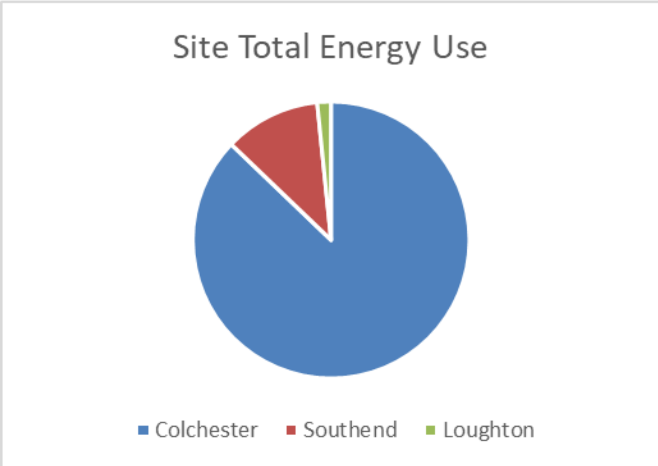
https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

The total electricity consumption for all three University sites amounted to 23,538,867 kWh for electricity, 34,277,466 kWh for gas and 503,378 kWh for solar PV. This equates to 6,302 tonnes of scope 1 CO_2 emissions and 6,017 tonnes of scope 2 CO_2 emissions. The other scope 1 emissions for refrigerant (F-gas), generator fuel and transport fuel for owned vehicles have been accounted for in the table below.

Energy Type	Period From	Period To	Usage	Unit of Measurement	Percentage of Total Energy Use %	CO_2 emissions tonnes	Percentage of Emissions
Electricity	01 Jan 2109	31 Dec 2019	**23,538,867**	kWh	**40.22%**	6,017	48.08%
Solar	01 Jan 2109	31 Dec 2019	**503,378**	kWh	**2.14%**	-	0.00%
Gas	01 Jan 2109	31 Dec 2019	**34,277,466**	kWh	**58.57%**	6,302	50.36%
Fugitive F-gas	01 Jan 2109	31 Dec 2019	**72**	kg	**0.00%**	139	1.11%
Fugitive Gen	01 Jan 2109	31 Dec 2019	**1,107**	litres	**0.00%**	3	0.02%
Transport	01 Jan 2109	31 Dec 2019	**202,055**	kWh	**0.35%**	52	0.42%
Total			**58,522,945**			**12,513**	







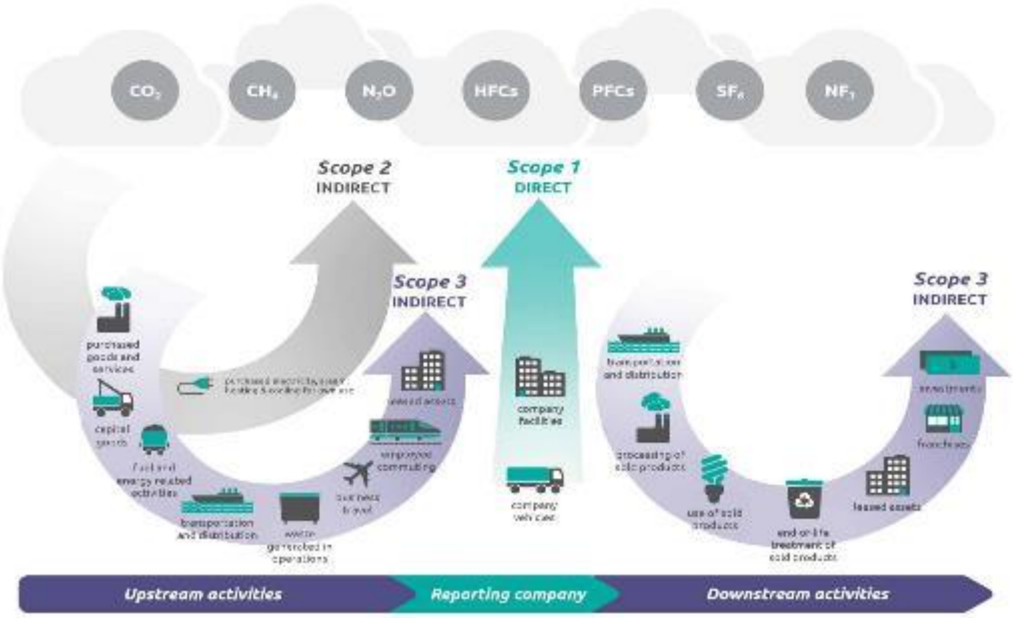
Site Total Energy Use	kWh	%age
Colchester	50,388,107	87.15%
Southend	6,495,961	11.24%
Loughton	932,265	1.61%
	57,816,333	100.00%

Emissions	CO_2 (tonne)	%age
Scope 1	6,496	51.92%
Scope 2	6,017	48.08%
Total	**12,513**	

SCOPE 3 EMISSIONS

The University traditionally have not included scope 3 emissions within their carbon reporting figures. It is our recommendation that a separate study is conducted to quantify scope 3.

Defining emissions associated with scope 3 can be challenging due to there being no definitive scale of measure. To ensure realistic and achievable goals are set, these indirect emissions need to be defined.



Reference: https://compareyourfootprint.com/difference-scope-1-2-3-emissions/

How universities define and compare scope 3 emissions alter slightly, which is to be expected considering they are significantly harder to measure.

In order to draw a generalised measure, scope 3 definitions and frames of reference have been drawn from several UK universities.

The table below shows guidance regarding the areas of activity that should be measured in order to produce a calculation of Scope 3 emissions

Area of activity	Source of data	Method of calculation
Waste production & disposal	University waste contractor data.	Composition & disposal method converted to t CO_2e.
Water use & treatment	Water utility bills.	Tonnes CO2e.
Business travel	Drawn from expenses system & university travel agents.	Milage statistics converted to t CO_2e & flight data from travel agents.
Staff & Student commuting	Bi-annual travel survey & student planning department.	Sample style surveys, using student postcodes to estimate emissions (both UK & overseas)
Procurement	Information drawn from finance department.	commodity code spend data converted to tCO2e.
Halls of residence	Provided by Energy team and data provided by utility bills/ smart meters.	Energy consumption data converted to tCO2e/ half hourly data.
Purchased goods and services	Supplier invoice data	Energy consumption data converted to tCO2e

Reference https://www.ntu.ac.uk/__data/assets/pdf_file/0021/1060473/Nottingham-Trent-University-Scope-3-carbon-emissions-report-2018-19.pdf

CARBON FOOTPRINTING

It is suggested that the British Gold Standard PAS2060 is used as the basis to calculate Scope 1, 2 and 3 emissions to quantify a complete carbon footprint.

PAS 2060 is a specification that outlines the standards of carbon neutrality outlined by the British Standards Institution, developed in 2009 and launched in 2010.
The specification was developed by a number of certified bodies including BREEAM, Carbon Clear, The Carbon Trust and the Department of Energy and Climate Change.

In order to comply with the PAS 2060 standard carbon footprint measures need to include 100% of emissions generated within scope 1 and 2 and any scope 3 emissions that contribute to more than 1%. There must be a developed Carbon Management Plan containing a public pledge to carbon neutrality outlining: a timeline to achieve, specific targets and means of achieving these targets.

These standards are measured in an audit and certified and can be achieved through self-validation, other party validation or third-party validation.

SITE ENERGY CONSUMPTION AND SPEND

The University of Essex consumed 58,319,711 kWh of energy per annum (based on the 12-month period from 1st January 2019 to 31st December 2019), costing an estimated £3,843,770 excluding CCL, standing charges and VAT. This is made up of 23,538,867 kWh of electricity, 34,277,466 kWh of gas and 503,378 of solar-generated electricity. All energy values are in terms of delivered energy.

Utility	Energy Consumption		Cost		CO_2	
	KWh/year	%	£/year	%	tonne	%
Electricity	23,538,867	40.36%	3,017,683	78.51	6,017	48.84
Gas	34,277,466	58.78%	826,087	21.49	6,302	51.16
Solar Generation	503,378	0.86%	0	-		
Total Energy	**58,319,711**	**100**	**3,843,770**	**100**	**12,318**	**100**

Energy consumption

PERFORMANCE METRICS

With a floor area of 284,706 m^2 across the estate, the University of Essex returned an energy performance metric of 206 kWh per square metre.

This compares favourably with the energy performance benchmark in CIBSE TM46 which sites a typical performance figure of 320 kWh per square metre for a University Campus. TM46 is the benchmarking guide that lies behind the performance rating of Display Energy Certificates.

With a student headcount of 17,385 FTE, that is a performance figure of 0.72 tonnes of carbon per student for Scope 1 and Scope 2 emissions.

Performance metrics related to occupants is less clear-cut as some universities use the metric of tonnes of carbon per full-time equivalent (FTE) which includes staff and students. However, 0.72 tonnes of carbon per student compares well to the following chart taken from Carbon Footprint Estimation in a University Campus: Evaluation and Insights published in 2019.

Author	Year	Country	Method	Results	Highlights
Lo-Iacono, et al. [14]	2018	Spain	ISO 14064	0.31 tCO_2e per student 2.69 tCO_2e per employee	Polytechnic University of Valencia considering 3 campuses. Measurement consider only scope 1 and 2
Güereca et al. [15]	2013	Mexico	Greenhouse Gas (GHG) Protocol	1.46 tCO_2e per person	National Autonomous University of Mexico. The measurement was focused in the Engineering Institute.
Cited by Vásquez et al. [16]	2015	Countries: Spain, México, USA, Norway	GHG Protocol	Average of 3.1 tCO_2e per student	University of Madrid (Faculty of Forestry), Autonomous University of Mexico, Minnesota State University of Mankato, Duquesne University and Norwegian University of Science and Technology.

Li et al. [17]	2015	China	Novel methodology based on survey	3.84 tCO_2e per person	Tongji University, Shanghai. Methodology includes only GHG emissions that can be linked directly to students' activities. They call this study as a personal carbon footprint because it truncates the system to the reasonable agency of a student.
Letete et al. [18]	2011	South Africa	Adapted GHG protocol	4.0 tCO_2e per student	University of Cape Town 3.2 t CO_2e per student is related to energy consumption (80%)
Larsen, et. al. [19]	2013	Norway	GHG protocol/EEIO	4.6 tCO_2e per student 16.7 tCO_2e per employee	Norwegian University of Science and Technology. Financial criteria focus on Scope 3
Cited by Almudafi and Irfan [20]	2016	USA	GHG Protocol	7.9 tCO_2e per student	University of Delaware
				13.1 tCO_2e per student	University of Pennsylvania
				24.6 tCO_2e per student	Yale University
				36.4 tCO_2e per student	Massachusetts Institute of Technology

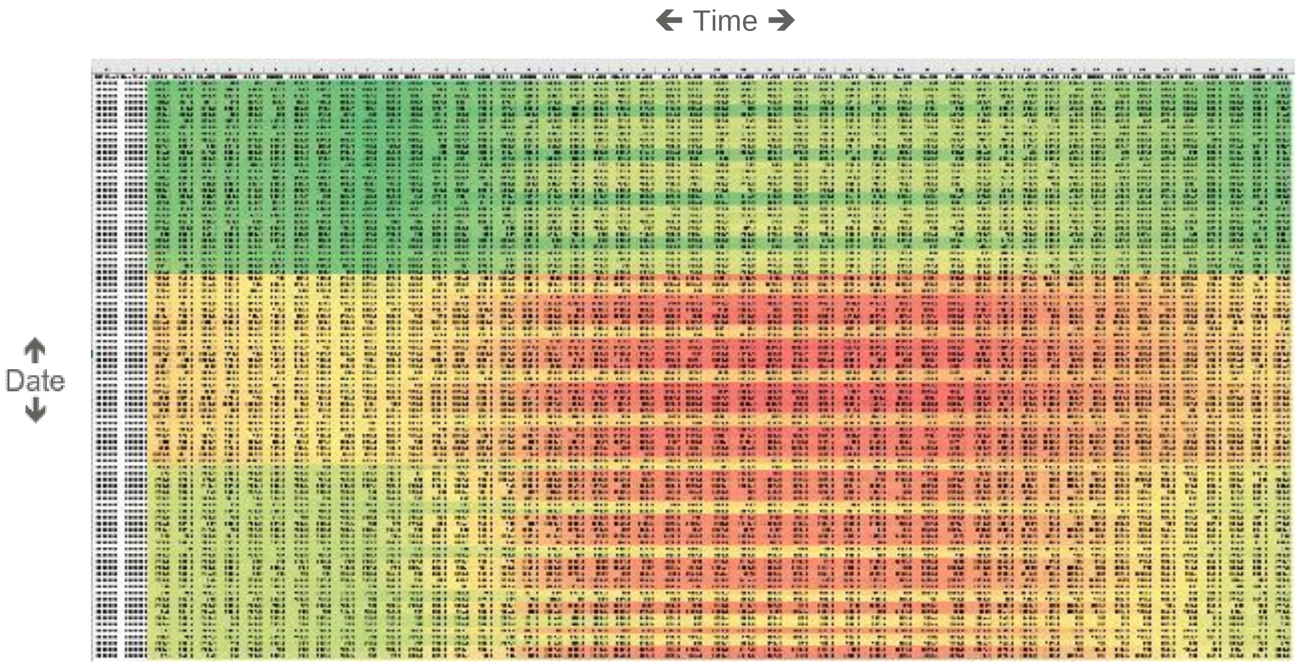
Studies of carbon footprint measured in universities.

Nottingham Trent University published their performance metric in 2018/2019 as being 0.312 tonnes of carbon emissions per FTE.

HALF HOURLY DATA

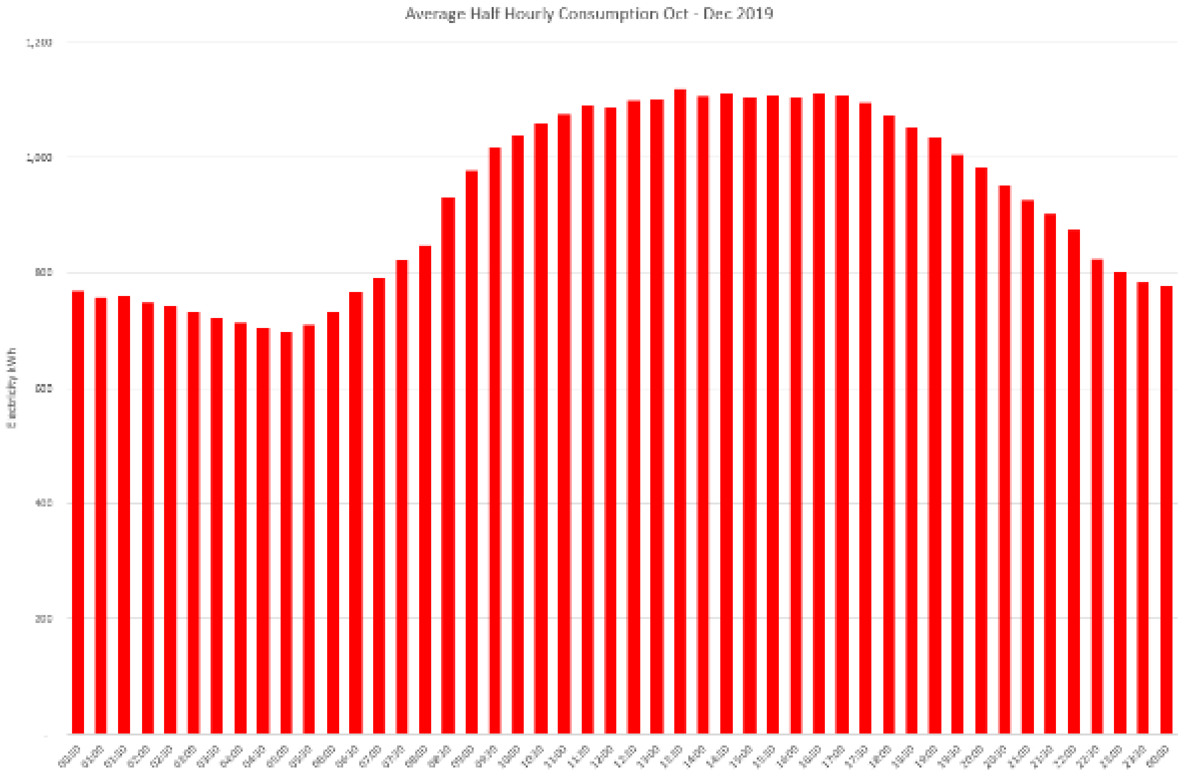
Half hourly electricity consumption data was provided for the two main incomers for the Colchester site contained in the Tony Rich Building, the Southend-on-Sea Student Accommodation, Innovation Centre, Hatfield House, E15 Acting School and the Knowledge Gateway. The reference period is September 2019 to December 2019 and unfortunately, the whole calendar year's consumption is not available. Half-hourly data is a valuable tool in analysing consumption and consumption patterns.

When a heat map (see below) is created for the two main incomers at Colchester campus from the half-hourly data where red denotes higher consumption and green, lower, an interesting pattern occurs. The timeline is on the x-axis from midnight to midnight at 30-minute intervals and each line on the y axis is a day. There are three distinct blocks for each month of October, November and December and within each day there is an increase in consumption from 08:00 and 20:00 on a weekday basis, creating a vertical column of red in the middle shouldered by green. The consumption decreases in the evenings and at the weekends and Bank Holidays. This suggests that the HVAC is set on a timed mode of operation, but the set points are altered on a monthly basis on the 1st of the month.



Colchester campus half hourly heat map Oct – Dec 2019

This heatmap is available to see in detail along with the other available MPANs in the embedded spreadsheet '2019 Half Hourly Data.xlsx'.



Colchester campus average half-hourly electricity consumption

The above chart shows the average half-hourly consumption for the Colchester campus from the two main incomers for the months of October to December 2019.

All organisations have a baseload where electrical plant and equipment will be running overnight, over weekends and during bank holidays when the offices and teaching spaces are unoccupied. Whilst it is appreciated that a university is a 24/7 environment, the baseload does seem high. The site consumes an average of 791 kWh every half an hour between 20:00 and 08:00 and an average of 1060 kWh between 08:00 and 20:00.

The baseload is 75% of the peak load, which suggests that there are electrical items that are left running unnecessarily. These could be AHUs, pumps, air conditioning, FCUs, lighting and equipment. It is suggested that the BMS is interrogated to automate turning off HVAC out of hours and a night walk-around is carried out to identify areas that are lit unnecessarily.

DISPLAY ENERGY CERTIFICATES

Display Energy Certificates (DECs) are a useful comparison when comparing with like-for-like buildings. DECs use CIBSE publication TM46 benchmarks where the performance indices are modified to consider building occupancy, size, activities, location and weather (degree days).

DECs are only required for buildings larger than 250m^2 and consequently not all buildings on site will be assessed. The DECs below have been sourced from the Government's Energy Performance of Buildings Register.

The sites perform well against industry benchmarks which suggest there is a good culture of energy efficiency within the organisation with an average rating of 79 / D where 100 would be considered the industry norm.

Building Name	Approx Size of Property m^2	DEC Rating	DEC Rating	DEC Elec Performance kWh/m2/year	DEC Gas Performance kWh/m2/year
Chemistry/ Biology	6,341	203	G	270	161
Computing	4,375	115	E	149	104
Constable	2,165	56	C	58	98
Maths	4,567	134	F	128	251
Learning Centre	2,406	107	E	179	0
Network Centre	3,166	109	E	160	66
Sports Centre	3,930	47	B	132	54
IC Lecture Hall	1,798	101	E	150	51
Health & Human Sciences	1,379	41	B	58	32
Main Building	45,418	113	E	127	176
STEM Building	2,993	23	A		
Innovation Centre	3,680	74	C	16	301
Physics	19,485	95	D	111	121
Day Nursery	736	76	D	62	25
Lecture Theatre	3,143	134	F	158	184
Library and Lakeside Theatre	8,091	90	D	58	261
SSRC	3,304	91	D	124	81
Silberrad Student Centre	6,081	39	B		
Sports Arena	5,507	50	B	96	178
Bertrand Russle Tower	4,028	38	B		
Centre for Brain Science	879	24	A	41	0
Square 1	3,316	57	C	47	137
The Causeway Teaching Centre	1,830	68	C	69	127
East 15 Acting School	2,606	60	C	58	97
Modular Dance Studio	492	57	C		
Hatfield House	610	60	C	58	97
Crobett Theatre	507	60	C	58	97
Courtyard Studios	485	60	C	58	97
Gateway Building	507				
10 Elmer Approach	12,253	121	E	146	154
University Square					
	5,203	**79**	**D**	**103**	**118**

DEC Ratings

ACTION PLAN(S) TO ACHIEVE NET ZERO

Projects have been identified across all three campuses which will reduce carbon emissions to achieve net zero initially by 2030 and are SMART, according to the mnemonic anacronym in that they are:

Specific
Measurable
Assignable
Realistic
Time related

The projects are listed under ‘Energy Reduction Plan’ and will achieve a 47% carbon saving based on 2019 figures and are ‘oven-ready’ offering the fastest payback which could potentially be submitted for part-funding under the Public Sector Decarbonisation Scheme.

The project cost and total costs to achieving net zero by 2040 and 2050 have been estimated in the tables below. Some variables have been factored into the calculations – salary rises, increased cost per tonne of projects, reduced conversion factors, increased cost of offsetting, year by year carbon reduction at a decreasing rate as projects become more challenging to identify after the low hanging fruit is harvested.

During all 3 periods (2030, 2040, 2050) decarbonisation of the grid will achieve a total reduction in carbon between 1,400 and 1,800 tonnes, while increases in student numbers and the growth of the physical estate will increase carbon emissions by about 80% of that figure. As these two variables are unpredictable and in effect cancel each other out they have been excluded from the calculations.

The Action Plan setting out the actions to achieve net zero by 2030, 2040 and 2050 with lead times can be seen in the spreadsheet embedded below:

UoE Action Plan.xlsx

Whilst the majority of the projects account for the first phase up to 2030, the momentum needs to carry on through those next two decades.

NET ZERO BY 2030

To achieve net zero by 2030 will require projects totalling £11m, excluding the cost of offsetting the residual carbon from 2030 to 2050. This equates to an average of £1.2m per annum between 2021 and 2030. Project funding could be split between the University (£744,775), Third Party Power Purchase Agreements (£4,762,000), Salix Loans (£1,775,000) and Government supported schemes such as the Public Sector Decarbonisation Scheme (£3,741,236), however the University may choose to spend at a greater level realising a more significant saving on utility bills.

Additional programme and project costs for concept design, resourcing and communications total an additional £4.7m up to 2030 to define, scope and deliver the net zero projects. These are likely to be revenue costs for the University of £0.5m per annum, however it may be possible to capitalise some of these costs based on the nature of the spend.

Due to the limited timeframe to deliver projects a significant reliance will be placed on carbon offsetting of the residual carbon of 6,619 tonnes, from just before the 2030 deadline and continuing thereafter per annum, or until remaining emissions are reduced to zero. It is expected that the cost of offsetting will increase over time to incentivise carbon reduction rather than just buying offsets, so the future per annum costs of offsetting could increase from 2030 to 2050. Current per tonnes offsetting costs are quoted at market rates between £50 and £200 per tonne, depending on the offsetting scheme, giving an annual offsetting costs of £0.39m to £0.88m from 2030 to deliver a net zero carbon figure. The total cost of offsetting in total from 2030 to 2050 would be approximately £13.99m.

Summary		
Viable Projects Implemented by 2030		
Project Capital cost	£ 11,023,011	
Carbon saving	5,894	47%
	Annual spend	By 2030
Annual Project Value	£ 1,224,779	£ 11,023,011
Concept design	£ 275,000	£ 2,475,000
Resourcing project development	varies	£ 1,777,844
Communications	£ 50,000	£ 450,000
Total		**£15,725,854**
Offsetting (2029-2050)	varies	£ 13,999,666

NET ZERO BY 2040

To achieve net zero by 2040 will require projects totalling £19.47m,excluding the cost of offsetting the residual carbon from 2040 to 2050. This would require an average project spend of £0.9m per annum. Project funding could be split across internal and 3rd party capital in line with available University funds.

Additional programme and project costs for concept design, resourcing and communications total an additional £10.57m up to 2040 to define, scope and deliver the net zero projects. These are likely to be revenue costs for the University of £0.5m per annum, however it may be possible to capitalise some of these costs based on the nature of the spend.

Due to the moderate time frame to deliver projects some reliance will be placed on carbon offsetting for 3,053 tonnes per annum, from just before the 2040 deadline and continuing thereafter per annum, or until remaining emissions are reduced to zero. The annual offsetting cost per annum using the rates identified above would be £0.39m to £0.66m or £5.8m in total.

Summary		
Viable Projects Implemented by 2040		
Project Capital cost	£ 19,469,286	
Cumulative Carbon saving	9,273	74%
	Annual spend	By 2040
Annual Project Value	£ 973,464	£ 19,469,286
Concept design	£ 275,000	£ 5,225,000
Resourcing project development	varies	£ 4,395,452
Communications	£ 50,000	£ 950,000
Total		**£ 30,039,738**
Offsetting (2040-2050)	varies	£ 5,836,121

NET ZERO BY 2050

To achieve net zero by 2050 will require projects totalling £25.6m, excluding the cost of offsetting in 2050. This would require an average project spend of £0.86m per annum. Project funding could be split across internal and 3rd party capital in line with available University funds.

Additional programme and project costs for concept design, resourcing and communications have been accounted at £17.34m up to 2050 to define, scope and deliver the net zero projects. These are likely to be revenue costs for the University of £0.57m per annum, however it may be possible to capitalise some of these costs based on the nature of the spend.

Due to the greater time frame to deliver projects a reduced reliance will be placed on carbon offsetting at 1,176 tonnes per annum, from just before the 2050 deadline and continuing thereafter per annum, or until remaining emissions are reduced to zero. The cost of offsetting in 2050 is likely to be £352,753.

Summary		
Viable Projects Implemented by 2050		
Project Capital cost	£ 25,663,221	
Cumulative Carbon saving	11,337	91%
	Annual spend	By 2050
Annual Project Value	£ 855,441	£ 25,663,221
Concept design	£ 275,000	£ 7,975,000
Resourcing project development	varies	£ 7,913,299
Communications	£ 50,000	£ 1,450,000
Total		**£43,001,520**
Offsetting (2050)		£ 352,753

ENERGY SAVING OPPORTUNITIES

1	Hydrogen Fuel Blending			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
-44,775	630	8,569,367	244,775	n/a

Detail

Natural gas consumption is responsible for 52% of the university's carbon emissions at 6,496 tonnes. Although gas as a fossil fuel has a relatively low carbon impact, using natural gas for heating generates about a third of our greenhouse gas emissions in the UK.

Hydrogen is the lightest and most abundant element in the universe. It can be used as a source of power, and it is an important feed stock for many petrochemical processes. Hydrogen can be used as a low-carbon fuel source. Hydrogen can be combusted directly, or it can be used in a fuel cell to produce electricity.

Since hydrogen produces minimal pollutants when combusted, it is envisioned by many as a core component of a cleaner energy future. Hydrogen has been recognised by the Committee on Climate Change – the UK's independent climate advisory body – as an essential part of the journey to net-zero and could be used for fuelling industry and transport networks, and heating buildings.

The great thing about hydrogen is that when it is combusted, it only produces water so there are zero carbon emissions. And it can be used for heat, power and even fuel for large vehicles like HGVs. Hydrogen holds a lot of energy, so it is great for transporting large amounts of energy to where it is needed.

The existing distribution network, boilers and cooking appliances would all need to be changed to support a 100% hydrogen network which would be a huge expense. However, trials at Keele University have shown that it is possible to continue using existing appliances by using a mix of 20% hydrogen and 80% natural gas. A blend can be used safely and effectively. 100 ordinary houses and 30 faculty buildings at Keele are using this blend to heat and cook with.

Although hydrogen does not emit carbon dioxide when it is burnt, but it can still be carbon-intensive depending on how it is made. At the moment, most hydrogen is made from natural gas via a process called steam reforming. This is extremely energy-intensive and uses more gas to create heat from hydrogen than if gas was used on its own. This is known as 'blue hydrogen' when natural gas is split into hydrogen and CO_2 either by Steam Methane Reforming (SMR) or Auto Thermal Reforming (ATR), but the CO_2 is captured and then stored. As the greenhouse gasses are captured, this mitigates the environmental impacts on the planet. The 'capturing' is done through a process called Carbon Capture Usage and Storage (CCUS).

Grey hydrogen uses a similar process to blue, but the CO_2 is not captured and released into the atmosphere.

Green hydrogen would be the preferred choice and is hydrogen produced by splitting water by electrolysis. This produces only hydrogen and oxygen. We can use the hydrogen and vent the oxygen to the atmosphere with no negative impact. To achieve the electrolysis we need electricity, we need power. This process to make green hydrogen is powered by renewable energy sources, such as wind or solar. That makes green hydrogen the cleanest option – hydrogen from renewable energy sources without CO_2 as a by-product.

It would be cost-prohibitive to produce hydrogen on-site, therefore it would be necessary to transport hydrogen filled cylinders to a site close to the main gas incomers serving the University. The hydrogen would be injected into the existing distribution service line downstream of the gas governors at the main incoming site meters.

It is predicted that the UK will see a transition period of 20-30 years where blue hydrogen will play a key role whilst green hydrogen production and distribution is developed.

Rationale

Although natural gas has the lowest carbon emissions of all fossil fuels it does have a significant carbon content. Hydrogen gas has no carbon contact so the replacement of some of the natural gas burnt in homes and industry with hydrogen would reduce carbon emissions at the point of use. However, in practice, not all the CO_2 produced during the manufacture of hydrogen from fossil fuel would be captured thus reducing the overall reduction which is achievable. Typical CO_2 emission reduction potential is shown in the table below:

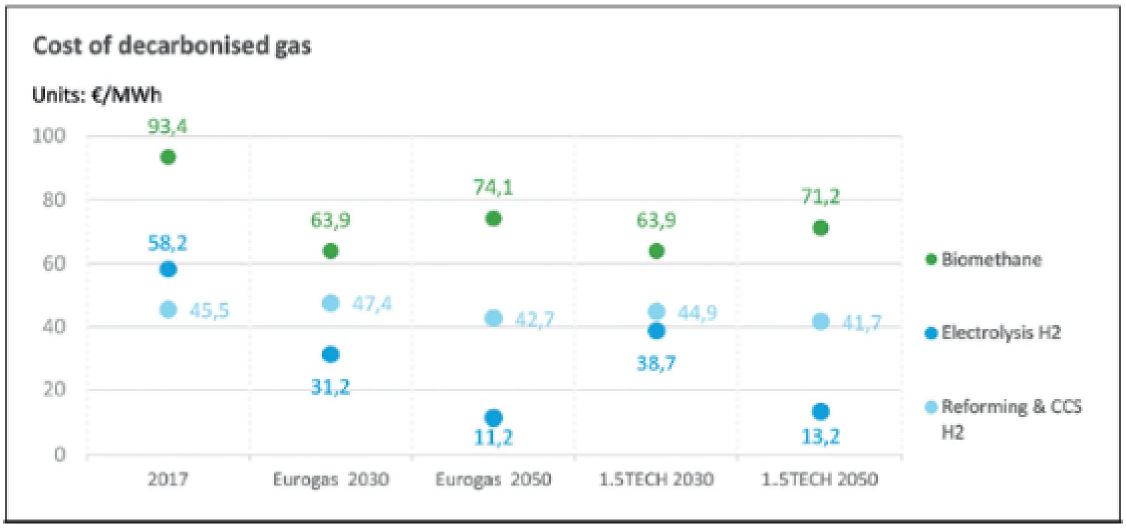
Gas	High calorific gas	Rel. CO_2 emission
H_2-content [vol%]	Relative Wobbe [%]	[%]
0	100	100
5	98.7	98.6
10	97.4	97.1
15	96.0	95.4
20	94.7	93.7
25	93.4	91.7
30	92.0	89.6
40	89,3	85,5
60	84,2	73,0
80	80,4	52,6
100	85,0	13,3

The relatively low calorific value of hydrogen on a volumetric basis means that replacing 25% of the volume of gas reduces the carbon emissions of gas by only ~10%

There is a cost difference between blue and green hydrogen. For the purpose of this report, it is assumed that blue hydrogen will be blended with the existing gas at a cost of 4.5p per kWh. This is almost double the cost of natural gas but the cost is expected to fall and accounts for the negative cost saving quoted.

If hydrogen is to be widely employed as a combustion fuel, the ability of green hydrogen to ultimately achieve a similar unit cost to that of natural gas is a key point of distinction.

The green hydrogen approach circumvents the uncertainties, complexities and costs associated with blue hydrogen production and CCS. Moreover, the characteristic cost

	down curve for green hydrogen suggests that taxpayer subsidies, which will be required to avoid market failure during the early years, can in time decline to zero. When compared with blue hydrogen, green hydrogen offers several advantages.  These are important factors for governments to consider in planning the transition to a climate-neutral energy system. It is recommended that to achieve this considerable carbon saving that 25% of the existing natural gas supply is blended with blue hydrogen. It remains to be seen what investment the UK government is prepared to put into producing green hydrogen and introducing a hydrogen grid. Whilst existing gas-fired boilers have life left in them, it would be economically prudent to retain them for space heating and other gas appliances for cooking with a blended mixture. It would cost an additional £44,775 per year to adopt hydrogen into the system but the saving of 630 tonnes of CO_2 gives a good cost per tonne ratio.
Risks	Whilst a conservative 25% blend of hydrogen is recommended to preserve the performance of the existing gas-fired boilers, it is a risk that they will not perform as well. Gas boilers that are older than 15-20 years old should be considered for upgrade to electrification if appropriate rather than replaced to run on gas / hydrogen. The University of Keele is keen to share knowledge and experiences.
Next Step	Obtain quotations from Hydrogen / Gas blending specialists, conduct surveys and design specifications suitable to the building's requirements. Liaise with Keele University to learn from their experience of hydrogen technologies.
Relevant Publications	Development in the global hydrogen market HyDeploy at Keele https://www.hy4heat.info/ Hydrogen to Homes heating network in Fife Converting the gas network to hydrogen Zero carbon hydrogen production Government UK Hydrogen Economy

2 - 4	Install Solar Panel PV Arrays			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
822,083	1,639	6,412,500	5,217,000	6.69

Detail

The University of Essex already has embraced the benefits of generating its own electricity and has installed 2,000 solar panels across 14 buildings generating over 500,000 kWh of electricity per year. In addition, the university purchases 100% renewable generated electricity on a green energy tariff from Haven Power.

Solar panel electricity systems, also known as photovoltaics (PV), capture the sun's energy using photovoltaic cells. These cells do not necessarily need direct sunlight to work – they can still generate some electricity on a cloudy day. The cells convert the sunlight into essentially free electricity which can be used onsite. Solar electricity is a renewable energy that will reduce the site's carbon emissions and grid energy consumption.

A two-phase scheme has already been scoped which will see an additional 2,613 solar panels installed across nine roofs by July 2022. This project needs to be re-tendered as COVID-19 put the Salix funded scheme on hold.

The university also has a large area of surface car parking where solar PV arrays could be installed on top of solar shaded parking. As the summer temperature increases, this shading would be welcomed by staff and students with the added bonus of generating electricity.

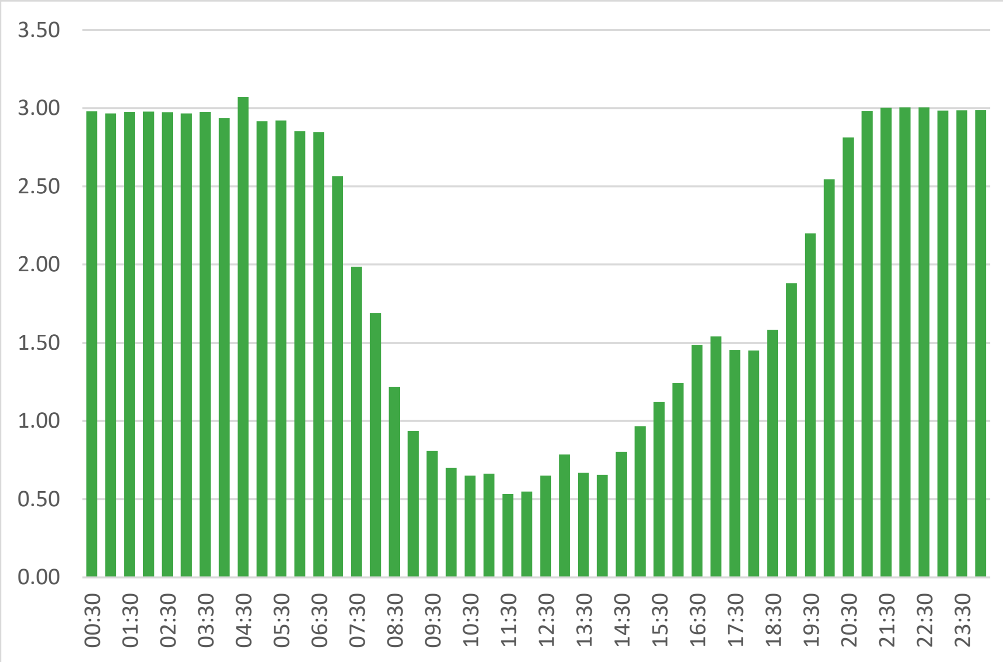
The Southend campus is the only one within the estate without a solar array. The Gateway Building and University Square accommodation buildings have a total surface area of 1,500 m^2 which could accommodate solar panels. Whilst there is plant and equipment which may preclude suitability at Gateway, the University Square buildings could probably host a 100kW array comfortably which would generate 95,000 kWh per year and save 24 tonnes of CO_2.

Rationale	Detailed studies of each recommended area should be carried out to establish if arrays were feasible. The Feed in Tariff (FIT) scheme has closed to new applicants, however, it is worth exploring the Smart Export Guarantee scheme to establish if this could be of benefit.
Risks	• The initial purchase price is high with a long payback, but there is minimum maintenance and 'free' electricity as the price of grid-supplied electricity is predicted to increase.
Next Step	• Get supplier to assess suitability of buildings and provide quotation for the design, installation and commissioning of the array.
Relevant Publications	Solar Farms could make fertile habitats Low Carbon Hub Renewable Energy Guide

5	Battey Storage and Vehicle to Grid			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
25,693	51	200,410	250,000	9.73

Detail

The sites at Colchester and Loughton have sizeable solar PV arrays and lend themselves to battery storage technology. With further arrays proposed across the sites, battery storage and VTG becomes an even more viable proposition. Colchester generates 493,000 kWh of electricity per year and Loughton is responsible for 9,508 kWh which is consumed on site with no grid export.



The chart above shows the typical building with PV half-hourly consumption data during the summer months. As the day progresses to the middle of the day, the solar panels are generating at their peak which then reduces as the hours of sunshine reduce. The site dependence on imported grid electricity reduces towards the middle of the day.

Rationale

Battery storage is another emerging technology that works well with solar technology. Energy can be stored for use when needed putting less reliance on the grid. Demand Side Response allows organisations to shift their electricity consumption to work in conjunction with the National Grid when national demand threatens to exceed supply. There are financial benefits to be had by shedding grid load during peak hours of 16:00 to 19:00. This is especially true during the TRIAD season when electricity suppliers charge huge amounts for energy consumed during the three highest consuming half-hour periods in the winter.

EV Charging Points are likely to be in high demand over the next few years. This is the ideal opportunity to install them in conjunction with the other technologies around the sites.

Vehicle to Grid. There is the option to consider how the buildings could be made more self-sustaining by generating as much of their own power as possible. With the University of Essex's healthy appetite for renewable energy comes the opportunity for V2G (Vehicle to Grid) technology in conjunction with battery storage and solar PV.

Incentives could be given to students/staff with electric vehicles who could, in return for free parking, volunteer their vehicle's excess energy to be used as power in the adjacent building.

Apps are available to ensure that a sufficient charge is held in the car to account for emergency use and charging is outside peak tariff times to avoid TRIAD charges.

Demand Side Response (DSR) is an intervention by consumers to flexibly alter consumption patterns in real-time at times of stress on the main electrical system, or in response to network operator price signals.

DSR enables businesses to save on import costs as well as generate income by reducing or shifting consumption – or switching to on-site generation – at opportune times. It can also involve increasing consumption at times when the system has too much capacity.

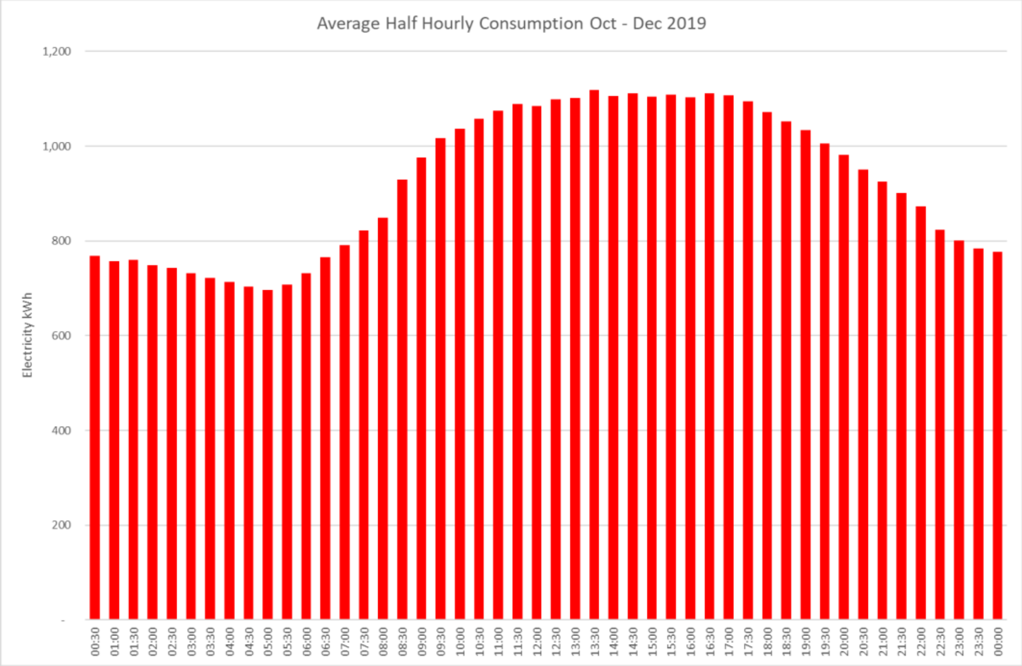
National Grid uses DSR as a tool to help balance national energy requirements. Through various balancing schemes, consumers are incentivised to 'flex' their electricity use at required times to resolve issues on the grid.

Demand Side Response could be considered which would benefit the country as a whole to ensure that power supply and demand are matched, and the grid is not overloaded. Financial incentives are given to energy users to turn down or off non-essential processes at times of peak demand. The readily available power source in the form of the EV car park could be used to keep the lights on while being paid not to draw electricity from the grid.

Costings and savings have been calculated based on similar battery storage and DSR projects at Birmingham Airport and Cherwell District Council.

Risks	A space the size of a shipping container would be required to house a battery storage system which would equate to 3 car parking spaces. Typically, battery storage systems are made up of second-hand EV batteries which may have a limited lifespan. It is hoped that this huge market for batteries will drive research and development into battery technologies, bringing down costs and improving performance in stationary storage applications.
Next Step	Engage with a company to conduct a feasibility review for the installation and operation of a battery storage system. V2G and DSR.
Relevant Publications	Demand Side Response Electricity System Flexibility Energy Storage

6	Behavioural Change Campaign			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Estimated Cost £**	**Payback Years**
76,875	616	1,156,327	50,000	1.65
Detail	Considerable carbon savings are achievable by encouraging staff and students to adopt behaviours that reduce energy and waste. It is a challenge in a university environment where the occupants do not necessarily pay for their energy costs directly. Student accommodation energy costs are wrapped up in the monthly charge and staff are not recharged for the energy that they use in heating, lighting and to power equipment. If accommodation was metered by the room it would be possible to accurately recharge the exact amount to each student, which would be an incentive for them to consider their utility usage. The saving quoted above is only 5% of the university energy spend. The Carbon Trust estimates that 10-15% savings are achievable. If a culture of empowerment is encouraged where students and staff show a degree of ownership over their energy use, then savings will follow. A success story at the University has been seen with the recent upgrade of Ultra Low Temperature (ULT) freezers. Research staff have been persuaded to run ULT freezers at minus-70°C rather than the industry norm of minus-86°C accounting for an immediate energy reduction of 22% with no degradation of sample quality. This was as a result of Dr David Knight's intervention with staff and students to adopt a new culture of energy efficiency in research. Switching it off is the oldest and most effective energy saving measure and if staff and students adopt this policy then savings will soon follow. All organisations will have a baseload where electrical plant and equipment will be running overnight, over weekends and during bank holidays when the lecture halls, offices and laboratories are unoccupied. The University has an average night consumption of 74.58% of the total consumption during the period 8:00pm to 8:00am. From the survey, it was noted that there were a number of items of electrical items which were left running when not required e.g., photocopiers, PCs, televisions, vending machines and water coolers. Investigating the baseload will detect potential sources of waste as well as determining the site's baseload.			
Rationale	It is important to note that there is inevitably going to be an electrical baseload at the site since it is continually operational as far as IT, fridges and freezers and alarms are concerned. However, it is not uncommon that at least 10% of the overall electrical consumption can be attributed to unnecessary electrical baseload.			



At the University out of hours consumption was 75% of the daytime load which warrants investigation.

There will be certain key areas that have a disproportionate effect on electrical baseload on sites of this nature. Primarily these are:

- Cultural behaviour of staff
- Individual Items of Plant e.g. (FCUs, warm air heaters, lighting)
- IT equipment

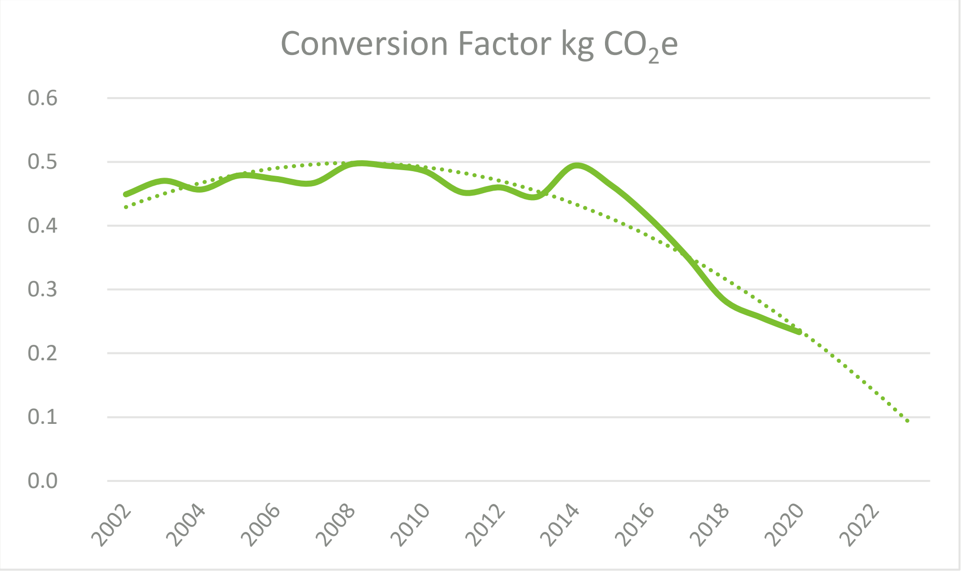
- **Staff Cultural Change**: This can be addressed as part of an awareness campaign, but it is advised that any change which is instigated in the university has to be long term and aimed at not only the immediate staff and students but also individual management areas and separate divisions.

  A laptop will consume 150W over the 8-hour working day whereas a monitor will be responsible for 400W – almost 4 times as much. If PCs are slow to boot up, just turning off your monitor when not in use will contribute a significant energy saving.

- **IT Equipment:** The vast majority of the PCs/workstations run by the university are operated and managed as part of a network. Members of staff have to log on to the network to operate the workstations. In order that the network can be maintained, IT managers routinely have to be able to shut down certain parts of the network. The majority of the software that is used by network managers has this feature built in. This procedure may have to be authorised by those who run the network.

In the event that the network cannot shut down the workstations remotely, the IT team should be able to configure individual PCs to shut down at a specific

	time unless overridden by the operator. This will also increase staff wellbeing by encouraging them not to work in the evening. The above procedure can be extremely useful when the heat load given out by the volume of PC's acts as a trigger for air conditioning to maintain the necessary environmental conditions. In some extreme conditions, this can also bring on the heating and the result is a continual fight between the heating and cooling, pushing up the electrical baseload. Good housekeeping plays an important role in reducing energy costs and this is particularly so with baseload reduction. The main items of plant which may have a disproportional effect on baseload are listed below: 1. IT servers 2. Lighting 3. Chiller Plant It is suggested that an end-of-day walk round is conducted just to ensure that HVAC and lighting are being switched off at night and weekends. Analysis of half-hourly data from the energy supplier will also verify this.
Risks	It should be noted that there is always some essential equipment that must be left running on-site and that this will constitute some degree of electrical baseload. Examples of this are security lights, servers, fridges and freezers etc.
Next Step	• Discuss proposals with management • Get an agreement on the operation of the network • Do a test run of the IT shutdown, comparing energy savings against current base loads • Communicate to all necessary parties.
Relevant Publications	How to conduct a walk round energy survey Low Carbon Behaviour Change Behaviour Change Interventions for Reduced Energy Use The role of UK universities in carbon reduction

7	Electrification of Heating			
Cost Saving £	**CO_2 Savings Tonnes/year**	**kWh £**	**Estimated Cost £**	**Payback Period**
117,717	**898**	**4,884,539**	**1,224,236**	**10.40**
Detail	There is a move towards the decarbonisation of heat and electrification of heating. Decarbonising heating through electricity seems more likely to be realised in practice. As things stand, electricity has a slightly higher carbon content than gas, when used for heating. But that is decreasing all the time. Emissions from grid electricity have reduced by nearly half over the last 20 years, principally as a result of retiring coal power stations and a massive surge in solar PV and offshore wind turbines. That trend is likely to continue. According to predictions from the Department of Business, Energy and Industrial Strategy (BEIS), electricity will become greener than oil, LPG and even natural gas per kWh of heat within five years.  The UK electricity factor is prone to fluctuate from year to year as the fuel mix consumed in UK power stations (and auto-generators) and the proportion of net imported electricity changes. These annual changes can be large as the factor depends very heavily on the relative prices of coal and natural gas as well as fluctuations in peak demand and renewables. In the 2020 GHG Conversion Factors, there was a 9% decrease in the UK electricity CO_2e factor compared to the previous year because there was a decrease in coal generation and an increase in gas and renewables generation. Since 2016 they have fallen by 11%, 15%, 19% and 10% each year. Natural gas is used mainly for heating buildings and water. 90% of homes have gas-fired boilers and the majority of the university's buildings are reliant			

	on gas. New builds have seen a move towards electric heating, but gas is still responsible for 50% of the university's carbon emissions. Heat pump systems have the potential to deliver immediate carbon emission savings. However, heat pumps are not a like-for-like replacement for gas boilers and good practice system design will be essential to their effective deployment.
Rationale	The Carbon Trust sites that heat pumps used for heating can offer carbon emission savings of around 30% when compared to conventional natural gas boilers. An Air Source Heat Pump (ASHP) is a refrigerant based system, like a refrigerator. The system can absorb low grade heat from the air and raise its temperature efficiently to be suitable for space heating and/or hot water. An air source heat pump system and can provide water temperatures of up to 60°C (without backup electric heater) in ambient temperatures as low as -25°C. The ratio of heat transferred into the building versus energy used to drive the refrigeration process is known as the Coefficient of Performance, or COP. Meaning that a standard space heating system with a COP of 3.0 is capable of providing 3kW of heat for every 1kW of supplied electricity. The increased electrical energy required by the heat pumps has been accounted for as negative savings of 1,221,135 kWh. A simple low temperature air to water system will raise water to around 40°C where it is at an ideal temperature for use with underfloor heating systems. This could make use of the existing underfloor system at the Nursery. It is possible to run the heat pumps in reverse to also provide cooling during the summer months. All sites should be assessed for suitability in terms of external locations away from obstructions. It is recommended that the existing gas fired boilers are retained as a backup. The recommended ASHPs will take up 95% of the required load. Ground Source Heat Pumps could also be considered. Relatively stable ground temperatures, approximately equal to the average air temperature, mean that heat pumps which use the ground as a source could be more efficient than those using ambient air. Interest is focused on closed loop systems which consist of a sealed loop of polyethylene or polybutylene pipe buried in the ground either in a shallow trench or vertically in a borehole and connected to the heat pump. Either refrigerant (direct system) or a water/antifreeze mixture (indirect system) is circulated through the ground coil. Direct circulation systems are more efficient than indirect systems but the design is more complex and there is the risk of refrigerant leaks. The majority of systems are indirect. This technology can be expensive because of the groundworks involved; however, they should be considered when any ground is broken for

	construction works or perhaps sports field drainage. The publication listed below does explore the opportunity to install GSHP in parks which would be suitable at Wivenhoe Park.
Risks	The temperate UK climate lends itself to the suitability of heat pump technology, but their performance reduces in colder temperatures. In colder temperatures, the heat pump system will be less efficient at drawing heat from external air as the compressor. It has to work harder to raise the temperature of the refrigerant for use in the building, this can significantly reduce the COP of the system. Frost can also build up on the evaporator which reduces the performance. Heat pumps are not a like-for-like replacement for gas boilers and good practice system design will be essential to their effective implementation. The existing distribution system is unlikely to be suitable for the low-grade heat produced by ASHPs and supplemental heaters or heat plate exchangers will be required. Allowances have been made elsewhere for these requirements.
Next Step	Commission ASHP and GSHP specialists to survey existing heat and hot water requirements across the estate and design heat pump solutions with a view to phasing out the reliance on gas-fired boilers.
Relevant Publications	Heat Pumps – Carbon Trust Heat Pump retrofit in London Powering Parks

8	Upgrade Heating Distribution Systems			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
6,694	51	277,751	217,000	32.42
Detail	Heat pump systems have the potential to deliver immediate carbon emission savings. However, heat pumps are not a like-for-like replacement for gas boilers and good practice system design will be essential to their effective deployment. This recommendation should be considered in conjunction with the electrification of heating The existing heat distribution systems vary across sites including wet radiators and pipework, air handling units, fan coil units and radiant panels. The controls are generally through building management systems with varying degrees of effectiveness. There are also local thermostatic controls in some buildings. Heat pumps work by absorbing energy from the ground or air and compressing the low-grade energy into high-grade heat. They then deliver the heat through a heating distribution system, such as radiators or underfloor heating, for reliable heating and domestic hot water through the seasons.			
Rationale	Underfloor heating is accepted as the best distribution system because it operates at lower flow temperatures. The large surface area of underfloor heating means the heat pump can deliver temperatures of 35°C. With underfloor heating, you can achieve higher efficiencies because of the low temperature required from the heat pump. Radiators either need to be correctly sized or replaced with bigger ones to cater for a lower flow temperature, or the heat pump needs to produce higher temperatures to emit sufficient heat from a smaller surface area. The only site with existing underfloor heating is the Nursey. This site would require the least alteration to make use of a heat pump system. However, the economic case needs to be considered as the gas-fired boiler has only recently been upgraded. Fan assisted radiators, could be used with a heat pump to enhance performance. These units combine a copper aluminium finned heat exchanger with a low water content and a number of small fans. As the fans increase airflow around the heat exchanger, the output of the radiator rises and can give up to 3 times more heat output than a conventional radiator with the same dimensions. As these units contain a low water content, they are quick to react to ambient changes and night set-back temperature. Fan assisted radiators operate with electrical fans, so they need to be connected to the electrical supply and have a small electrical consumption of around 2-3 watts.			
Risks	Good design is essential to ensure that radiators are sized appropriately to deliver flow temperatures compatible with the heat pump. Heat pumps traditionally will supply a lower grade heat supply than gas-fired boilers. Consideration should be given to areas with a high space volume such as sports halls. These areas may be better suited to electrical radiant heating.			

	In order to reap the full benefits of an air source heat pump, you will need a well-insulated building to begin with. However, this is true for any heating system. If heat can easily escape through windows, doors, or through walls, then you will need more energy to keep the space warm. Current levels of insulation should be investigated and increased if practicable.
Next Step	Appoint heating design engineers to assess current distribution systems and advise on their suitability for upgrade to air source heat pump systems. The estimated cost is in conjunction with the previous recommendation to install heat pumps. Buildings with end-of-life boilers and potential for good insulation should be prioritised.
Relevant Publications	Building Heating Systems Heating Ventilation and Air Conditioning CIBSE Guide A: Environmental Design

10	**Replace Hand Dryers**			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Estimated Cost £**	**Payback Years**
56,921	113	444,000	120,000	2.11
Detail	There are an estimated 1,000 hand dryers of varying age and energy efficiency. The University has replaced some of these with high-efficiency versions already and these have been excluded from the calculations. However, the calculated savings have been based on 300 hand dryers in the high footfall areas. They are rated at 2kW on average. The NHS has provided guidelines on how long and when to wash your hands. As a rule of thumb each person, in a building, is likely to wash and dry their hands about every two hours. However, this may be considerably more in today's COVID climate. Experts from the World Health Organisation state that proper hand hygiene is the best defence against the spread of germs, including coronavirus. This usage can add up to significant energy consumption. The older low airflow warm air hand dryers will take around 45 seconds to dry hands. For 300 hand dryers, this could add up to 540,000 kWh of energy consumption.			
Rationale	1.6kW (the power consumption of a *Dyson Airblade*) is considered the industry standard for energy efficient hand dryers in the low-energy category. Although 1.6 kW is not a great reduction on the existing 2 kW models, modern hand dryers use a super-fast drying speed of around ten seconds. This would equate to an 82% reduction in energy consumption and if we assume an installed cost of £350 per unit this could provide a payback of 2.2 years. (Calculations have been included in the accompanying 'UoE Energy Report' spreadsheet).			
Risks	As the circuit feeding the existing hand dryers is likely to be shared with other lighting and small power, a clamp meter should be installed to accurately measure actual consumption. This meter could also be used post-installation to verify savings.			
Next Step	Invite suppliers to quote for the supply, install and commissioning of energy efficient hand dryers			
Relevant Publications	Top 11 low energy high speed hand dryers Clearing the air about warm air hand dryers			

11	Building Fabric Insulation			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
58,509	446	2,427,772	800,000	13.67

Detail

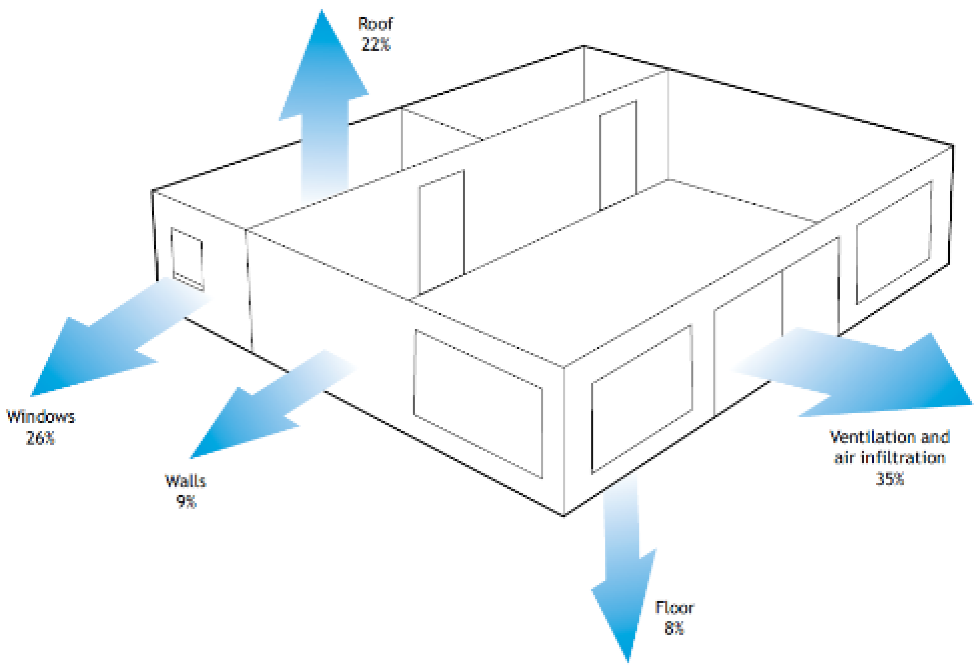
The building fabric for many of the original 1960's buildings at Colchester is typical of plate glass universities. The brutalist contemporary architecture is famous for its high degree of single glazed fenestration and use of concrete. The buildings around 'The Squares' and the Albert Sloman Library are typical of this type of architecture and provide the greatest opportunity for insulation upgrades.

Unfortunately, building regulations of the day did not specify insulation or double glazing, and buildings were left with high R and U-values, and consequently high levels of heat loss (and gain).

Around 9% of heat loss from a building is through its walls.

Given the year of construction and materials used it is suspected that there is a high degree of thermal (cold) bridging where there is a direct connection between the inside and outside. It is thought that there is no insulation in place but that warrants further investigation. Investigative boreholes or thermal imaging could be used to investigate the presence of any existing insulation.

Figure 3 Heat loss from a commercial building



Rationale

Installing cavity wall insulation would be the preferred option if and where there any cavities. Expanded polystyrene beads or mineral wool are the most commonly used materials for existing buildings and most cavity fill

	materials can plug gaps up to 12m high. It is usually possible to install specialist insulation in buildings up to 25m high. Filling cavities provides a more comfortable environment for occupants, reduces draughts as well as the risk of condensation. In buildings where rain penetration is already a problem, cavity insulation should be avoided. Installation must be carried out in accordance with the manufacturer's instructions to prevent any bridging caused by mortar droppings or other debris which could lead to damp penetration. The addition of insulation to the internal face external walls is a less expensive option, but disruption to building occupants can restrict this to times of major internal refurbishment projects. Insulation can be fixed to battens and covered with plasterboard or incorporated in a single 'composite' board (consisting of insulation and plasterboard together). It is important to incorporate a vapour control layer on the warm side of the insulation to avoid condensation between the wall and the insulation. Another alternative is the addition of external insulated cladding to the outside walls. An effective way to protect buildings against penetrating damp, external wall insulation provides a weatherproof layer on the outside surface of the structure, which also works to slow heat loss. External insulated cladding is designed to provide thermal and aesthetic improvements to all forms of construction types but are especially suited for solid walls. Heat energy losses are decreased, and the effects of cold bridging can be overcome, reducing condensation and damp. The cladding protects the building fabric from weathering. The original wall construction can be used as a heat store. This thermal mass helps to reduce temperature fluctuations and maintains a more comfortable internal environment. Installation can take place without disruption to the occupants and there is no reduction in interior living or working space. The costs and savings have been calculated based on an estimated average installed cost of insulation per square metre. The elevations of the 1960s buildings that comprise the Squares and the Albert Solman Library on the Central Campus have been targeted for this insulation. These have been selected as they are likely to be uninsulated and would benefit most from external insulation.
Risks	When applying internal insulation, consideration should be given to heavy items such as radiators which may require additional support. When putting in services such as electric sockets and pipework, penetration of the insulating layer should be minimised in order to maintain the insulating properties of the material. Insulation is a Category 2 technology that does not directly contribute to the heat decarbonisation of the building but will reduce overall energy demand and so will help future heat decarbonisation.

	Since Grenfell, the public perception of external cladding has been tainted and the fire-retardant properties of the cladding should be paramount in specifying the product.
Next Step	Engage insulation specialists to investigate potential and provide quotation for recommended insulation solution.
Relevant Publications	Building fabric guide Carbon Trust CIBSE Guide A: Environmental Design Cavity Wall Insulation Solid Wall Insulation

12	Glazing Upgrade			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
82,609	630	3,427,747	1,500,00	18.16
Detail	The University of Essex buildings dating from the 1960s have a high degree of fenestration which leads to a high level of solar thermal gain and conversely also thermal loss. The 1960s estate particularly around 'The Squares', have floor to ceiling glazing which is also single-paned. From the exterior, the glazing goes to floor level but from the inside is protected by a thin layer of plastic, which does not seem to have any insulation properties.  The level of fenestration in the Albert Sloman Library is such that it suffers from solar gain in the summer and thermal loss in the winter. An alternative to double glazing is a combination of secondary glazing and solar film which is considerably cheaper and as effective. Solar control window film can act to reduce solar gain through a building's glazing, while low emissivity films can also reduce heat loss. This reduces the energy requirements of heating, cooling and ventilation systems (HVAC) which can often be responsible for over 50% of carbon emissions in commercial buildings. 			

	As well as helping to control heat levels, solar control films will deliver additional benefits such as glare reduction, improved privacy and blast protection, greater staff comfort levels, reduced cooling demand, and improved security. Solar film is cost effective when compared to alternatives such as: low-emissivity glazing; insulation; air conditioning; tree planting; or solar shading. However, solar film has a shorter life (10-15 years) than some other solutions. Film is easy to install and offers a quick installation solution to solar gain compared to its more costly competitors. The U-values of glazing can vary from $6W/m^2K$ (single glazing) to $1W/m^2K$ (triple glazing) and consequently have a great contribution to a building's temperature rise through solar gain and conversely heat loss during the winter months. This means a better return on investment can be seen in adding solar film to single glazing than to double or triple glazing. The summers of 2017, 2018 and 2019 have seen unseasonably high temperatures, above the 20-year average with an increased demand for cooling and therefore energy consumption, which would be reduced through better solar shading, as offered by solar film.
Rationale	The installation of solar film on South facing windows will improve personal comfort levels, increase privacy, and reduced the cooling load which will return an energy, cost and CO_2 saving. The costs and savings have been based on a similar solar film installation at Royal Berkshire Hospital in November 2020 and calculated by multiplying the surface area of glazing by the installed cost of the product. The installation would be non-disruptive as it can be installed internally by hand without the need for disturbing asbestos panels or window frames with scaffolding and ladders. However, it can also be externally fitted, if preferred. Like the estimated cost of insulation, the cost has been estimated for the Squares buildings and the Library based on an average installed cost of solar film per square metre.

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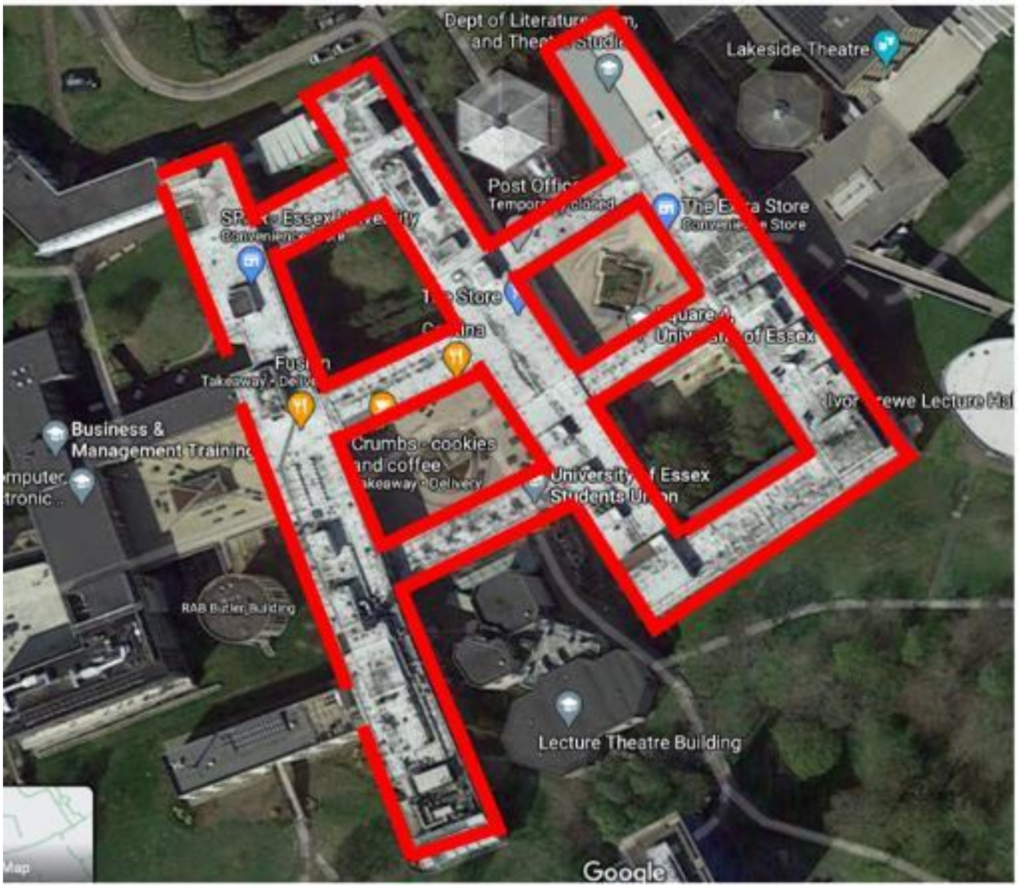
<tr><td></td><td>

The estimated cost is based on the level of fenestration in square metres for the ‘Squares’ and the Albert Sloman Library.</td></tr>
<tr><td>Risks</td><td>Solar film cannot be fitted to some types of windows such as textured or frosted glass.</td></tr>
</table>

	Staff should be encouraged not to attach anything to the solar film once it is installed as its performance will degrade if posters are attached with glue or sticky tape. Although this technology is not listed on the Salix Category List, a technology type of 'secondary glazing' has been suggested as this is the closest type.
Next Step	It is recommended that a solar film supplier is engaged to attend site to assess existing glazing and its suitability for this technology. Following this, we recommend you use their report to advise a technical specification for a procurement process involving three or more potential suppliers.
Relevant Publications	Window film has potential to even out solar heating Review on window-glazing technologies and future prospects Film studies – retrofitting window film - CIBSE

13	Replace Physical Servers with Virtual Host Servers			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
75,000	500	1,956,182	300,000	5

Detail

There are two major data centres at the University of Essex, one is used internally and the other is for the Centre for Business and Local Government Data. It is not unusual for a data centre to have a consumption of 4 to 5 times more than what would be expected for the building as is intimated by the level of cooling apparent.

This data centre and others across the university could be consuming up to 8% of the organisation's total electricity. A review of the existing data centres and server rooms should be undertaken to ensure they are working as efficiently as possible.

Consider outsourcing – this would cut the on-site consumption and move the emissions to another organisation with potentially better Power Usage Effectiveness PUE's. As interconnect services, cloud providers, the Internet of Things (IoT) and edge services continue to proliferate, the rationale to stay in a traditional data centre reduces.

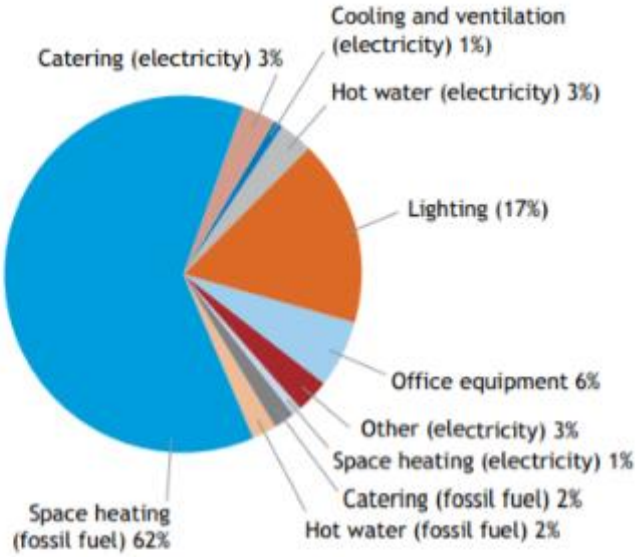
Most computer rooms are over-chilled, 24°C to 25°C is an acceptable temperature that will require less cooling and save energy. We suggest reviewing the temperature of computer rooms air conditioning units. The newer the equipment, the higher the temperature can be.

It is worth considering the possibility of using your CHP units or PV to power the data centres maybe as an incremental source of power.

Check that all servers are actually in use and that areas of the server room are not being chilled unnecessarily. It is also worth ensuring that the servers are kept clean and dust free as this affects performance.

Rationale

Server virtualisation offers a way to consolidate servers by allowing you to run multiple different workloads on one physical host server. A "virtual

	server" is a software implementation that executes programs like a real server. Multiple virtual servers can work simultaneously on one physical host server. Therefore, instead of operating many servers at low utilisation, virtualisation combines the processing power onto fewer servers that operate at higher total utilisation. Evaporative cooling making use of free cooling when the outside air temperature is low enough can lead to considerable savings. The use of EC fans (as discussed within AHU upgrades below) provide Increased speed control and low power usage at partial loads.
Risks	Ensure that all stakeholders are happy with proposed changes. Data security is vitally important and should not be compromised for the sake of energy savings. The data ownership should also be clarified as the data will no longer be stored on a physically owned asset. The energy consumption calculations and savings are difficult to quantify as they are not separately metered. For the purpose of this report, the data centres saving has been calculated as being 55% of the total consumption attributed to IT across the three campuses. This has been estimated as being 6% of energy use by the Carbon Trust: ***Figure 1** FHE – percentage energy use* 
Next Step	Consult with IT department to review existing local operating procedures and explore energy efficiency options with their agreement
Relevant Publications	Google data centre cooling The energy and carbon footprint of the Global ICT and E&M Sectors Dirty Data – Carbon Trust BCS goes green CTV020 Sector Overview Further and Higher Education

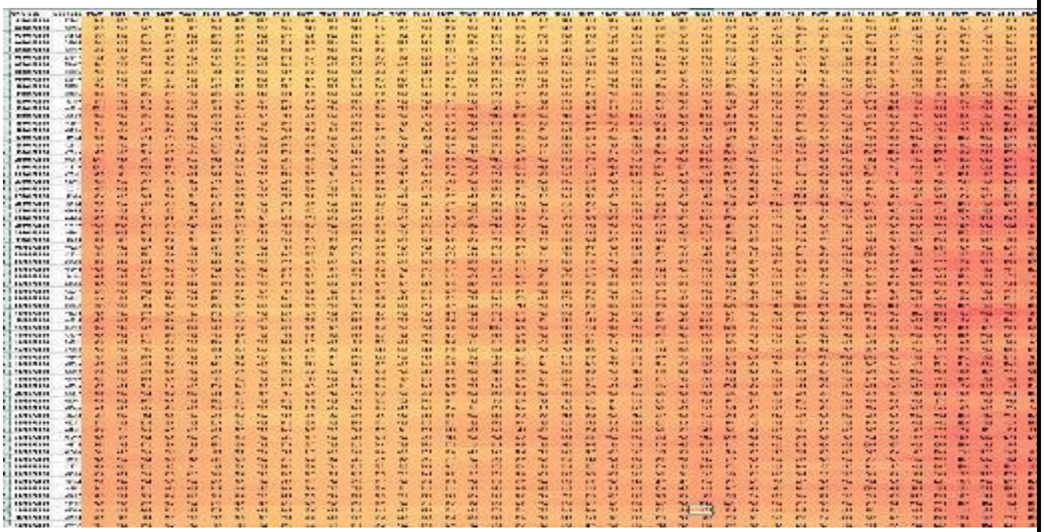
15	SMART LED Lighting Upgrade			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Cost £**	**Payback Years**
63,551	127	495,718	250,000	3.93

Detail

The University of Essex has commendably upgraded to LED lighting across 75% of the estate. They already have invested heavily in LED lighting technology across their sites both inside and out, but there are further areas which would also benefit from an upgrade: The Southend University Square accommodation blocks specifically would benefit from re-lamping as would stairwells, plant rooms and ‘The Houses’.

The Southend University Square accommodation blocks currently have 2D fittings. The normal lamp fitted into the 2D bulkhead fitting is a compact fluorescent (CFL) which generally come in sizes of 16, 28 and 38 watts and with either 2 or 4 pin connectors.

Also, 2D lamps are often on for very long periods. As an example, the half-hourly data in the chart below shows the Southend Accommodation for the first three months of 2020 which shows very little variation in consumption for the time of day or day of the week suggesting that lighting (and HVAC) is on 24/7 and uncontrolled.



The 2D lamp has a lifespan of around 35,000 hours which is typically 4 times longer than its CFL counterpart. This means that not only will failures be avoided and the disruption that they cause but additionally there is less maintenance cost for making the lamp changes.

The 2D LED lamp also has a directional capability typically with a beam angle of 120 degrees. As a consequence, you can direct the light straight out of the light fitting as opposed to with CFL 2D lamps where there is a lot of wasted light which is cast back into the fitting and if this is not reflected out just serves to heat up the unit. LUX level will be higher using the 2D LED lamp than the CFL 2D lamp whilst using half the energy.

	The 2D LED lamp has its own driver and does not need an external ballast or driver. Technology has moved on and 'SMART' lighting systems are providing even more energy, carbon and financial savings. Whilst the university has installed LED lighting, the control afforded by SMART lighting will provide even greater energy and carbon savings. Smart lighting is to become one of the largest IoT (Internet of Things) systems in the next 5-10 years.
Rationale	It is worthwhile investigating 'smart' LED lighting technology which combines movement/absence detectors with photocell sensors and the lamps are linked wirelessly with each other. Each fitting has its own integrated motion/presence sensor, daylight sensor, infrared (IR) receiver and IR transmitter. There is simple plug-and-play programming via remote control with thousands of customisable parameters. Having a SMART sensor in every fitting allows for savings to be maximised without compromising light quality. Where and when daylight is available, light output is automatically controlled according to the pre-determined profiles. The panels can communicate with each other so that light will ripple across a room/corridor as motion is detected. As a space is entered, the detecting panel and the ones next to it go to 100% and panels in the next positions go to 80%, 40% and 20% respectively rippling across the space. As the person moves across the space, the pool of light moves with them. For low circulation areas, where a basic level of lighting at all times is required, the lighting can be programmed to dim to a set lux level, consuming less energy and returning to the required brightness when a person enters the space. In the working environment, the best type of light for working is natural light rather than artificial light from electric lights. In order to reduce lighting used in offices with windows to the outside world and to ensure there are times when there is adequate natural light, smart photocell sensors could be installed to turn off/dim lights when the natural light levels reach a set level, and to come back on when natural light levels drop. Ensure that the correct and most appropriate fitting is selected for the space in use. A dimmer could be fitted to the controls to allow occupants to select their own preferred lighting level. Speculative office lighting and, to a degree lighting for any large office, is still thought of as needing to be uniform across the office space, however, there is no reason why the emphasis cannot be placed instead on the task area. It is also possible to monitor the energy consumption of each fitting and even set up text/email alerts when consumption exceeds an expected range. Excessive consumption can be a sign of a lamp about to fail. The external lighting can be a hidden energy consumer where it is on time-clock control this can fall out of sync with daylight hours. Review of the settings on a monthly basis or installation of photocell controls can also provide additional savings.

	The costs and savings have been calculated for the existing and proposed solution based on similar lighting projects at Birmingham Airport and Broomfield Hospital. Although the University has already upgraded 75% of its lighting to LED, the costs and savings calculated here are based on upgrading 5% of the remaining 25% and targeting the Southend University Square accommodation.
Risks	▪ Acceptance of colour rendering index and temperature by staff ▪ Concern regarding safety in dimly lit areas ▪ Lamps do not strike immediately ▪ Disposing of existing lamps
Next Step	• Engage experts to review the building lighting strategies and propose alterations and/or upgrades to daylighting provisions, luminaires and their control systems and an implementation plan.
Relevant Publications	https://www.lighting.philips.co.uk/campaigns/art-led-technology https://www.theclimategroup.org/sites/default/files/led_indoor-briefing-2018_0.pdf https://warwick.ac.uk/services/healthsafetywellbeing/guidance/officelighting/

16	BMS Controls			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Estimated Cost £**	**Payback Years**
32,050	64	250,000	150,000	4.68
Detail	The majority of the University buildings are controlled via several Building Management System (BMS) which are not integrated. They can set the temperature in numerous zones and allow for different time schedules. It is thought that further advantage could be taken to realise its full potential in reducing energy consumption. It should be ensured that unoccupied areas are not heated or cooled unnecessarily. The ventilation rates could be changed to match the number of people in the building using occupation data. • Work with departments and room bookings to better understand actual usage requirements • Put in place optimisation strategies, for example, use CO_2 control where appropriate to match ventilation to occupancy levels • Ensure settings are typically adjusted regularly in response to user feedback, faults and maintenance. Regular reviews or in-built systems to reset settings which ensure savings are maintained • Restricting what users can adjust will make the process easier to control For a building to be genuinely low carbon it not only needs appropriate controls to be specified, designed, procured and installed but also the correct interaction between the controls and the building's users. If this interaction is missing or inadequate, it will not be possible to achieve a low carbon performance. The calibration of the BMS controls should be checked regularly to ensure that desired temperatures are achieved. It may be beneficial to install a smart lighting system on the BMS where possible. Large energy savings are possible using combined time, photocell and occupancy sensors. By trimming the BMS controls, additional savings can be achieved whilst not affecting staff and student comfort levels.			
Rationale	A lack of BMS control was particularly apparent at both the Southend and Loughton campuses and further evidenced by the half-hourly electricity data. Site visits were conducted on cold days in early January when students were still on their Christmas break. All of the unoccupied rooms, studios and offices were being heated and some overheated. It was stated that the BMS controls were centrally controlled from the Colchester site and did not account for low or no occupancy. Considerable energy savings could be made if heating were limited to periods of occupancy. The cost is an estimate of integrating the existing systems, trimming controls, adding additional functionality from a central function. It would be beneficial to include the Southend and Loughton sites as they demonstrated the least control.			

	Site visits were conducted on cold days in early January when students were still on their Christmas break. All of the unoccupied rooms, studios and offices were being heated and some overheated. It was stated that the BMS controls were centrally controlled from the Colchester site and did not account for low or no occupancy. Considerable energy savings could be made if heating were limited to periods of occupancy. The BMS and controls could help improve performance by: • Working with departments and room bookings to better understand actual usage requirements • Put in place optimisation strategies, for example use CO_2 control where appropriate to match ventilation to occupancy levels • Ensure settings are typically adjusted regularly in response to user feedback, faults and maintenance. Regular reviews or in-built systems to reset settings which ensure savings are maintained • Restricting what users can adjust will make the process easier to control
Risks	None. Student and staff comfort will be improved as well as energy and carbon savings realised.
Next Step	Engage BMS specialists or Estates staff to review all operational times and functionality of the BMS and trim settings whilst maintaining occupant comfort.
Relevant Publications	Taking control of your building controls Heating Ventilation and Air Conditioning Guide CIBSE Guide H building controls

17	Consider AHU Plug Fan Technology			
Cost Saving £	**CO_2 Savings Tonnes/year**	**Energy Savings kWh/year**	**Estimated Cost £**	**Payback Years**
64,100	128	500,000	700,000	10.92
Detail	The University of Essex makes use of traditional belt-driven fans contained in the Air Handling Units (AHU) across the estate. It is proposed that each fan is replaced with a larger number of direct drive plug fans coupled with EC motors. These fans would operate as a fan wall to achieve full duty. The electronically commutated EC fans are designed to replace older belt-driven fan technology, direct drive plug fan technology removes the needs for belts and pulleys resulting in fewer losses and less maintenance. They do not use any existing inverter / belt drives as they have inbuilt controls. The controls can be linked to the existing BMS system. The combined electrical power of the replacement fans can be up to 60% less. They have been designed with redundancy in the fan wall too, to enable the unit to continue service if a fan or two drops out for any reason, maintaining uptime and increasing resilience. Plug fans are available in either inverter-driven direct drive or EC versions. EC plug fans are suitable for smaller AHUs and lower air flows, and energy savings can be achieved even with short operating hours. In addition, their reduced profile means they can be fitted into tighter spaces. Modern plug-fan technology can be used to significantly increase the duty (both the volume and pressure) of the air being supplied through HVAC equipment, potentially alleviating the need to install additional AHUs to serve an increased load. In addition to delivering energy savings, plug fans offer lower noise levels and are easy to fit and maintain. For many building owners, a quick and simple retrofitting process is crucial to minimise downtime for occupiers. Typically, the savings provide a short return on investment. The following AHUs should be prioritised: ✓ AHUs that run for most of the time (24/7 is ideal) ✓ AHU's that have motors greater than 18kW ✓ AHU's that don't have a total pressure greater than 2000Pa ✓ AHU's with no inverter ✓ Places that can make use of the MODbus interface to better control the fans, saving more energy with improved controls ✓ Chiller and condenser fan with AC motors The costs and savings have been calculated based on data from a completed project at Birmingham Airport and Kings College London. It has been estimated that there are over 100 belt driven fans across the Colchester campus and a further 30 at Southend and Loughton. The estimated cost would be to replace all of these with plug fan technology.			

Rationale	The combined electrical power of the replacement fans can be up to 60% less. They have been designed with redundancy in the fan wall too, to enable the unit to continue service if a fan or two drops out for any reason.
Risks	Potential operational disruption as the fans are replaced
Next Step	Commission a supplier to assess current AHUs with a view to replacement with plug fan technology
Relevant Publications	CIBSE: Fans for ducted ventilation systems AHU Upgrade saves 58% energy at Birmingham Airport

FUNDING

The University has options open to them when it comes to funding carbon saving projects which broadly are:

- Capital Investment
- Government & Salix Grant / Loan Funding
- Third Party Funding

CAPITAL INVESTMENT

The higher education sector has several sources of funding available for capital, that can be obtained and used for innovative building and facilities projects. One way this type of capital can be obtained is through capital grant funding from an internal funding body or research council.

Some higher education institutions have used public bonds as a loan mechanism as the borrowed interest rate often remains fixed and unchanged by inflation, unlike bank loans. Public bonds are more often seen as a sustainable solution to funding, as high interest rates can make borrowing large sums of money problematic for public bodies like the university.

Fundraising and donations may also be able to provide at least part of the capital needed to fund a sustainability project, this however takes time, and in many cases is not a feasible solution for immediate plan and action. If the use of own capital is unsuitable, there several alternative options that may provide a more deliverable roadmap to net zero.

GOVERNMENT & SALIX GRANT / LOAN FUNDING

Public Sector Decarbonisation Scheme

Launched by the Department for Business, Energy & Industrial Strategy (BEIS), the Public Sector Decarbonisation Scheme is a £1.75bn fund designed to encourage green growth across the public sector and affiliated bodies. The scheme aims to help eligible organisations align with the UK’s Net Zero carbon targets and deliver significant carbon savings in the public sector. It also aims to promote economic activity during these difficult times.

Funding for the scheme is delivered through Salix Finance, which has a long history of supporting public sector organisations financially on energy efficiency and carbon reduction projects.

The scheme is open to Public Sector organisations only, such as government departments, Local Authorities, further and higher education institutions and NHS Trusts.

Funding applications will be reviewed, with the overriding project concept being focused on carbon reduction as the primary driver.

There is also a keen focus on project management and deliverability – and Salix will have strong oversight on projects from beginning to end, judging them against the technical case for implementation, financial viability, and the levels of governance in place throughout project delivery.

Carbon and cost savings generated through funded projects need to be directly beneficial to the public sector body itself.

There is a list of eligible technologies which are fundable through the grant, and these are largely broken down into four categories:
Category 1: Technologies that have a direct heat decarbonisation impact, such as air source heat pumps and ground source heat pumps.

Category 2: Technologies that have a direct energy demand reduction impact, which will therefore facilitate further decarbonisation. This includes upgrades to building management systems, improvements to heat systems, HVAC system enhancements, and improvements to building fabric through improved insulation.

Category 3: Technologies which in themselves facilitate downstream heat decarbonisation, such as improved metering or battery storage.

Category 4: Direct replacements for coal and fuel heating systems where low carbon heating systems are not viable.

Salix will judge the projects and preferentially consider those that finish earlier. So, simply put, the faster you deliver the project the more likely you are to secure funding.

Public Sector Decarbonisation Scheme Phase 2

Phase 2 is aimed at taking a ‘whole building’ approach to heat decarbonisation. It is centred around the reduction in fossil fuel heating and identifying opportunity to transition to low carbon alternatives.

Phase 2 has been launched to provide funding to those public sector organisations which are ready to take the step to a low carbon future. £75 million of grant funding has been allocated and all projects to be installed and completed before March 2022.

There is a maximum application £5 million (no minimum sum) and no restriction on applying for phase 2 if an organisation was successfully funded in Phase 1, however, deadlines must continue to be met.

The carbon cost threshold for phase 2 is set to a maximum of £325 per tonne of non-traded carbon saved (CO_2e) over the lifetime of a project.

The application portal will be open Wednesday 7th April.

Main criteria for PSDS eligibility

- Applicants must be using a fossil-fuelled heating system (new criteria).
- The heating system in question must be coming to the end of its useful life (new criteria).
- Applications must include a measure to contribute to decarbonise the heating with a low carbon heating system.
- Applicants can include energy efficiency measures and other enabling works where they support a 'whole building' approach to decarbonisation.
- The funding provided to save a tonne of non-traded carbon (CO_2e) over the lifetime of the project (the Carbon Cost Threshold (CCT) must be no more than £325, which is automatically calculated by the Support Tool in the Grant Application Form.
- Phase 2 PSDS is primarily for capital works, however, external consultancy and management fees may be included. Existing employee costs or any costs previously incurred may not be included.
- Reasonable enabling and ancillary works may be included in the application, provided they are directly linked to the core technologies being installed, and these will be reviewed for value for money.
- Individual applications can be made up to, but should not exceed, £5 million in value although an Applicant can submit more than one application.
- Eligible bodies must either own the building that the funding is being used to upgrade or have a long-term lease arrangement where the contract allows for any savings to be passed to the eligible body.
- Projects must be in a position to complete by 31st March 2022. Funding is not available for projects that cannot deliver to this timeframe, and projects which do not complete before 31st March 2022 will be liable for any project costs incurred after this date.

Other Public Sector Funding Streams

The Renewable Heat Incentive which encouraged the installation of renewable energy technologies for heating such as ASHP, GSHP Biomass Boilers and Solar Thermal in the non-domestic market. However, the scheme closed to new applicants on 31/03/21.

It is thought that in order to meet the Government's net zero emissions target by 2050, this scheme will have to be replaced by a credible alternative. Decarbonisation of heat is recognised as one of the biggest challenges we face in meeting our climate targets. The government is aiming to publish a Heat and Buildings Strategy later this year, which will set out the immediate actions we will take for reducing emissions from buildings.

https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat This may involve introducing a Green Gas Support Scheme where hydrogen will be blended with the gas network.

There is a consultation in place called the Green Heat Network Fund which is being reviewed at the moment: https://www.gov.uk/government/consultations/green-heat-network-fund-proposals-for-the-scheme-design

The Green Homes Grant currently offers £5,000 to £10,000 in grant funding for domestic homes to upgrade their gas-fired boilers to ASHPs – it is likely that this will be extended to the non-domestic market.

THIRD PARTY FUNDING

Public Finance Initiatives

Public Finance Initiatives or PFI agreements are designed to mobilise private sector money and expertise of public services. They can be a practical means to achieving projects and can be applied to sustainability projects. Since its establishment in 1992 under the Conservative government, PFIs have funded over £60 billion private sector projects.

Under a PFI, the private company handles the upfront cost of finances which are consequently leased to the public. The government then makes annual payments to the private company for their initial investment.

Depending on the type of agreement, PFI contracts are typically paid back over the course of 20 – 30 years, along with an interest amount that ensures profit incentives for the company.

These types of agreements can be attractive due to the structure of the contract. PFIs are intended to improve on-time project completion and mitigate some of the key risks associated with large scale capital investment.

There is an increased use of PFI contracts in most public projects and services globally, this increase has been linked to the central aim of a PFI to increase greater efficiency of quality services at minimal cost.

In today's market, these projects can be expensive to finance, however they can provide an effective way for private sector bodies to receive immediate funding for necessary projects.

Purchase Power Agreements (PPA)

Where the market has responded to a demand for renewable energy has been with a Power Purchase Agreement which is a long-term contract under which a business agrees to purchase electricity directly from a renewable energy generator. A supplier such as Lightsource, Hive Energy or RWE will design, finance and construct the solar array or wind farm that supplies renewable electricity to your organisation.

Whilst the type of PPA does not directly have an impact on the carbon saving, the financing options do allow a larger project than could perhaps be funded internally, allowing, in turn, greater carbon savings.

PPAs can be an advantageous way of financing a long-term power delivery, whilst reducing markets risks and the overall cost of delivering renewable energy projects. The agreement is typically between two parties, one looking to purchase electricity and one which produces it, although occasionally there are additional parties involved.

PPAs are typically split into three categories: On-site PPA, off-site PPA or sleeved PPA. On-site PPA refers to a direct physical supply of electricity. The PPA generation plant is located behind the meter or at the same location as the consumer, installed free of charge in return for a long-term fixed electricity cost. The project developer maintains and runs the plant on behalf of the consumer and the electricity is billed as per usage needs.

Retail-sleeved PPAs are the arrangement between a solar farm and an energy retailer. An intermediary utility company is involved in the transfer of both energy and money to the renewable energy source, on behalf of the buyer. This form of PPA provides the renewable energy supply to the consumer load at the precise moment it is generated and negotiated at a fixed cost.

The third of the agreements refers to off-site PPAs in which the consumer agrees to buy a physical quantity of electricity as outlined in the contracted PPA, this is delivered through the public grid. Unlike on-site PPAs, the plant does not need to be located close to the consumer. This type of PPA is also typically negotiated at a fixed cost, providing price stability for the consumer.

PPAs are usually signed on a contractual basis of 10– 20 years, depending on the energy provider or the type of agreement. They mitigate much of the risks associated with electrical sale and purchase and do not always have to be signed at a fixed price, providing flexibility for the consumer.

Unfortunately, there is no standardised model for quantifying the carbon reductions achieved by PPAs and therefore a comparison of each model is difficult to achieve. Each has its own benefits and drawbacks, and the potential savings are dependent on the size of project as well as other variable factors. The main selling point for each of these agreements is the reduced risk associated is with financing a project from a single source.

Twenty of the UK's universities have signed up to buy renewable energy directly from British wind farms for the first time under a PPA.

There are also many investors willing to put money into renewable energy projects as there will be a good return on investment. These schemes are particularly prevalent in the community marketplace or the Green Climate Fund may be a source of financing projects to provide climate-smart investment opportunities.

It is suggested that as and when funding is secured from whatever source that it is 'ring-fenced into a carbon fund which can roll over from year to year to avoid the pressure of spending in a given financial year.

University of Essex

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