Swansea University

Decarbonisation Action Plan

July 2022

FINAL

Executive Summary

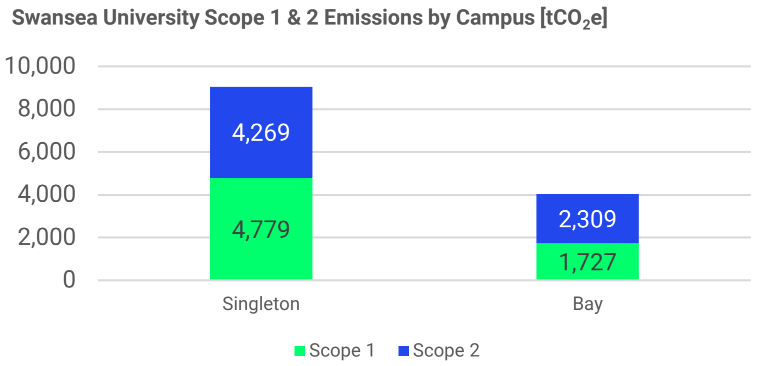
- In 2020 Swansea University set a target to achieve a 100% reduction in scope 1 & 2 carbon emissions by 2035, and a 50% reduction in scope 3 emissions by the same date.
- To support progress towards achieving this target, Carbon Trust have worked collaboratively with Swansea University to develop an action plan to set out the carbon reduction projects needed.
- The graphic below shows the steps that were followed on this project to develop the action plan. Key steps involved collecting data to set a carbon baseline, modelling business as usual (BAU) emissions to 2035 (a "do nothing" scenario), development of carbon reduction projects, modelling the "phasing" of the projects and consideration of key implementation requirements .

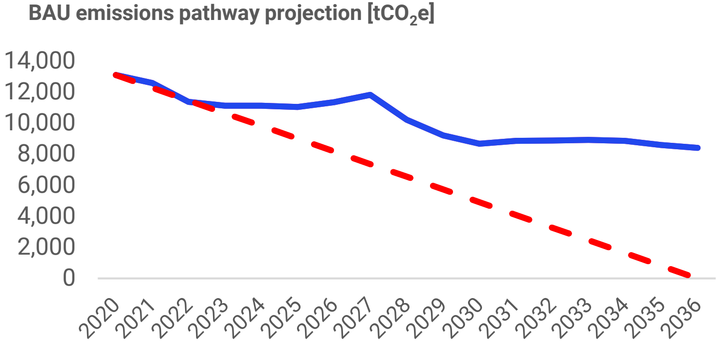
1. **Data Collection** →
2. **BAU projection** →
3. **Opportunity Identification** →
4. **Pathway Analysis** →
5. **Action Plan Development**

Executive Summary

- This action plan focuses on scope 1 & 2 carbon emissions from Swansea University's buildings portfolio that arise from the consumption of natural gas and electricity. A summary of the 2019/20 baseline emissions used within this report is shown top right. The total carbon footprint across emissions sources included was calculated to be 13,084 tCO_2e.

- The graph bottom right shows the projected business as usual (BAU) carbon emissions (blue line) against Swansea University's reduction target (red line). As the UK switches more of its electricity generation to renewable sources, over time the grid electricity consumed will be less carbon intensive. Therefore, it is forecast that in a 'do-nothing' BAU scenario, total emissions within the boundary will reduce by 35.8% between 2019/20 and the target year of 2035/36. The BAU represents the scenario where no further decarbonisation action is taken.





Executive Summary

CARBON TRUST

- Projects included in this action plan are summarised below. These projects have been grouped together under the headings of energy governance (black), Energy controls (light blue), Energy efficiency (dark blue) and Low carbon energy (turquoise).

Energy management: Engagement, policy and procurement to enable savings

Ventilation system improvements: Refurbishment of air handling systems

LED lighting: Upgrade of all lighting to LED standards with controls

Maintenance management: Shift towards preventative maintenance and removal of backlog

Cooling efficiency: rationalisation & formation of cooling stations to reduce cooling energy

EC drives and IE5 motors: Upgrade of all motors and drives to high performance standards

BMS improvements: Upgrades for closer alignment of energy consumption with building occupancy

Air leakage: Reduction of thermal losses through door seals

Electrified heat: Installing heat pumps and upgrading the network to an electrified solution

Voltage trim: Reduction of voltage through transformers taps

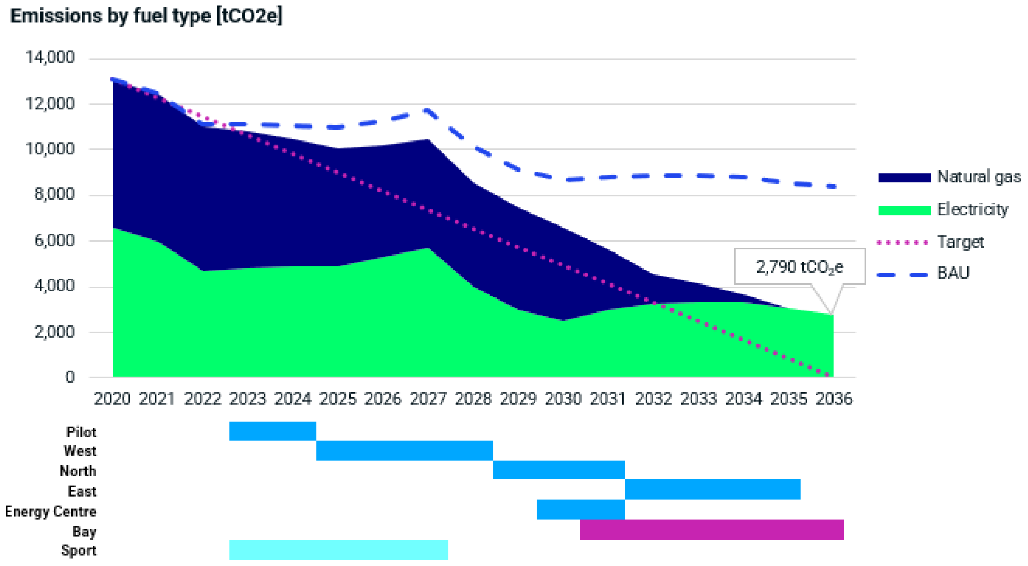
Fabric and insulation improvements: Retrofit of building fabric and other thermal elements

Solar PV: On-site renewable technology to boost zero carbon energy supply

Executive Summary

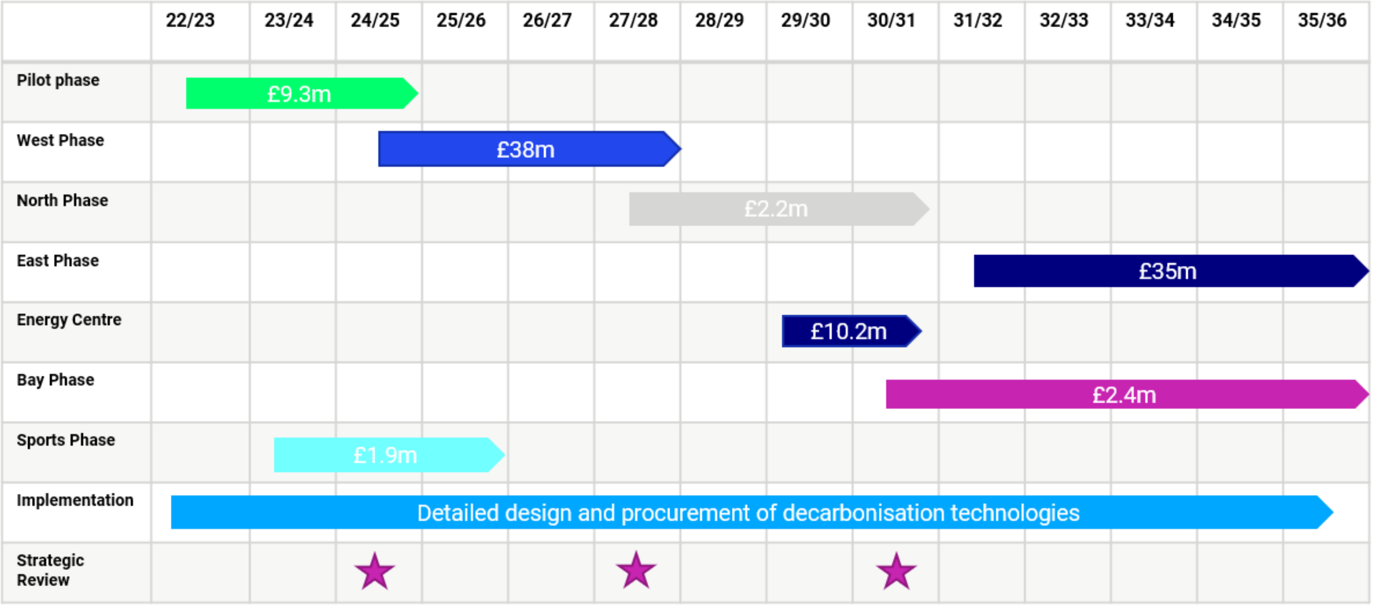
CARBON TRUST

- In collaboration with SU estates and sustainability teams, the projects have been aggregated and phased as shown on the right. It is proposed that measures are brought together in 6 main phases on a whole building basis, and implemented primarily on a spatial basis e.g. the "West" (portion of Singleton campus). Other factors have also been considered such as the need to address poorly performing buildings early on.
- Under the core reduction scenario, carbon emissions are reduced from 13,084 tCO_2e in the baseline year to 2,790 tCO_2e in the target year (academic year 2035/36 shown as calendar year 2036 to align with available future emission factor scenarios).



Executive Summary

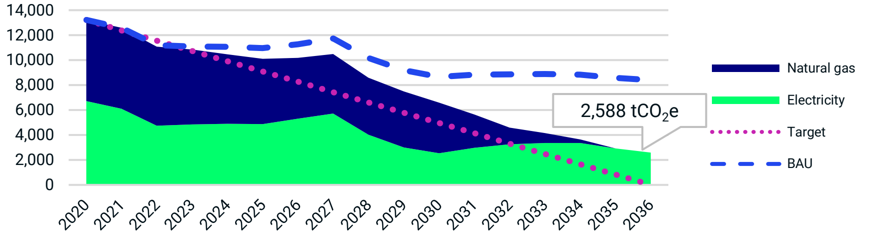
- The total capital cost to implement all measures included in each of the phases has been estimated at approximately **£99 million**.



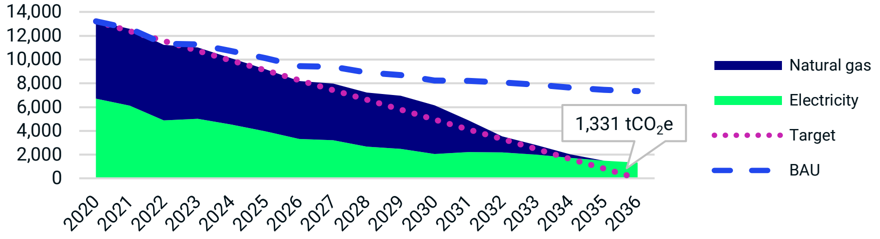
Executive Summary

- The Action Plan focuses on known solutions that can be implemented between the present-day and 2035. However, this does not seek to imply that activities surrounding technology innovation should not be pursued. The size of the remaining emissions may shrink as SU progress towards 2035, impacted by emerging technologies and technology innovation that could help the University to accelerate progress.
- The graph top right illustrates the additional effect of introducing a 1MW wind turbine and a large car park based Solar PV system at Bay Campus (in 2035), reducing the remaining emission to 2,588 tCO_2e.
- The graph bottom right illustrates the effect of using a more “ambitious” future energy scenario for emissions associated with consumption of electricity from the national grid. In this instance, remaining emissions could reach as low as 1,331 tCO_2e with no additional changes to the core reduction scenario.
- The purpose of including additional scenarios is to illustrate that various “sensitivities” exist in relation to carbon reduction planning over long timeframes. Nonetheless, Swansea University should be confident to take forward the projects presented in this report as “no regrets” actions that form a fundamental core of decarbonisation action on direct emissions.

Emissions by fuel type [tCO2e]



Emissions by fuel type [tCO2e]



Executive Summary

Implementation of the plan will require an ongoing strong governance approach, and sustained momentum for project delivery. To support this the University will require support across the estates, procurement, and departments, as well as project management capacity to drive activity.

Implementation support is available from Welsh Government. The Welsh Government Energy Service is in place to provide technical and commercial assistance to project development, and further, the Re:fit Cymru framework is in place if a Energy Performance Contract (EnPC) delivery route is chosen.

The delivery mechanism chosen may vary per phase of delivery and technology solution. Where a major refurbishment is required, the decarbonisation requirements should be built into the remit of the design team. Outside of EnPCs, there are a growing number low carbon specialist frameworks in place to deliver design works or turn-key solutions for projects. No matter which implementation option chosen, the planning and project design work should align with the funding opportunities available:

Potential Funding	Detail
Swansea University	Swansea University should utilise its own resources and prioritise funding for decarbonisation initiatives in order to support action in reaching the target.
Higher Education Funding Council for Wales (HEFCW)	Capital funding is made available through HEFCW.[1] Additional funding ringfenced to support the transition to net zero has previously been made available, with £40m for the 2021/22 academic year.
Wales Funding Programme – Invest to Save	The Wales Funding Programme is supported by the Welsh Government Energy Service, with funding applications administered by Salix Finance.[2] Funding is then provided from Welsh Government on a repayable basis, with criteria limits on payback and carbon cost effectiveness.
Welsh Government – Public Sector Low Carbon Heat Grant	The Welsh Government Energy Service and Salix Finance has overseen a pilot 'Public Sector Low Carbon Heat Grant' in 2021/21, this totalled £2.4m in value. No capital grant funding is available for 2022/23, however it is planned that a funding scheme will follow in 2023/24. Development grant funding is available now (2022/23) to support projects to an investment ready position.

[1] https://www.hefcw.ac.uk/en/publications/circulars/w22-07he-additional-funding-for-academic-year-2021-22/
[2] https://www.salixfinance.co.uk/loans/welsh-loans

Executive Summary

- A key factor linking the action plan to on the ground implementation is a clear structure for how projects will be assessed, designed and implemented. Carbon Trust have not investigated internal implementation mechanisms in detail, but it should be recognised that in order to achieve its ambitious 2035 target, the University may require additional resource and capacity support for the estates and sustainability teams. It would be prudent to review internal processes needed to support the implementation of this plan as an immediate first step.
- Consideration should be given to the development of a suite of action plan working documents. Such documents could be set up as "live" trackers and management documents that contain real time information on the development of the plan. Such documents could be created for each phase/ building, and contain key info such as projects status, roles/ responsibilities, live costs, carbon reduction estimates etc. Without a well defined document management system, the detailed and complex information involved could easily become "lost" and difficult to track.
- It is anticipated that through the "pilot" phase, significant learnings can be gained regarding any unfamiliar areas of feasibility, design and implementation of projects/ technologies. These should be captured in order to document any barriers and issues to inform future implementation of projects across the building stock. Swansea University should also assess and carefully capture pre & post installation energy consumption/ carbon emissions information as accurately as possible in order to communicate success and build the business case to gain momentum for decarbonisation action.
- Alongside implementation, it is envisaged that Swansea University conduct an ongoing programme of detailed design and procurement programme of decarbonisation technologies in order to successfully implement optimal solutions for the University's needs.

Contents

Key Contacts

Robert Hatcher
Project Manager
Robert.Hatcher@carbontrust.com

Paul Bennett
Project Assessment
Paul.Bennett@carbontrust.com

Charlotte Sinden
Project Support
Charlotte.Sinden@carbontrust.com

Ben Noble
Project Support
Ben.Noble@carbontrust.com

John Llewellyn
Energy and Carbon Manager
J.R.Llewellyn@Swansea.ac.uk

Teifion Maddocks
Sustainability Manager
T.H.Maddocks@swansea.ac.uk

Greg Ducie
Director of Estates and Facilities Management
G.J.Ducie@swansea.ac.uk

Stuart Henson
Associate Director of Infrastructure Services
S.M.Henson@swansea.ac.uk

CARBON TRUST

OUR MISSION

To accelerate the move to a decarbonised future.

SECTION 1

Introduction & Background

Back to Contents Page

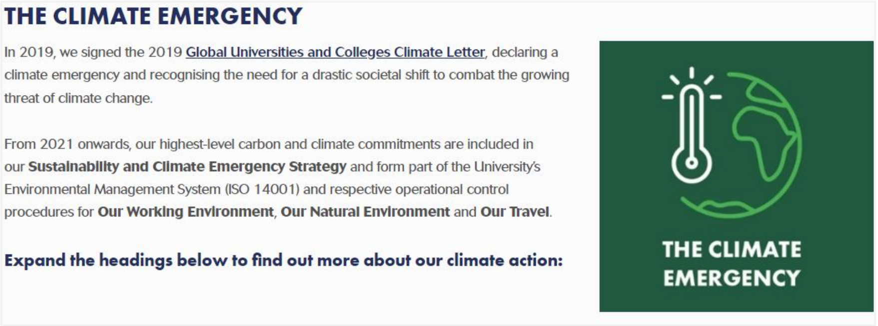
Section Overview

Introduction & Background

- In section 1 we provide an introduction to the report which includes information on Swansea University’s (SU) stated goals, current progress and intentions of this study.
- Additional information is provided on the broader background and context for decarbonisation action such as Welsh Government goals and high level information on climate change.
- In addition we provide information on the process of developing this action plan set in context to the scope and development timeframes to provide the reader with an understanding of the context and limits of this study.
- A core element of the work conducted in developing this report was the onsite surveys and analysis behind the core project pathway. In the introduction we provide additional information on this project identification process.

Swansea University

- In October 2019, SU declared a Climate Emergency and committed to being carbon neutral by 2035. In 2020 the University then set out a strategic "Climate Emergency Plan" which provided a high level roadmap of broad measures needed to reach zero carbon. The strategy mapped out the University's scope 1 & 2 target of 100% carbon emissions reduction by 2035, and its broader scope 3 target of a 50% reduction by 2035.
- To support in achieving this vision, Carbon Trust has worked collaboratively with Swansea University to develop an action plan to frame the practical steps needed to achieve its target **by 2035 from its scope 1 & 2 emissions**.
- This report sets out the core projects Swansea University should progress, the estimated budgets needed to fund these projects and commentary on implementation fundamentals required for decarbonising its scope 1&2 carbon emissions across SU's building portfolio.


THE CLIMATE EMERGENCY

In 2019, we signed the 2019 Global Universities and Colleges Climate Letter, declaring a climate emergency and recognising the need for a drastic societal shift to combat the growing threat of climate change.

From 2021 onwards, our highest-level carbon and climate commitments are included in our **Sustainability and Climate Emergency Strategy** and form part of the University's Environmental Management System (ISO 14001) and respective operational control procedures for **Our Working Environment**, **Our Natural Environment** and **Our Travel**.

Expand the headings below to find out more about our climate action:

[1] – https://www.swansea.ac.uk/sustainability/climate-emergency/

Climate Change

Since the industrial revolution the amount of greenhouse gases (GHGs) in the atmosphere has increased by almost 50%. This has resulted in an increase in annual average global temperatures of almost 1°C. [1]

If we, as a global society, continue to emit GHGs at the current rate then we can expect the global average temperature to increase by a further 2.6 to 4.8°C by the end of the century.[2]

Such warming will have serious implications: increased extreme weather events, droughts and crop shortages, rising sea levels, increased spread of typically geographically limited diseases. These particular implications and their knock-on effects are undoubtedly of grave concern.

Across the globe, almost all nations now understand the importance and urgency of addressing climate change. As such, most have signed the Paris Climate Accord – an agreement to limit global warming to well below 2°C and ideally 1.5°C.[3]

The Intergovernmental Panel on Climate Change (IPCC) has run numerous scenarios to determine the carbon reduction pathways needed to limit warming to that outlined in the Paris Climate Accord – and these show that net zero emissions must be achieved between 2042 – 2059.[4]

The UK made the decision to be net zero by 2050, the most ambitious national target at the time the decision was taken, in 2019.

Most businesses and public sector bodies are aware of the importance of limiting the effects of climate change and have set equivalent, or more ambitious targets, such as Swansea University's 2035 ambition.

[1] – https://cdiac.ess-dive.lbl.gov/pns/current_ghg.html
[2] – https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/
[3] – https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[4] – https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf

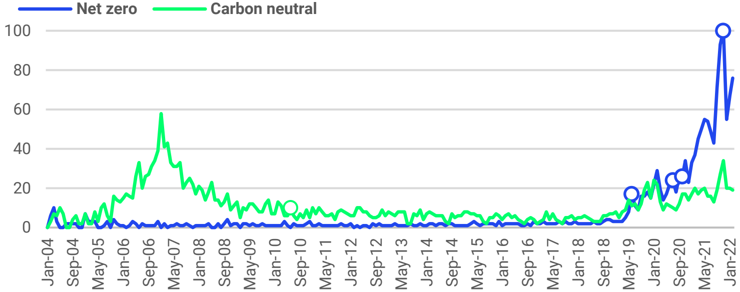
Net Zero

CARBON TRUST

The prevalence of 'net-zero' in the UK has increased rapidly in recent years (see below), accelerating with the Committee on Climate Change's recommendation for the UK to adopt a 2050 net-zero target. This was followed by an eruption of climate commitments, including the declaration of Climate Emergencies across a large part of the UK's public sector, a lot of whom set out the aim of becoming net-zero or carbon neutral. Unlike carbon neutrality, where an international standard was first introduced in 2010, net-zero is a relatively new concept and a robust definition of what is means to be net-zero has not existed until recently.

Google trends analysis of search terms in the UK

The axis is normalised with 100 representing 'peak popularity'



June 2010 Standard for carbon neutrality (PAS2060) is launched

May 2019 The Committee on Climate Change recommends a 2050 net zero target for the UK

Oct' 2019 SU signs the Global HE/FE Climate Letter and committed to being carbon neutral by 2035

Oct' 2021 The science-based target initiative (SBTi) launches the first comprehensive net-zero standard

SU set-out their intention to become a "carbon zero" organisation a year before the first net-zero standard was officially launched. Whilst the standard is aimed at corporates, and a comprehensive net-zero standard for the public sector does not exist, it is generally viewed as best-practice and the University should understand their alignment to the standard alongside WG guidelines.

The net-zero landscape has shifted dramatically in recent years and even since SU's target was set, best-practice has continued to develop and evolve. Alignment to standards is recommended although it is recognised that existing standards are predominantly aimed at corporates, and public-sector accreditation is not possible and may not be desirable in some cases (science based target initiative).The Carbon Trust has worked in collaboration with SU to identify core carbon reduction measures across Singleton and Bay Campuses, and the implementation of these would represent ambitious climate action. However, the SBTi standard outlines that any 2030 net-zero target is extremely hard to achieve, and potentially unattainable (*see SBTi net-zero standard*). Whilst aligning to standards is recommended, impactful climate action can still be realised without strict alignment. At its core, transparent communication of SU's aspirations and subsequent actions should be the primary validation of SU's climate credentials.

Welsh Government Policy Context

Welsh Government have demonstrated ambition in reducing Wales' carbon footprint in recent years through passing legislation and developing a decarbonisation strategy detailing new policies. Key legislative changes include the Well-being of Future Generations (Wales) Act in 2015, and the Environment (Wales) Act in 2016 (amended in 2021 to include the Wales Net Zero 2050), the former explicitly linking climate change and environmental hazards to public health, and the latter establishing targets for emissions reduction and regulations for managing natural resources.

In 2021, Net Zero Wales: Carbon Budget 2 (2021-2025) (superseding Prosperity for all: A low carbon Wales low carbon delivery plan) was published, which sets out key policies required to achieve the decarbonisation across a range of sectors necessary to meet Wales's net zero 2050 target. The net zero target is accompanied by a number of interim targets and **carbon budgets**.

Within this delivery plan, the Welsh government have also set a number of other ambitious **targets relating to specific sectors, relevant to Swansea University.**

Llywodraeth Cymru
Welsh Government

Carbon Budgets

- ✓ 2030: 45% reduction
- ✓ 2040: 67% reduction
- ✓ Carbon budget 1 (2016-20): Average of 23% reduction
- ✓ Carbon budget 2 (2021-25): Average of 33% reduction

Sectoral Targets

- ✓ Public sector to be net zero by 2030
- ✓ Public sector buildings should be supplied with renewable electricity by 2020, or as soon as contractually able and, where practicably possible, are supplied with low carbon heat by 2030
- ✓ Achieve a 40% reduction in building emissions by 2030, through heat decarbonisation and reducing energy demand
- ✓ 70% of electricity consumption in Wales will be renewable by 2030
- ✓ Achieve a 37% in power sector emissions by 2030 (relative to 1990 baseline)

Development Process

The graphic below shows steps that were followed on this project to develop the action plan. The action plan has been informed by the development of established energy demand reduction, heat decarbonisation and renewable energy generation interventions (stage 3). However, key steps have also involved setting a baseline, modelling "BAU" emissions to 2035 (a "do nothing" scenario), modelling the "phasing" of the projects and development of implementation considerations found in this report.

1 → Data Collection

Review existing energy consumption data and building-level energy performance. Gather footprint data and calculate Scope 1 & 2 emissions.

2 → BAU projection

Project the carbon footprint forward to 2035, taking in to account business growth, operations, and transformation in a business as usual (BAU) context.

3 → Opportunity Identification

Conduct site visits to conduct feasibility calculations and develop estimates for low-carbon opportunities.

4 → Pathway Analysis

Quantification of the carbon reduction opportunities, in order to map out the action-specific decarbonisation pathway and the potential 'gap to target'.

5 Action Plan Development

Development of a decarbonisation action plan. This includes where SU currently are, where they need to get to, and how they can start to pursue this.

Project Identification

- A key element of this project has focused on identifying a core list of fundamental measures required to bring SU's building portfolio across the estate in line with requirements for a decarbonised future.
- High level site surveys of each building were undertaken in order to visually inspect and investigate the energy performance of the various mechanical and electrical systems across both campuses. This work was built upon SU's existing comprehensive maintenance and improvement programme, and conducted by working closely with the estates team, alongside its various third party contractors.
- A key area of focus for action was building heat decarbonisation. This included an initial assessment of potential building fabric upgrades required to improve heat losses across poorly performing buildings on Singleton campus. Alongside this, heat pump technology has been assessed as the main solution to replace existing fossil fuel based heating systems, taking advantage of the lower carbon intensity of the electricity grid over the coming years (see section 2). Focus was also given to Singleton Campus over Bay, given the relative age and energy performance of the building stock at Singleton. However, potential projects for Bay campus have been initially assessed for implementation post 2030, ahead of the 2035 target date.

SECTION 2

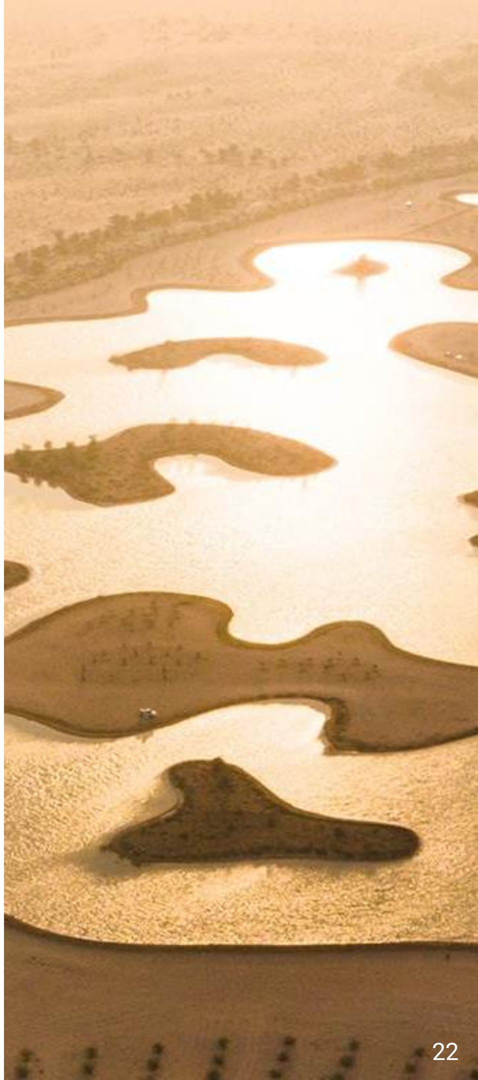
Carbon Baseline

Back to Contents Page

Section Overview

Carbon Baseline

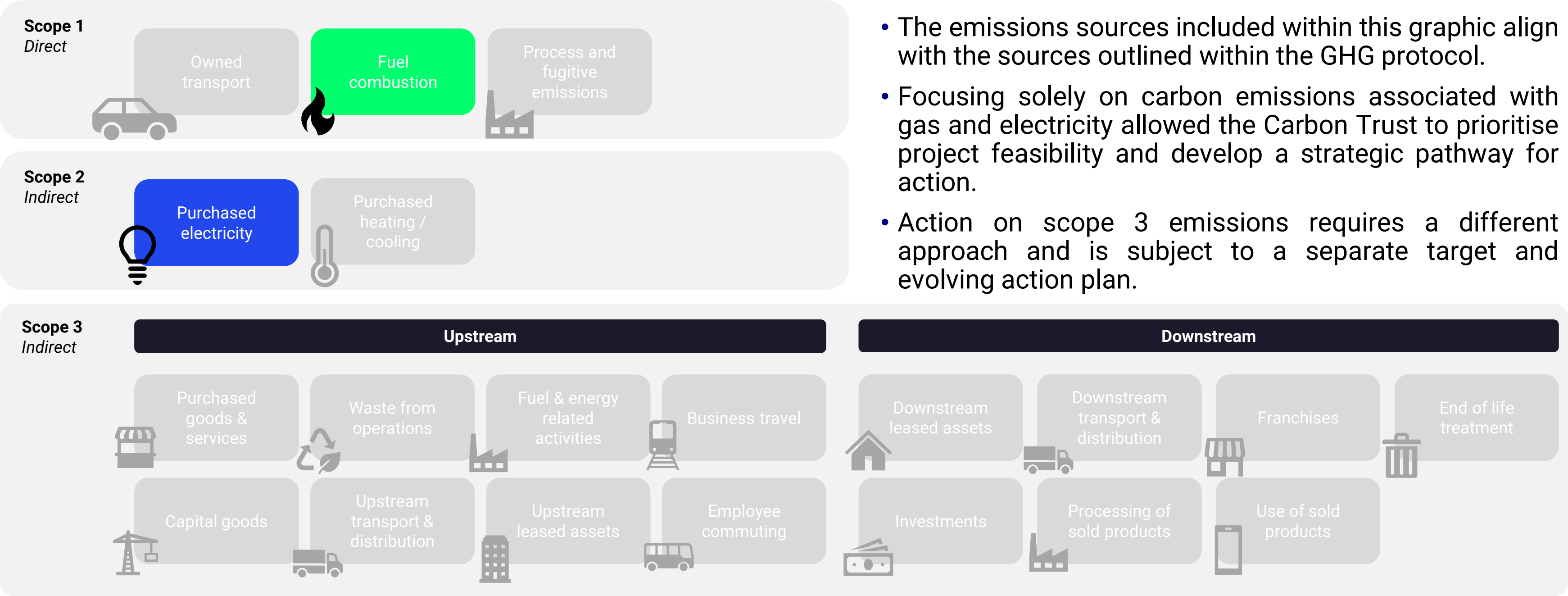
- In section 2 we provide the carbon baseline for this action plan. This includes review of the emission boundary and the methodological step taken to set the carbon baseline.
- This section is not however intended to provide an extensive analytical breakdown of the emissions within the boundary of this report. SU are well versed in carbon accounting and reporting particularly in regards to those direct emissions associated within this action plan. As such only a high level review of carbon emission is present to form the basis of the plan action.
- Detailed review of energy consumption information is also not presented here given the scope and intention of this study. However, it should be noted that as part of the project identification and analysis process, energy consumption information for SU’s buildings was reviewed in order to inform potential areas of focus and interventions to investigate.



EMISSIONS BOUNDARY

Background

The emissions sources highlighted below were selected for inclusion in the carbon footprint which forms the basis of suggested carbon reduction action found in this report. As illustrated, this includes operational emissions from scope 1 and 2, namely those arising from natural gas currently used in boiler systems for heating and hot water and electricity purchased from the national grid. Further emissions are not included here, although it is noted these are included in SU's broader carbon reduction targets.



- The emissions sources included within this graphic align with the sources outlined within the GHG protocol.
- Focusing solely on carbon emissions associated with gas and electricity allowed the Carbon Trust to prioritise project feasibility and develop a strategic pathway for action.
- Action on scope 3 emissions requires a different approach and is subject to a separate target and evolving action plan.

METHODLOGY

Carbon Baseline

- Greenhouse gases are not limited to CO_2 and under the Kyoto protocol we must consider the emissions of several other GHGs when producing a footprint.
- Each GHG has a specific global warming potential (GWP).
- All of the illustrated gases on the right are represented in this report as tCO_2e – tonnes of carbon dioxide equivalent; this reflects the global warming potential of each key green house gas relative to CO_2.
- When a footprint is quoted in terms of CO_2e, this means that all gases under the Kyoto protocol are included.

	GWP	Main Source
CO_2	1	Fossil fuel combustion
N_2O	310	Agriculture and soil management
PFCs	~10,000	Aluminium and semi-conductor production
HFCs	1,500–15,000	Refrigeration and air conditioning
SF_6	23,900	Electricity supply equipment
CH_4	21	Agriculture and waste
NF_3	16,100	Semi-conductor and electronics production

METHODLOGY

Carbon Baseline

- The methodology used to calculate the carbon footprint follows the guidance set out in the GHG Protocol's *corporate standard*.
- This requires an activity to be matched to a relevant emission factor to calculate the actual emissions from that activity.
- Activity may refer to emission sources such as gas and electricity consumption, fleet usage, purchasing goods and services. In each of these instances primary data (utility bills, expense forms, mileage cards) should be mapped to each activity outlined under the GHG protocol and within the emission boundary. Where primary data is unavailable estimates can be made using proxies.
- Emission factors for numerous activities can be found publicly, and the most common activities have their relevant emission factors provided by the UK Government. The calculation methodology can be seen below.
- An explanation of the "scopes" of emissions as defined by the GHG protocol can also be found below.

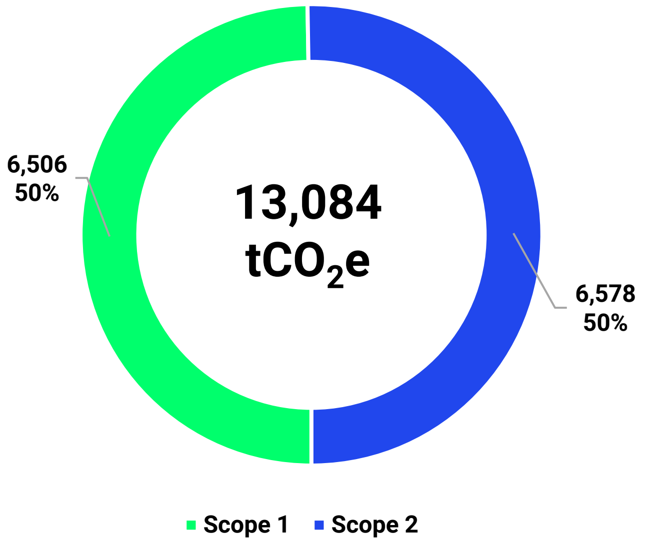
Activity Data ✖ Emission Factor = Emissions

Scope 1	Emissions directly emitted by the organisation (i.e. gas burnt in a gas boiler, tail pipe emissions from a vehicle).
Scope 2	Emissions indirectly emitted from the consumption of purchased electricity, heat or steam.
Scope 3	All other indirect emissions, such as the extraction and production of purchased materials and fuels, transport related activities in vehicles not owned or controlled by the reporting entity, water consumption, waste disposal, etc.

FOOTPRINT ANALYSIS

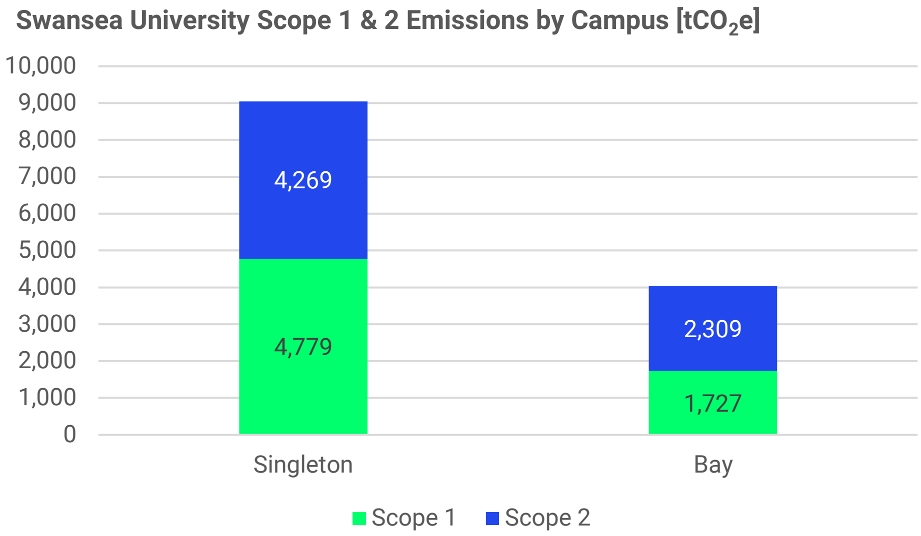
Carbon Baseline

- The 19/20 carbon footprint for Swansea University used in this action plan equates to **13,084 tCO_2e**. Scope 1 emissions stated here relate to natural gas only, and scope 2 emissions relate to grid derived electricity only.
- Half of the footprint arises from scope 1 emissions – these are operational emissions as a direct result of the combustion of fossil fuels within the organisation i.e. natural gas.
- The other half of emissions arise from indirect scope 2 sources – emissions that arise elsewhere (in terms of generation) as a result of the consumption of electricity.
- No further emission sources are included within the boundary of this assessment. This includes those from fugitive emissions (scope 1) and any upstream impacts from the consumption of gas and electricity (e.g. WTT and T&D). Where action is taken on gas and electricity carbon reduction, upstream impacts will reduce accordingly however.
- In terms of expenditure on these utilities, in FY19/20 SU spent approximately £5.25m on energy. £1.11m on natural gas and £4.14m on electricity. Considering the current energy price rises, under the same consumption figures, costs in FY 22/23 are now significantly higher, with continued volatility expected for some time to come.



Carbon Baseline

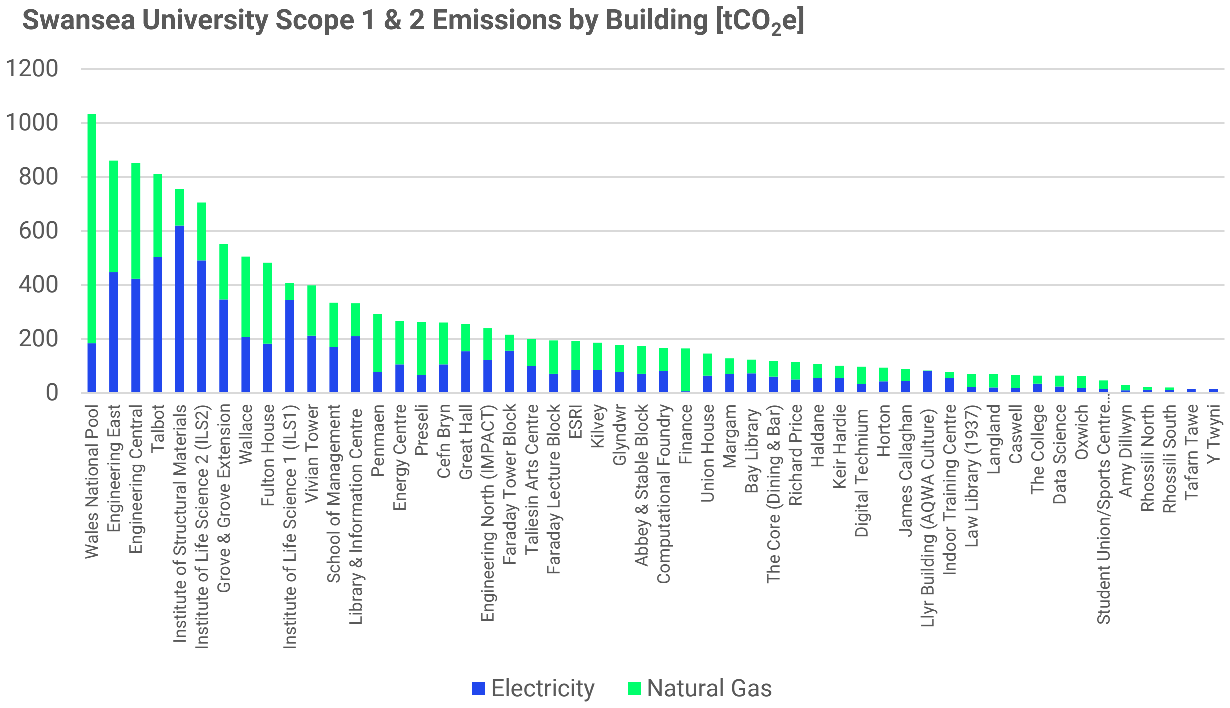
- The chart (right) provides a further breakdown of emissions per scope and source across SU's campuses[1].
- As shown the majority of emissions currently arise from the use of natural gas boiler systems and consumption of electricity at Singleton Campus (~70%).
- Approximately 30% of the emissions within the boundary of this assessment arise from activities at Bay campus.
- Whilst action is required on both campuses, based on the total proportion of emissions, there is a **clear indication that action on Singleton campus should be prioritised.**
- Fugitive emissions from refrigerants used in air conditioning systems is currently not included due to data restraints.



[1] – Hendrefoelan Student Village is excluded from this analysis due to SU vacating the properties in 2023

Carbon Baseline

- The chart (right) provides further breakdown of in scope emissions per building across both campuses
- WNP has the highest emissions per building due to the large gas demand for the heating requirements of the pool.
- Other high emission buildings include ISM and the Engineering buildings at Bay Campus and Talbot, ISL1/2, Grove, Wallace, Fulton House and Vivian Tower at Singleton.
- Specified carbon emissions per building for the baseline can be found in Appendix 1



SECTION 3

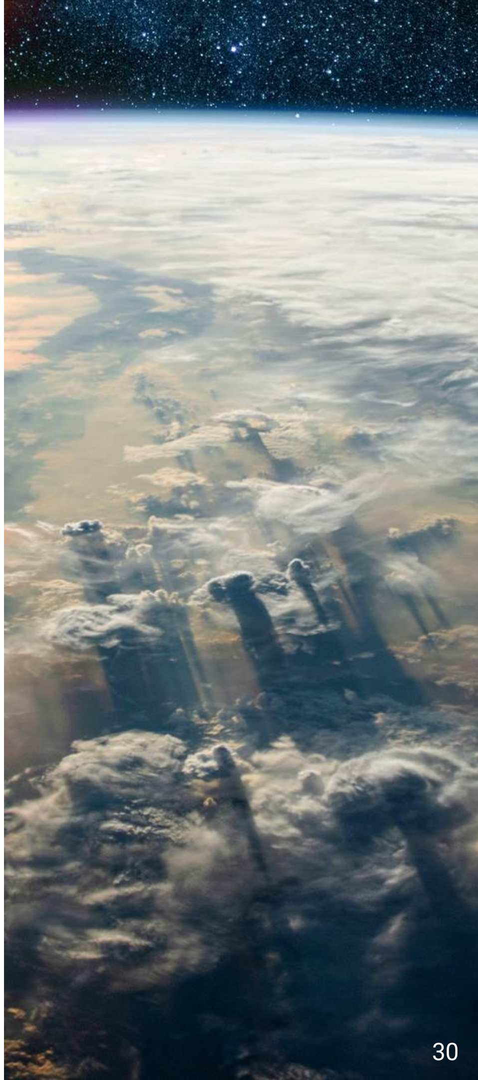
Target & Business as Usual

Back to Contents Page

Section Overview

Target & Business as Usual

- In section 3 we provide the summary outputs from the business as usual (BAU) analysis.
- Information is provided on the need for setting a BAU pathway, alongside the assumptions and analysis. A BAU pathway factors in assumptions on potential changes to activities/operations and future emission factors thus setting an effective “year-on-year” baseline for the target period.
- A select number of changes to SU’s building portfolio are described alongside the scenario for the forecasted carbon intensity of the electricity grid within the target period.
- The BAU is used as the “baseline” for the phased project pathway presented in section 5.



Business as Usual

- In order to more accurately estimate the emissions reduction achievable from the measures suggested in this report, forecasted change of emissions from a “do-nothing-scenario” are necessary. This forecast provides a year-on-year hypothetical baseline of emissions up to the target date.
- This is done through the creation of a ‘business as usual’ (BAU) scenario which describes how the footprint will change year-on-year if SU were to make no efforts to reduce their footprint.
- The BAU forecast provides a foundation against which the carbon reduction measures can be more accurately based. Given the importance of the BAU forecast for understanding future emissions and thus potential progress against targets, it is essential to try and make the forecast as accurate and realistic as possible.
- We have set the BAU forecast by aligning changes in activity with information provided by SU following consultation on the development of the scenario.
- The following pages provide background on the key factors that go into developing a BAU forecast. Namely changes in activity and changes in the predicted carbon intensity of those activities.
- The BAU is set against the target to illustrate the “gap-to-target” which provides a clearer picture on the scale of emissions reductions required over the coming years (as opposed to against todays emissions only).
- BAU modelling assumptions can be found in Appendix 2.

Business as Usual

The illustrative graph opposite aims to demonstrate how a BAU forecast is created, as described in the following steps:

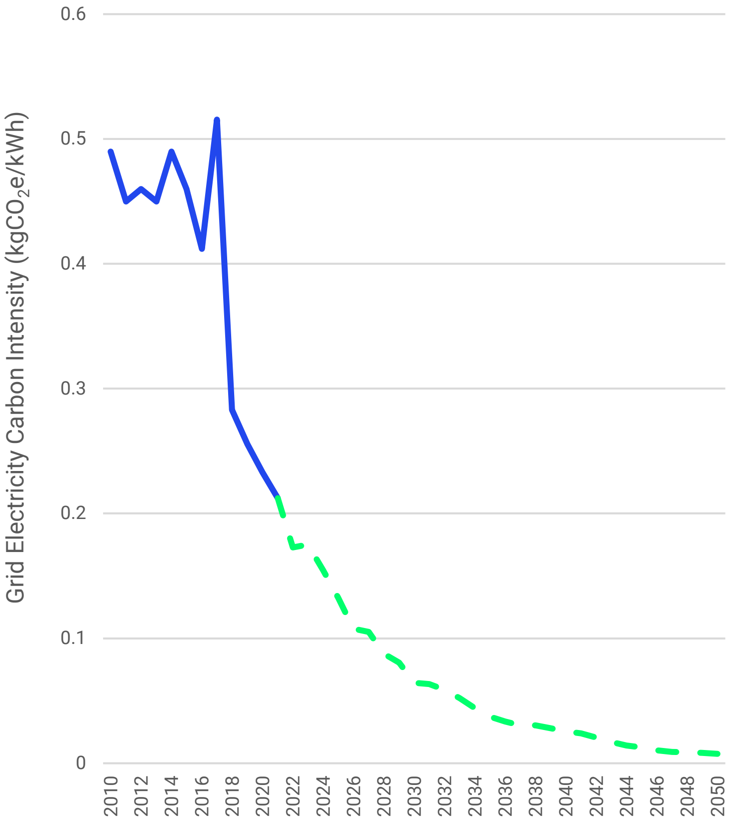
1. Activity data from the baseline year for each activity is projected at a constant rate to the target.
2. The activity can then be aligned with an appropriate change metric. As an example, it may be assumed that the consumption of natural gas is closely tied to the floor area and if we expect a 1% year on year increase of floor area then a similar BAU year on year change can be expected in natural gas consumption.
3. Any major confirmed projects are taken in to account. The example given here may be a jump in natural gas consumption through the construction of a building; the graph demonstrates this with a step up in activity in the year 2035.

NB. when converting to carbon emissions, it is assumed that all activities other than electricity have a constant emissions factor. The electricity grid emissions factor reduces over time due to the planned decarbonisation of the electricity generation sector, with data supplied from National Grid (see next page).

CARBON TRUST

Business as Usual

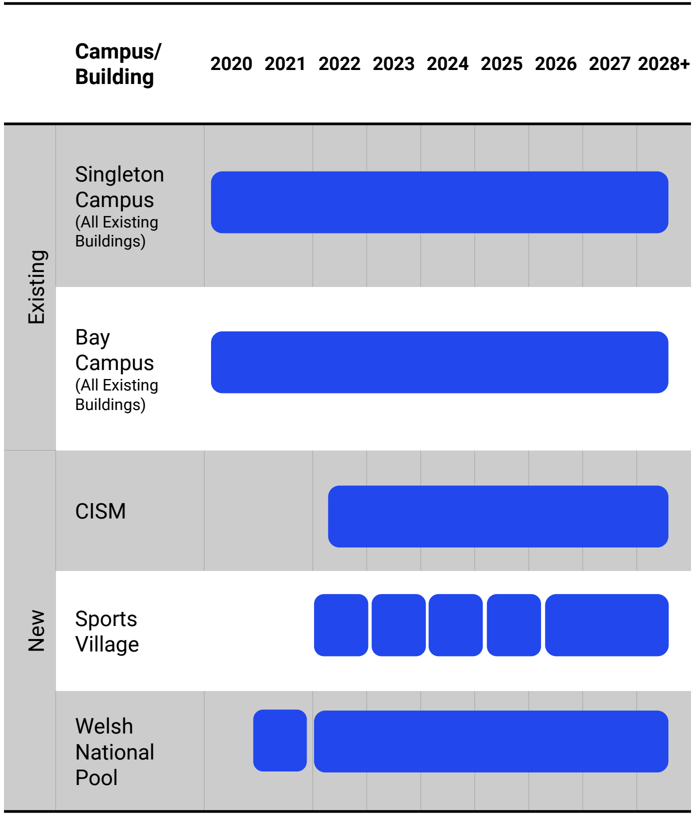
- As the UK switches more of its electricity generation to renewable sources, less CO_2 will be produced by this activity. This means over time the grid electricity consumed by end-users will become less carbon intensive.
- Already, between 2010 and 2020 the carbon intensity of grid electricity has decreased by over 50%. This has largely been driven by coal-fired power plants being taken off line and the large scale rollout of offshore wind farms.
- Projections of grid electricity carbon intensity are produced by National Grid's Future Energy Scenarios.[1] It is expected that by 2050 the carbon intensity of UK grid electricity will be just 2% of 2010's values.
- More ambitious projections produced by National Grid have carbon intensity becoming negative under certain scenarios – through the roll out of bioenergy with carbon capture and storage.
- This "greening of the grid" makes electrification of building heat and vehicles attractive from a carbon reduction perspective. Already, the grid is green enough to mean travelling one kilometre in an electric vehicle is less carbon intensive than one kilometre in a petrol/diesel vehicle. In regards to this action plan, it is anticipated that in just a few years the grid will have decarbonised enough to mean one kWh of heat provided by an electric heater will be less carbon intensive than one kWh of heating provided by a gas boiler.



[1] - National Grid Future Energy Scenarios – Steady Progression

Business as Usual

- Three major "events" have been factored into the BAU model as shown below. This includes CISM building on Bay Campus, the phased development at the Sports Village and inclusion of the Welsh National Pool (WNP) within SU's estate.
- Following consultation with SU estates team it was determined that no other major changes are currently planned to the estate. In addition, no metric is currently available that provides a good proxy for BAU changes in demand. As such it was agreed that energy consumption across both campuses would be modelled as per the baseline with the exception of CISM, Sports Village and WNP.
- **CISM Building:** fully online in 2022 with an assumed gas consumption of 1,120,000kWh and electricity consumption of 561,524kWh (per year). Consumption is assumed to be static year on year for purposes of the modelling subsequently.
- **Sports Village:** Floor area data for five phases of development has been used to estimate potential energy consumption using benchmarks alongside an estimate for electricity required for flood lighting. Any heating and cooling systems are assumed to be all electric. Cumulative demand has been modelled between 2022-2028. Consumption is assumed to be static year on year for purposes of the modelling subsequently.
- **Welsh National Pool:** From 2021 electricity and gas consumption figures have been set at 1,300,000kWh and 3,300,000 to reflect the CHP switch off. Consumption is assumed to be static year on year for purposes of the modelling subsequently.



Business as Usual: Wales Funding Programme Projects

During 2021 Swansea University worked with the Welsh Government Energy Service to apply for funding to support a number of discrete carbon reduction projects. The original survey work was completed early in 2021 with the initial application submitted in Spring 2021. At the time of writing, the below projects are currently progressed to tender stage with installation of the upgrades anticipated to be complete within academic year 22/23 (Autumn-Spring). As confirmed with SU, these projects have been included within the BAU for the purposes of this study to provide a clear delineation between the projects already “signed-off” and those that have put forward as future project suggestions in this study. By including these projects within the BAU, energy savings estimates are captured against the forecasted “baseline” and not lost within the modelled outputs. NB. The energy savings reduction from these projects are upfront estimates. Actual savings achieved (or energy generated from the Solar PV arrays) could vary.

Boiler Controls/BMS Upgrades

Building	Energy Saving kWh/year	Capital Cost £
• James Callaghan • Faraday Lecture Block • Glyndwr • Richard Price • Residential Oxwich, Langland and Caswell	~500,000	~£165k

LED Lighting

Building	Energy Saving kWh/year	Capital Cost £
• James Callaghan • Law Library • Richard Price • Haldane • Library & IC • Grove & Grove Extension • Talbot • Bay Campus External Lighting	~800,000	£TBC

Solar PV

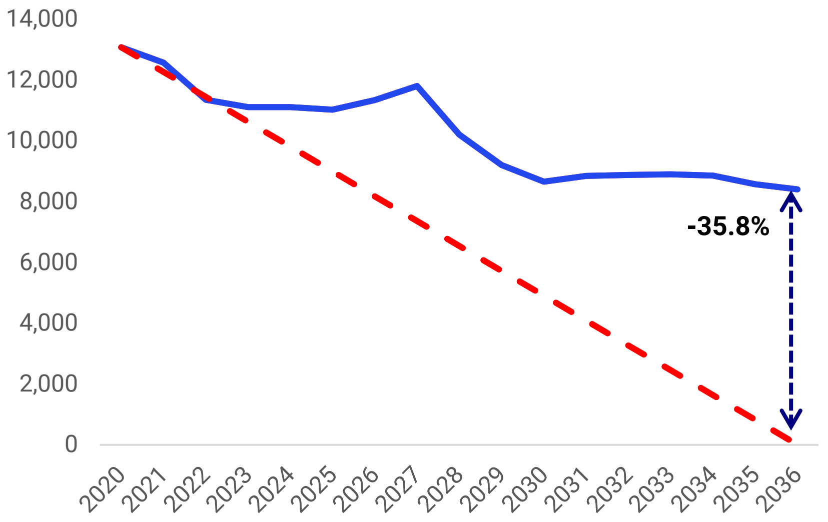
Building	Energy Saving kWh/year	Capital Cost £
• Union House • Library & Information Centre • Glyndwr • Fulton House • Talbot • Engineering Central • Bay Library	~450,000[1]	~£780k

[1] – 100% utilisation on site with no export assumed, as confirmed with SU

Total Emissions

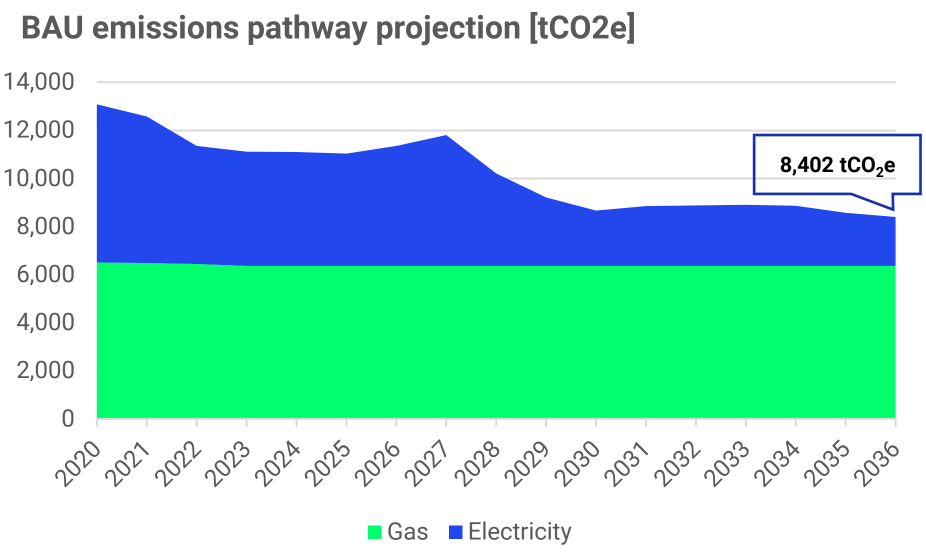
- The graph (right) shows the projected BAU carbon emissions (blue line) against the SU's reduction target (red line).
- It is forecast that under the BAU, total emissions within the boundary will reduce by 35.8% between 2019/20 and the target year of 2035/36.
- The analysis used here is centred on an indexed version of the National Grid's *Steady Progression* in their *Future Energy Scenarios 2021*. This is a conservative but optimistic projection which assumes:
  - Offshore wind capacity will reach 40GW by 2040 (10.5GW in 2020)
  - First Carbon Capture Usage and Storage (CCUS) power station operational by 2035
  - Bioenergy with Carbon Capture and Storage's (BECCS) negative emissions and generation output is excluded.
- In this BAU scenario, a **gap-to-target of 8,402 tCO_2e remains in AY 2035/36.**
- The modelling uses future emission factors that are available on a calendar year only. As such, and in accordance with SU's stated carbon budgets, the precise target time line runs from academic year 19/20 to 35/36, finishing in August 2036.

BAU emissions pathway projection [tCO_2e]



Emissions by Activity

- The graph here shows the change from each emission source over time within the BAU projection.
- At the current time, no information is factored into the model on significant changes to the estate beyond those stated above. Given the relatively minor effect of these changes, the change in BAU emissions is primarily driven by the reducing emission intensity of grid derived electricity.
- The model does not include any change to natural gas consumption beyond the relatively minor changes seen early on in the target timeframe at CISM and WNP. Given the emission factor for natural gas does not change, the model for gas manifests as a "flat-line" out to 2035/2036.
- For electricity emissions, the change is primarily driven by the reducing grid emission factor over the target timeframe, with any increases associated with the additional energy consumption from CISM, Sports Village and WNP countered by reductions from the Wales Funding Programme projects.
- The "spike" in emissions during 2027 is primarily a factor of the predicted emission intensity trending upwards between 2025-2027 before dropping back down from that point (within the FES "Steady Progression" scenario).



SECTION 4

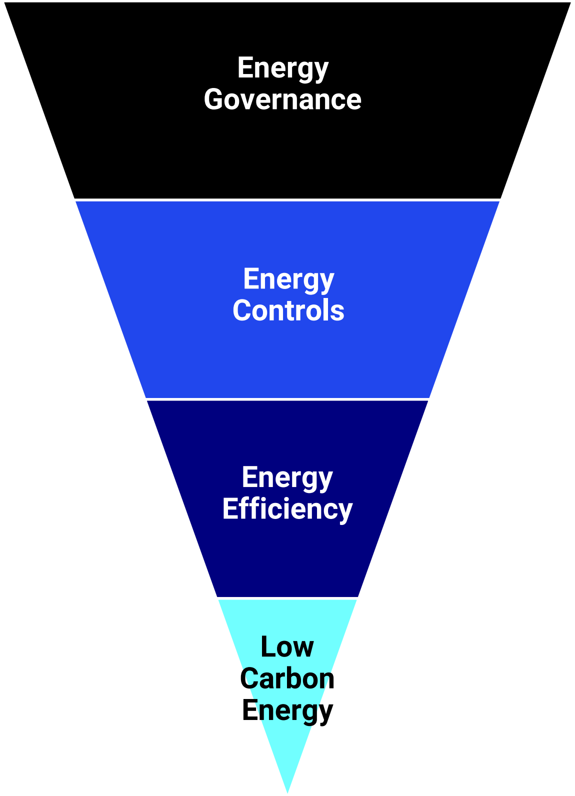
Carbon Reduction Projects

Back to Contents Page

Section Overview

Carbon Reduction Projects

- In section 4 we outline the identified carbon reduction opportunities. In the first instance, projects have been categorised under the broad headings as shown on the right. An important guiding approach to all building energy decarbonisation is the prioritisation of energy demand reduction first through efficiency measures before any low carbon generation is installed. This process dictates that any new heating/ cooling systems can be sized against a reduced demand; and renewables can be selected appropriately based on the lowest possible needs.
- Projects are presented descriptively in section 4 to introduce the 12 main actions that sit under the broad categories on the right (see next page). Rationale is also provided for each intervention based on the evidence gathered during the development process. For some measures, projects are only applicable to a sub set of buildings. This is indicated in this section (as “buildings applicable”) but fully presented in section 5.
- In section 5, projects are grouped across sets of buildings under “phases”. Each phase has individually assigned financial budgets required for implementation alongside the estimated carbon emissions reductions apportioned to those phases.
- Projects have been developed through a collaborative process engaging with SU estates team and third party contractors. Carbon Trust conducted high level surveys of each building, M+E systems etc. and collecting data to inform the opportunities.



Projects overview

Energy management: Engagement, policy and procurement to enable savings

Ventilation system improvements: Refurbishment of air handling systems

LED lighting: Upgrade of all lighting to LED standards with controls

Maintenance management: Shift towards preventative maintenance and removal of backlog

Cooling efficiency: rationalisation & formation of cooling stations to reduce cooling energy

EC drives and IE5 motors: Upgrade of all motors and drives to high performance standards

BMS improvements: Upgrades for closer alignment of energy consumption with building occupancy

Air leakage: Reduction of thermal losses through door seals

Electrified heat: Installing heat pumps and upgrading the network to an electrified solution

Voltage trim: Reduction of voltage through transformer taps

Fabric and insulation improvements: Retrofit of building fabric and other thermal elements

Solar PV: On-site renewable technology to boost zero carbon energy supply

Energy Management

Key Info	Description
     	**Engagement:** The way occupants interact with building energy systems can create energy waste and increase carbon emissions. This is seen to manifest itself via the 24/7 operation of buildings (not well matched to occupancy), windows left open for long periods (in winter) and lighting activated in unoccupied areas. In addition, the refurbishment of faculties has not been considered at the whole building level i.e. piecemeal & fragmented approach. Stronger engagement with faculties is needed in regards to reducing energy consumption, alongside consideration of engagement with security and cleaning staff on manual shut down of lights with mandatory energy waste reporting. **Policy:** The university tends to install DX / VRV cooling at the request of academics. This cooling is provided ad-hoc without consideration to wider energy management needs. The following is suggested; Cooling loads are properly appraised and appropriately sized solutions provided (to prevent over-sizing). Cooling is only selected with the highest SCoP and SEER. All cooling is controlled from the BMS (as well as local control). Auxiliary heat exchanger connections are provided for the recovery of heat for the use of future heat pumps. **Procurement:** The acquisition of the new plant, equipment and appliances should be planned, designed and delivered using optimum low energy versions. In particular this should focus on new IT equipment, catering equipment, lab equipment and new build developments (e.g. Sports Village). Reference to high performing criteria/products from the energy technology list is recommended.
Buildings Applicable	All
Estimated Energy Savings	None assigned[1]
Estimated Capital Cost	None assigned[2]
Risks	Faculty Resistance

[1] Enabling measure without savings / marginal savings or picked up elsewhere e.g. through BMS improvements
[2] Revenue / non-capital costs only

ENERGY GOVERNANCE

Maintenance Management

Key Info	Description
	Maintenance on mechanical and electrical systems at the University is dealt with on reactive basis only. Additionally, a backlog of works exist, due to limitations with resource, budgets etc. It is essential that the University provides the support required to clear the maintenance backlog and move towards a planned and preventative approach. There is a very strong link between effective maintenance and energy efficiency: The more efficiently/effectively plant or equipment works, the less energy is used. This will enable optimised low carbon operation of M&E systems and prepare the University for meeting its target. A move towards a planned maintenance approach will require tasks such as: • Catch up on maintenance projects. • Implement flushing and pipework replacement on heating systems. • Replacement of old air handling units (see ventilation system improvements). • Visibility of the BMS system to improve maintenance activities. • Waste reporting. • Energy KPI's set on a building by building basis. Further information on proactive maintenance can be found in Appendix 3.
Buildings Applicable	All - focus on Singleton campus 1950-1980's builds in particular
Estimated Energy Savings	None assigned[1]
Estimated Capital Cost	None assigned[2]
Risks	Changing from reactive to planned maintenance and removing backlog projects will requires funds and resources

[1] Enabling measure without savings / marginal savings or picked up elsewhere e.g. through BMS improvements
[2] Revenue / non-capital costs only

ENERGY CONTROLS

Building Management System (BMS) Improvements

Key Info	Description
 	Singleton and Bay campuses are provided with good BMS platforms with integrated building level energy metering capabilities. There is an opportunity however to further improve the application of the BMS in supporting the reduction of energy consumption across many buildings. This includes improving elements of the BMS hardware/software to more closely link energy consumption with occupancy. Schneider Electric are currently working closely with SU to develop an implementation plan to roll out their *Building Advisor* system which provides key insights building operations by monitoring systems and identifying faults to proactively address building inefficiencies. Occupancy matching will form a key part of the mechanism to reduce energy consumption alongside introduction of close control system with the management infrastructure such as carbon dioxide sensors. Its is also anticipated that continuous commissioning of services will be supported through this measure. Real time information on the over/under performance of systems will allow ongoing control changes to create energy savings. BMS Improvement modelling assumptions can be found in Appendix 4.
Buildings Applicable	All
Estimated Energy Savings	5%-15% of building level electricity and gas consumption
Estimated Capital Cost	£1,959,760
Risks	None

Voltage Trim

Key Info	Description
	Voltage measurement samples were taken during the on site surveys. The voltage across the Singleton and Bay campuses was found to vary from 230V to 240V with many readings at or close to 240V. The required voltage across the campuses is 230V. The higher the voltage the more power is consumed by inductive loads such as motors and older lighting systems. A 230V linear appliance used on a 240V supply will take 4.3% more current and will consume almost 9% more energy in addition to only achieving 55% of its rated life. Maintenance savings are also probable from inductive loads that have a more appropriately matched voltage supply i.e. less time involved with maintaining motors/drives that have properly matched voltage to their needs. Expensive/complex voltage management or optimisation solutions are unlikely to be required. An exercise of voltage trim (re-tapping transformers) should be considered however. Voltage trim modelling assumptions can be found in Appendix 5.
Buildings Applicable	27 buildings across Singleton and Bay (at the transformer level)
Estimated Energy Savings	0.3% – 1.8% of building electricity consumption
Estimated Total Capital Cost	£40,500
Risks	Undervoltage but easily mitigated with proper implementation

Ventilation System Improvements

CARBON TRUST

Key Info	Description
 	In a number of the 1960s – 1980s buildings on Singleton campus, original ventilation systems still exist, which incorporate aged fans and motors. Whilst the Air Handling Units (AHU's) and components are still operationally viable, they are not operating at optimum energy efficiency standards. These systems include fans with outdated belt driven systems with no facility for heat recovery, commensurate with modern standards. The AHU's/components should be re-sized to suit modern needs and replaced with EC (electrically commutated) Fans with heat recovery (thermal wheel/plate heat exchange as appropriate). EC motors are more efficient than AC motors because they use permanent magnets rather than induce a secondary magnetic field in the rotor. EC fans consume, on average, about 70% less electricity than conventional AC fans. They also provide significant noise and heat reduction. A full inventory and comprehensive inspection of all AHUs/fan/motors was not possible/available for this study. However it is estimated that a total capacity of 117kW of maximum fan power is associated with these units. SU should engage with its contractors/third party suppliers to arrange a full inspection, detailed quotations and rollout of upgrades for the systems in question. Ventilation System Improvements modelling assumptions can be found in Appendix 6.
Buildings Applicable	Singleton Campus: Faraday Teaching Building, Fulton House, Union House, Vivian Tower, Taliesin Arts Centre, Grove & Grove Extension, Law Library, Library and Info Centre.
Estimated Energy Savings	328,474 kWh/year of electricity and 1,503,264 kWh/year of gas
Estimated Total Capital Cost	£1,395,000
Risks	None

Cooling Efficiency

Key Info	Description
 	Whilst cooling energy consumption is not a major part of SU's energy baseline, their exists widespread use of small split direct expansion units (DX) across Singleton campus. These units are understood to be used for a variety of space cooling needs and specific academic uses. Units have been installed "organically" over time at the specific request of faculties, but not subject to a wider policy/strategy on the use of standalone DX type cooling. The use of DX units cooling should be re-considered and if possible removed. Alternative water based chillers could be centralised or clustered with the formation of cooling stations. These could be formed using ultra low energy chillers (high CoP) with heat recovery. The installation of such centralised systems will create savings through a reduction in system losses, and upgrades to lower energy versions with high efficiency will be more cost effective. In addition, fugitive losses of refrigerant would be more easily managed and reduced. Heat rejected from chillers could also be recovered and used in the district heating system. Additionally, in buildings such as Llyr, the cooling systems is oversized/duplicated and should be rationalised. Cooling efficiency modelling assumptions can be found in Appendix 7.
Buildings Applicable	Faraday Teaching Block, Llyr Building, ILS1, ILS2,
Estimated Energy Savings	142,042 kWh/year of electricity
Estimated Total Capital Cost	£500,000
Risks	Faculty Resistance

ENERGY EFFICIENCY

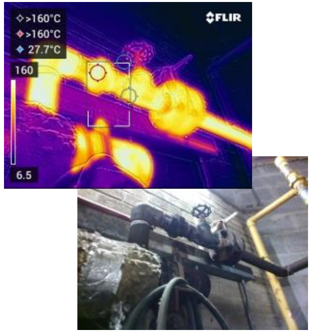
Air Leakage

Key Info	Description
 	A thermal imaging survey across Bay Campus identified that the majority of fire escape doors have poor draught/thermal seals and are causing air leakage. Whilst a relatively minor source of energy loss, this leakage will be causing draughts and discomfort for users in close proximity to these doors, alongside unnecessary air infiltration heat losses. Appropriate seals should be investigated and installed. The installation of improved seals will be a low cost measure that should be prioritised as a quick win. Thermal imaging should be used pre-post installation to confirmed leakages have been reduced. Air Leakage modelling assumptions can be found in Appendix 8.
Buildings Applicable	All Bay Campus buildings
Estimated Energy Savings	47,520 kWh/year natural gas
Estimated Total Capital Cost	£36,000
Risks	None

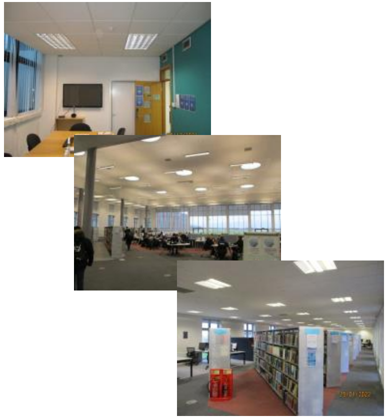
Fabric Improvements

Key Info	Description
	**Building Fabric:** a number of building across Singleton have poor building fabric which causes high losses and creates user discomfort and complaints. This is particularly prudent where older building have single glazing still in place. A comprehensive building fabric improvement upgrade of the buildings in question should be rolled to include upgrades to double glazing, installation of cavity wall insulation where appropriate, newly insulated over-cladding, roofs and removal of cold bridges. Fabric & Insulation Improvements modelling assumptions can be found in Appendix 9.
Target Buildings:	**Building Fabric:** Abbey & Stable Block, Law Library, Richard Price, Amy Dillwyn, Mosque, Union House, Library, Talbot Building, Margam Building, Glyndwr Building, Vivian Tower, Fulton House, Grove Building
Estimated Energy Savings	**Building Fabric:** 10%-60% of total building level heating gas consumption
Estimated Total Capital Cost	**Building Fabric:** £70,000,000
Risks	Planning considerations.

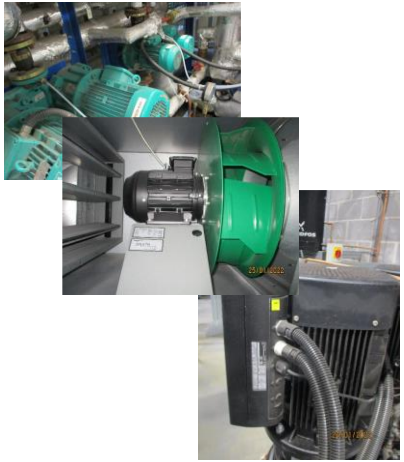
Insulation Improvements

Key Info	Description
	**Steam & heating pipework:** Whilst the level of thermal insulation for pipework and valves is good there are still in some plant rooms exposed dosing pots, heat exchangers, valves and sections of pipework. £10,000 has already been spent in May 2022 to improve space heating and DHW pipework, and valve insulation at Singleton Campus. **WNP pool cover:** An excessive amount of heat is lost through the lack of any pool covers at WNP. The installation of a pool cover would create a large amount of carbon savings and a way forward should be sought to install a systems that works for all involved. SU has already allocated £70,000 to install a cover to the 25m training pool. Fabric & Insulation Improvements modelling assumptions can be found in Appendix 9.
Target Buildings:	**Steam Heating & Pipework:** Finance, Richard Price, Haldane, Union House, Taliesin Arts Centre, Keir Hardie, Library & Information Centre, Wallace, Glyndwr, Grove & Grove Extension, Fulton House, Faraday Lecture Block, WNP, Engineering Central, ESRI, The College
Estimated Energy Savings	**Steam Heating & Pipework**: 125,603 kWh/year **WNP Pool Cover:** 10% of total site gas consumption
Estimated Total Capital Cost	**Steam Heating & Pipework:** £17,000 (£10,000 already allocated) **WNP Pool Cover:** £120,000 (£70,000 already allocated)
Risks	Planning considerations.

LED Lighting

Key Info	Description
	Whilst LED lighting is installed in numerous corridors and faculty areas, only Engineering North and Computation Foundry on Bay campus have 100% LED. The rate of LED installed varies from area to area (estimated at ~10% to ~80% from building to building). Whilst there are plans to refurbish lighting in a small number of buildings – all buildings should be refurbished with LED lighting with smart (automatic) controls. LED lighting technology has improved substantially in recent years, to the extent that it is now the standard option in commercial premises and is more efficacious and efficient than almost all legacy lighting sources. High quality LED lamps and luminaires offer good spectral distribution, colour temperatures and can last over 50,000 hours (at L70B10 rating). In addition to being intrinsically more efficacious than most other lamp types, LED offers additional advantages through significantly reduced maintenance costs. Care must be taken to ensure that emergency lighting provision is not compromised by any modifications. LED Lighting Modelling assumptions can be found in Appendix 10.
Buildings Applicable	All buildings except Engineering North and Computational Foundry
Estimated Energy Savings	1,288,028 kWh / year of electricity
Estimated Total Capital Cost	£1,899,000
Risks	Inaccurate matching of lighting/lux/rendering requirements

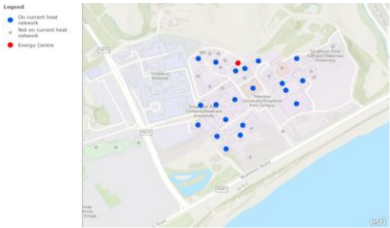
EC drives and IE5 motors

Key Info	Description
	**Singleton:** A significant end user of energy across Singleton Campus is from motors and drives. Key end uses include: lifts, heating & cooling water circulation pumps, compressors and fume cupboard fans. A programme of replacing the mature motors and drives initially should commence with replacement of older less efficient versions (IE2/IE3) to low energy IE4 or IE5 motors. **Bay:** Retrofit EC Fans to all traditional direct drive air handling units should be considered. The Bay Campus has a significant number of air handling units that are mostly furnished with direct drive AC motors. These should be retrofitted with lower energy EC Fans. These not only consume lower levels of energy but can also be speed controlled using 0-10V signals negating the need for variable speed drives. Whilst it is understood there is unlikely to be any appetite to upgrade these systems in the near term, units across Bay will have reached the end of their economically serviceable life by 2030-2035 when the phased set of measures is recommended (see section 5). In addition, a number of IE2/IE3 motors were also identified on the Bay campus. These motors should also be replaced with IE4/IE5 motors when possible. EC drives and IE5 motors modelling assumptions can be found in Appendix 11.
Buildings Applicable	All expect Engineering North and Computational Foundry
Estimated Energy Savings	598,598 kWh / year of electricity
Estimated Total Capital Cost	£1,150,000
Risks	None

Electrified Heat

Key Info	Description
 	Electrifying heat through the installation of high efficiency heat pumps (either air-source or ground-source) is recommended as the primary route to decarbonising the University's heat demand. In order to achieve the overall target SU will need to proactively target a significant reduction in natural gas use across the estate and transition to low-carbon fuels. Detailed feasibility studies are required to confirm the optimum configurations of heat pumps across SU's estate and should be commissioned as a priority in advance of heating system replacements. The challenge of heat decarbonisation is multi-faceted and there is no 'one-size-fits-all' solution that can be implemented across the estate. Key to the approach is following the heat hierarchy (see Appendix 12). Rationale is included in the Appendix 13 for excluding hydrogen and biomass heating from this assessment (often cited alongside heat pumps as potential low-carbon heat sources). While excluded from analysis at this stage, it should be noted that both of these options would be preferred over continued use of natural gas, should further studies deem heat pumps an inappropriate solution. It is also re-emphasised that energy efficiency to reduce end heat must be maximised, regardless of the ultimate heat source. Electrified heat modelling assumptions can be found in Appendix 14.
Buildings Applicable	All buildings not on the network (inc. those at Bay and WNP)
Estimated Energy Savings	100% natural gas savings but with an increase in electricity consumption
Estimated Total Capital Cost	£10,240,000
Risks	Increased operational costs, electrical capacity issues, technology cost and supply chain maturity, unfamiliarity with technology (resistance from within), space requirements, reliance on national grid decarbonisation for carbon savings

Electrified Heat: Heat Network

Key Info	Description
	To achieve the University's target, the current heat network on Singleton must be converted from using gas-fired CHP and boilers as a heat source to a low-carbon alternative such as heat pumps. Initial feasibility was conducted as part of the *Swansea University Heat Strategy March 2022* produced by the Welsh Government Energy Service. Replacing part of the heat load currently met with the existing gas-CHP and gas boilers with a closed-loop ground-source heat pump (GSHP) was indicated to be preferred solution to decarbonise the network. However, because of the nature of the study, the assessment was only able to provide a high level view. There is exists a variety of potential heat sources beyond an exclusive ground source solution, therefore the optimum configuration for a low carbon heat network should be the focus of detailed techno-economic feasibility study. The assessment should investigate both the preferred GSHP solution alongside the secondary opportunities for decarbonising the heat network. Heat network modelling assumptions can be found in Appendix 15.
Buildings Applicable	Buildings on the heat network
Estimated Energy Savings	100% natural gas savings but with an increase in electricity consumption
Estimated Total Capital Cost	£10,180,000
Risks	Increased operational costs, electrical capacity issues, technology cost and supply chain maturity, unfamiliarity with technology (resistance from within), space requirements, reliance on national grid decarbonisation for carbon savings

Solar PV

Key Info	Description
	Solar photovoltaics (PV) are the most affordable method of producing on-site renewable electricity. Cost reductions in the technology over the past decade have resulted in its accelerated roll-out at both utility and smaller scale. SU already operate a number of systems with further arrays planned. However, there are additional roofs at Singleton Campus that have favourable conditions to accommodate productive Solar PV (e.g. clear flat roofs, south facing). On Bay campus, PV is located on most roofs but there also remains a small number of areas where additional PV could be installed. SU should engage with suppliers in order to gather quiets and cost estimates for comprehensive coverage of on site Solar PV across Singleton and Bay over the coming years Assumptions for the estimated generation potential can be found in Appendix 16. As conformed by SU, 100% utilisation of estimated energy generated is currently assumed to be used on site (no export).
Buildings Applicable	Finance, James Callaghan, Law Library (1937), Richard Price, Haldane, Rhossili North, Rhossili South, Llyr Building, Wallace, Grove & Grove Extension, Institute of Life Science 2 (ILS2), Faraday Tower Block, Institute of Life Science 1, Penmaen, Horton, Oxwich, Langland, Caswell, Wales National Pool, The College (Academic L5)
Estimated Energy Savings	1,399,735 kWh / year of electricity
Estimated Total Capital Cost	£1,075,000
Risks	Limited but integration with existing systems should be carefully considered. Savings will be degraded if the 100% onsite utilisation assumption is not met.

SECTION 5

Project Phasing & Budgets

Back to Contents Page

Section Overview

Project Phasing & Budgets

- In section 5 the carbon reduction projects that were introduced in section 4 are grouped together across sets of buildings under "phases". This approach was developed in consultation with SU estates team in order to aggregate the capital budgets and the associated carbon reductions on a whole building and spatially "zoned" basis, rather than on a technology-by-technology basis i.e., all measures appropriate to a certain building/group of buildings, rather then focussed on one technology rolled out across the campuses.
- This phased design has been chosen in order to minimise disruption to the campus. Phases have therefore primarily been put forward in a spatial sense e.g. North, West, East etc. Other criteria have also been considered however including bringing forward priority buildings (poor performers) and assigning later dates in the target period to newer buildings e.g. Bay Campus.
- Cost estimates have been informed by supplier quotations where possible to reduce uncertainty, based on current prices (2022). Costs provided are based on the application of technical principles and professional evaluation. The evaluations are however limited by the information made available and conditioned by data limits, scope of work and time. All suggested projects will require verification and detailed assessment prior to proceeding with implementation. Costs provided should not be used to inform investment grade proposals.
- The figures quoted do not include development/design costs. A rule of thumb of 5-10% of the capital costs can be applied to this however. Information on potential implementation mechanisms can be found in section 7.

Phasing Overview

CARBON TRUST

The suggested below phasing has been allocated. The building contained within each phase can be found on the subsequent pages For each phase, the timeframe (aligned to academic years) and high level rationale for their phasing have been included in the table below.

Suggested Phases	Start	Finish	Description/Notes
Pilot	Sep-22	Aug-24	Decarbonisation measures implemented on worst performing buildings: Pilot projects will build expertise and confidence for wider role out.
West	Sep-24	Aug-28	Main programme of retrofit measures based on location (starting with buildings connected to the network)
North	Sep-28	Aug-31	Main programme of retrofit measures based on location to cover the residential area
East	Sep-31	Aug-35	Main programme of retrofit measures based on location (final stage)
Energy Centre	Sep-29	Aug-31	Energy centre heat pump installation and network upgrades
Bay	Sep-30	Aug-35	Starts in parallel with last phases of work on Singleton campus. Delayed since buildings have relatively new building services equipment installed
Sport	Sep-22	Aug-27	Sports facilities to West of Singleton hospital. Due to be regenerated[1]

[1] The cost of the main development is not included within this action plan

CARBON TRUST

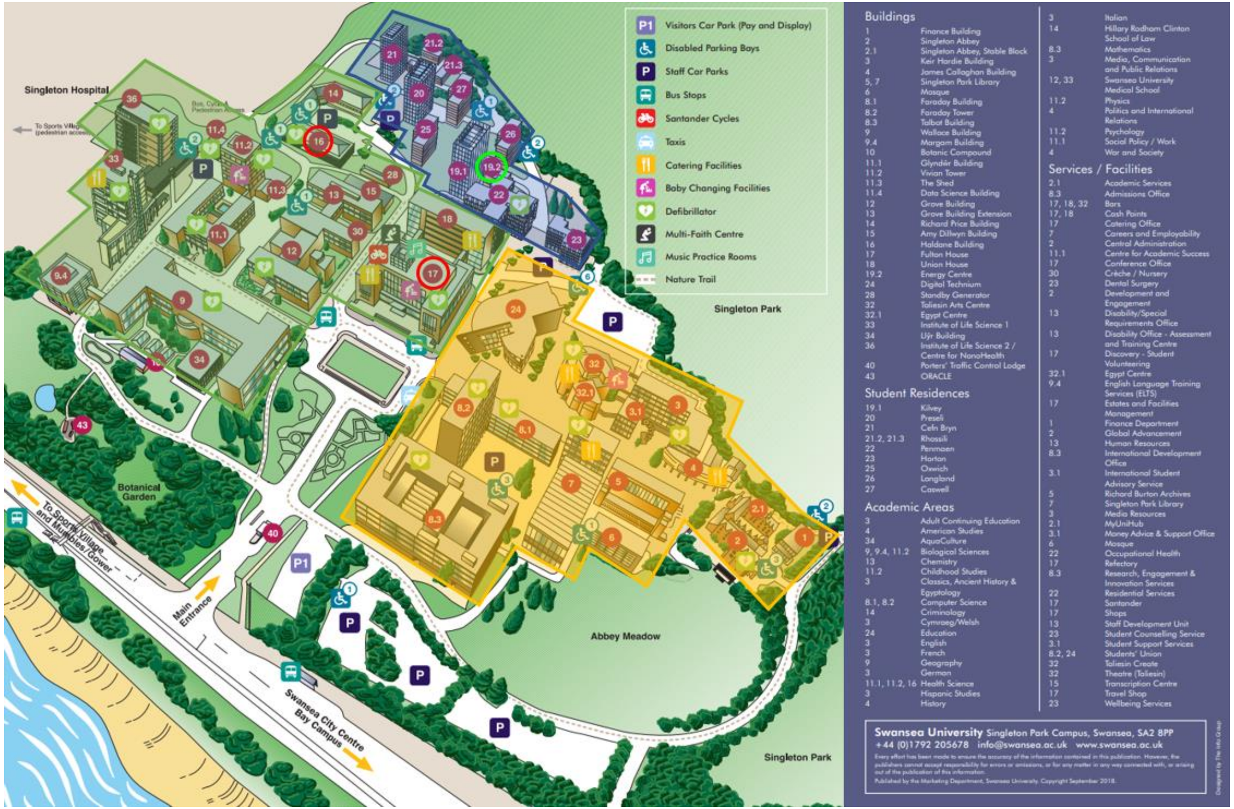
Phase mapping – Singleton Campus

To illustrate the spatial areas within each phase, a mark-up of the Singleton campus site map has been created.

The map does not show the ‘Sport’ phase, which includes decarbonisation of Wales National Pool, and the ‘Bay’ phase which will occur in the five years preceding Swansea University’s target, since the buildings on Bay campus.

Buildings included in each phase are listed on following slides.

Phase	Symbol
Pilot	
Energy Centre	
West	
North	
East	



Phase Breakdown: Demonstration Pilot phase

Programme of decarbonisation measures to run AY 2022/23 – AY 2023/24. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 2 buildings included in the demonstration pilot phase. Buildings have been ordered by energy performance within each phase.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
				1. BMS	2. Continuous Commissioning	3. Voltage Trim	1. Ventilation System Improvements	2. Cooling efficiency improvements	3. Air leakage improvements	4. Fabric and Insulation	5. LED lighting throughout building	6. EC Drives and/or IE5 motors	7. Electrified heat	8. Electrified heat: Heat Network	9. Rooftop Solar PV
Fulton House	✓	196	£ 8,955,000	✓			✓			✓	✓	✓		✓	
Haldane		113	£ 315,000	✓	✓							✓	✓		✓

Estimated capital costs relate specifically to suggested decarbonisation measures. Any renovation costs that are additional to decarbonisation measures have not been accounted for.

1. BMS
2. Continuous Commissioning
3. Voltage Trim

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

PROJECT PHASING & BUDGETS

Phase Breakdown: West Phase

Programme of decarbonisation measures to run AY 2024/25 – AY 2027/28. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 12 buildings included in the West phase. Buildings have been ordered by energy performance within each phase.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
				1	2	3	1	2	3	4	5	6	7	8	9
Amy Dillwyn		184	£ 670,000							✓	✓	✓	✓		
Wallace	✓	184	£ 650,000	✓		✓					✓	✓		✓	✓
Institute of Life Science 2 (ILS2)	✓	174	£ 600,000	✓	✓	✓		✓			✓	✓		✓	✓
Union House		128	£ 4,250,000				✓			✓	✓		✓		
Richard Price		124	£ 480,000	✓		✓				✓		✓	✓		✓
Grove & Grove Extension	✓	119	£ 965,000	✓		✓	✓			✓		✓		✓	✓
Glyndwr	✓	104	£ 5,550,000	✓		✓				✓	✓	✓		✓	
Vivian Tower	✓	103	£ 10,610,000	✓		✓	✓			✓	✓	✓		✓	
Margam	✓	83	£ 4,090,000			✓				✓	✓			✓	
Data Science	✓	73	£ 205,000		✓	✓								✓	
Institute of Life Science 1 (ILS1)	✓	61	£ 505,000	✓	✓	✓		✓			✓	✓		✓	✓
Llyr Building (AQWA Culture)		19	£ 345,000		✓			✓			✓		✓		✓

1. BMS
2. Continuous Commissioning
3. Voltage Trim

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

PROJECT PHASING & BUDGETS

Phase Breakdown: North Phase

Programme of decarbonisation measures to run AY 2027/28 – AY 2030/31. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 10 buildings included in the North phase. Buildings have been ordered by energy performance within each phase.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
				BMS	Continuous Commissioning	Voltage Trim	Ventilation System Improvements	Cooling efficiency improvements	Air leakage improvements	Fabric and Insulation	LED lighting throughout building	EC Drives and/or IE5 motors	Electrified heat	Electrified heat: Heat Network	Rooftop Solar PV
Preseli		277	£ 295,000								✓		✓		
Cefn Bryn	✓	225	£ 240,000								✓			✓	✓
Penmaen	✓	148	£ 385,000								✓			✓	✓
Rhossili North	✓	142	£ 205,000								✓			✓	✓
Oxwich		142	£ 135,000								✓		✓		
Kilvey	✓	141	£ 245,000								✓			✓	✓
Horton	✓	134	£ 260,000								✓			✓	✓
Rhossili South	✓	131	£ 205,000								✓			✓	✓
Langland		128	£165,000								✓		✓		✓
Caswell		124	£140,000								✓		✓		✓

1. BMS
2. Continuous Commissioning
3. Voltage Trim

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

Phase Breakdown: East Phase

Programme of decarbonisation measures to run AY 2031/32 – AY 2035/36. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 12 buildings included in the East phase. Buildings have been ordered by energy performance within each phase.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
				1	2	3	1	2	3	4	5	6	7	8	9
Finance		877	£ 795,000			✓					✓	✓	✓		✓
Faraday Lecture Block		186	£ 860,000				✓	✓			✓	✓	✓	✓	
Abbey & Stable Block		154	£ 1,665,000	✓		✓				✓	✓		✓	✓	
Taliesin Arts Centre		132	£ 590,000	✓			✓				✓	✓	✓		
Digital Technium		104	£ 455,000	✓	✓	✓					✓	✓	✓		
Law Library (1937)		103	£ 2,980,000	✓			✓			✓		✓	✓		✓
Talbot	✓	98	£ 435,000	✓						✓		✓	✓	✓	
James Callaghan		83	£ 395,000			✓						✓	✓		✓
Library & Information Centre	✓	80	£ 8,685,000	✓			✓			✓		✓		✓	
Faraday Tower Block	✓	68	£ 230,000								✓			✓	✓
Keir Hardie	✓	43	£ 430,000	✓		✓					✓	✓		✓	✓
Mosque		-	£ 480,000							✓	✓				

1. BMS
2. Continuous Commissioning
3. Voltage Trim

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

Phase Breakdown: Bay Campus Phase

Programme of decarbonisation measures to run AY 2030/31 – AY 2035/36. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 15 buildings included in the Bay campus phase. Buildings have been ordered by energy performance within each phase.

Building	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
			1	2	3	1	2	3	4	5	6	7	8	9
The Core (Dining & Bar)	-		✓											
Student Union/Sports Centre (Building 15/16)	-	£ 15,000	✓							✓				
Tafarn Tawe (Coffee Shop)	-		✓											
Centre for Integrative Semiconductor Materials (CISM)	-													
Engineering Central (Innovation Hub)	260	£ 425,000	✓	✓	✓			✓		✓	✓	✓		
Institute of Structural Materials (SMaRT)	237	£ 165,000	✓	✓	✓			✓		✓	✓	✓		
Engineering East (Manufacturing)	219	£ 335,000	✓	✓	✓			✓		✓	✓	✓		
ESRI	159	£ 150,000	✓	✓	✓			✓		✓	✓	✓		
Great Hall	145	£ 250,000	✓	✓	✓			✓		✓	✓	✓		
School of Management (CBE)	134	£ 360,000	✓	✓	✓			✓		✓	✓	✓		
Library (LRC)	116	£ 155,000	✓	✓	✓			✓		✓	✓	✓		
Engineering North (IMPACT)	89	£ 135,000	✓	✓	✓			✓				✓		
Computational Foundry	60	£ 140,000		✓	✓			✓				✓		
The College (Academic L5)	43	£ 125,000	✓	✓	✓			✓			✓	✓		✓
Y Twyni	-	£ 15,000		✓	✓			✓						

Energy Controls Measures:

1. BMS
2. Continuous Commissioning
3. Voltage Trim

Energy Efficiency Measures:

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

Low Carbon Energy:

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

Phase Breakdown: Energy Centre Phase

The Energy centre phase has been modelled to occur between AY 2029/30 and AY 2030/2031, the phase is intended to include pipework upgrades to the network wherever necessary, and the installation of a heat pump to generate heat for the network in place of gas boilers or CHP. The Energy centre phase has been initially estimated to cost £10.18M.

Cost estimates and energy savings is based on the *Swansea University Heat Strategy March 2022* produced by the Welsh Government Energy Service (further details on the rationale have been included in on page 53).

Significant capital investment will be required to decarbonise the network, however, it will be essential to meet the universities Net Zero targets.

Phase Breakdown: Sport Phase

Programme of decarbonisation measures to run AY 2022/23 – AY 2026/27. Capital costs have been estimated based on the recommended energy control, energy efficiency and heat decarbonisation measures listed.

The table below shows the breakdown of the 2 buildings included in the Sport phase. Buildings have been ordered by energy performance within each phase.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
				BMS	Continuous Commissioning	Voltage Trim	Ventilation System Improvements	Cooling efficiency improvements	Air leakage improvements	Fabric and Insulation	LED lighting throughout building	EC Drives and/or IE5 motors	Electrified heat	Electrified heat: Heat Network	Rooftop Solar PV
Wales National Pool		788	£ 1,775,000			✓					✓	✓	✓		✓
Indoor Training Centre		53	£ 225,000										✓		

1. BMS
2. Continuous Commissioning
3. Voltage Trim

1. Ventilation System Improvements
2. Cooling efficiency improvements
3. Air leakage improvements
4. Fabric and Insulation
5. LED lighting throughout building
6. EC Drives and/or IE5 motors

7. Electrified heat
8. Electrified heat: Heat Network
9. Rooftop Solar PV

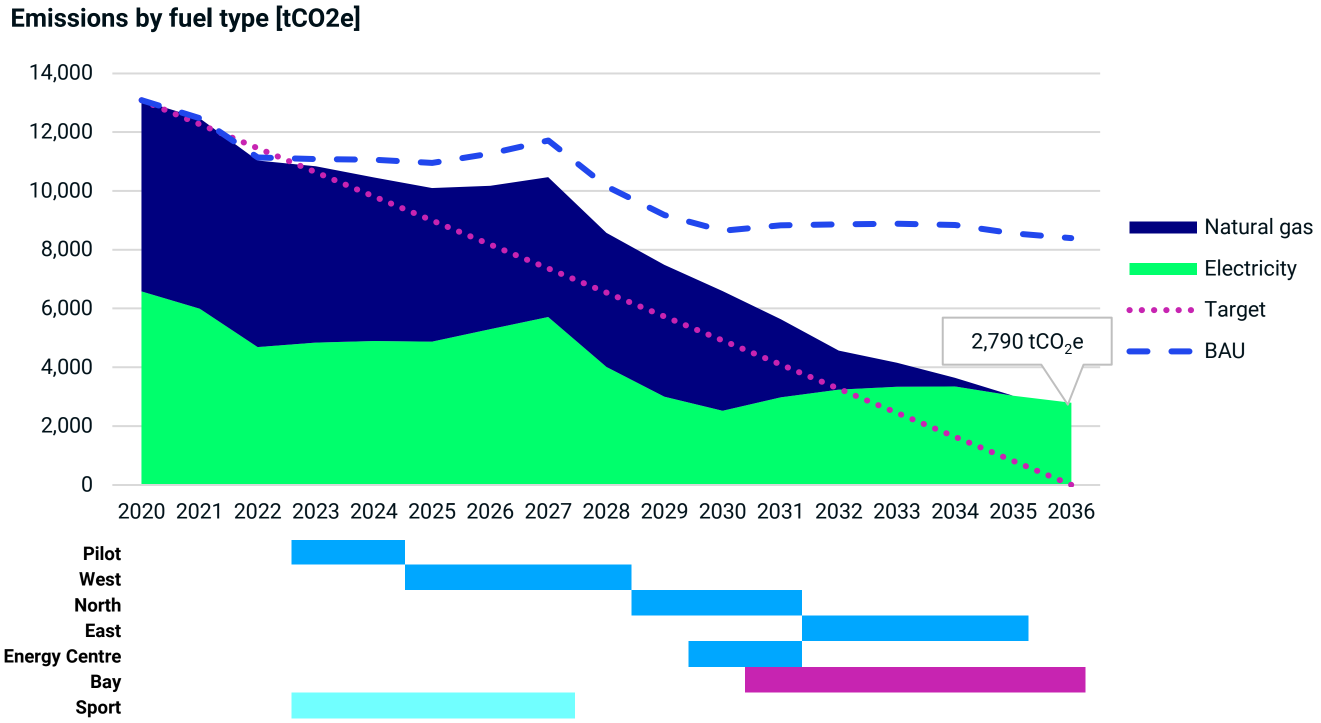
Emissions projection

Combining the decarbonisation measures recommended for each of the measures, SU's scope 1 and 2 emissions projected out to AY 2035/36 are categorised as follows. Both the target reduction and business as usual scenario (BAU) have been plotted as a comparison.

For each of the phases, emissions as a result of gas consumption (blue area on the graph) will decrease.

During the East and West phases, emissions resulting from electricity consumption are shown to increase, despite energy efficiency measures and Solar PV being installed. This is a consequence of heating being electrified as natural gas boilers are decommissioned. The increase in electricity consumption is counteracted by the falling carbon intensity of the national grid and the improved efficiency of heat pumps compared to gas boilers, subsequently decreasing emissions overall.

The graph demonstrates a significant improvement on the BAU scenario, but also highlights **a gap to target of 2,790 tCO_2e.**



Cost projection

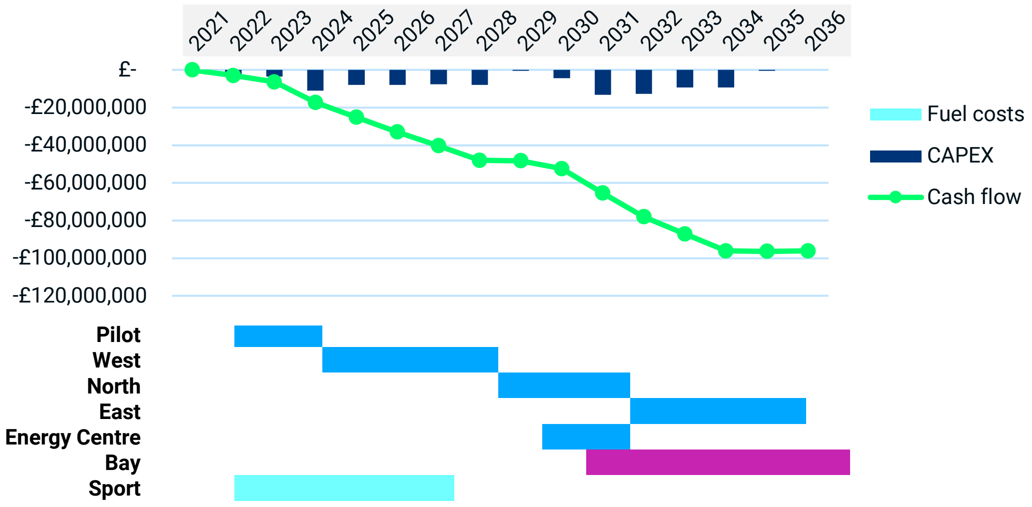
The total estimation capital cost to implement all measures included in each of the phases was calculated to be approximately **£99 million**. The capital costs associated with each phase have been modelled apportioned equally across the phasing timeframe to spread costs. The most significant investments will be required during the West and East phases on Singleton campus, which represent approximately £38m and £35m respectively of required capital funding over the years in which they run (4 years each, 8 in total).

The total cash flow has been plotted to show the cumulative costs over time below. Additionally, fuel costs have been included within this cash flow chart, however, they represent a small proportion of overall costs. Operation and maintenance costs (and savings) have not been considered, along with any potential export revenue from onsite renewables generation, where not utilised onsite.

SU should be mindful that savings will not compare favourably to the capital investment required over the target period. The £99m in capital investment is estimated to save only ~£2.9m in energy costs over the target period meaning there is no tangible return on investment (ROI). Deep decarbonisation measures often require consideration of emissions reduction potential over and above financial metrics such as return on investment e.g. building fabric upgrades provide additional benefits such as improved asset value, aesthetics and occupier comfort.

It should be noted that future fuel costs, particularly for fossil fuels, are subject to significant fluctuations due to market pressures and future policy changes. Therefore, although cost savings are modest based on conservative fuel price projections used in the scenario model, the reduction in energy consumption (~37% overall by 2035 with 100% reduction in natural gas consumption) will mitigate SU's exposure to these fluctuations, and have the potential to improve the financial case significantly.

Financial impact [GBP]



Emissions reductions by phase

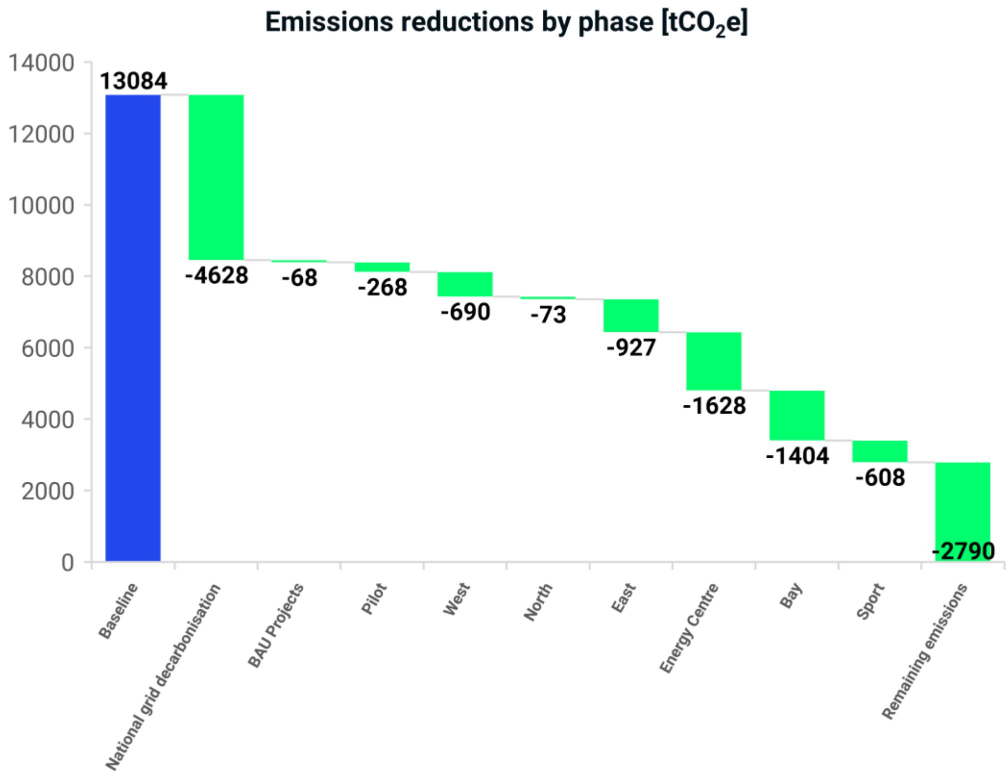
The Waterfall chart shows how the emissions reduce against each phase of works, starting from the baseline and cumulatively decreasing with each phase of works completed.

The most significant reduction in emissions occurs as a direct result of the projected carbon factor of the grid. This emphasises the need to eradicate natural gas and switch to electric heating to take advantage of the falling carbon intensity of the grid.

The Energy Centre phase represents another significant reduction in emissions. The reduction in scope 1 emissions (as a result of natural gas consumption) associated with electrifying all buildings on the network (via the energy centre) are represented within the 1,481 tCO_2e reduction.

The remaining emissions have been calculated as 2,790 tCO_2e per annum in this core scenario.

Remaining emissions are discussed within section 8 of this report.



SECTION 6

Demonstration Pilot

Back to Contents Page

Section Overview

Demonstration Pilot

- In section 6 we provide further detail related to the first phase of the suggested actions; the demonstration pilot phase.
- A pilot phase is suggested ahead of the main phases on Singleton as the immediate next step, suggested for completion between 2022-2025. The main reasons for conducting a pilot phase on a select group of building are to:
  - Deal with the worst performing priority buildings as they provide the greatest opportunity to reduce emissions in the short term and the highest risk to meeting SU's target.
  - Inform latter phases and upskill estates and maintenance staff in low and zero carbon technologies, particularly those related to heat pump technology.
  - Incorporate imminent existing maintenance plans into the estate decarbonisation phases.
  - Improve the business case for implementing decarbonisation measures where essential works are due to be completed in the short term (i.e. replacing aging boiler plant)
- In consultation with SU, the following buildings on Singleton have been put forward for the pilot phase:
  - **Fulton House**
  - **Haldane Building**
- The following pages provide detail on the suggested measures for implementation and key considerations.

DEMONSTRATION PILOT

Fulton House

- Fulton House is a Grade II listed building that is home to many of the University's catering and retail facilities. The building was constructed in 1961 with a floor area of 8,325 m^2. The baseline annual electricity consumption is ~780,000kWh/year with gas consumption of ~1,600,000 kWh/year. The building is one of the larger sites on Singleton campus which provides a useful contrast to the decarbonisation refurbishment at Haldane.
- The building has relatively simple M&E systems (e.g. basic wet radiator heating system) and so representants a good opportunity to "test" the rollout of the core measures needed for decarbonisation requirements on a "standard" building (in M&E and fabric terms). The building is already undergoing refurbishment and is aligned with existing plans and allocated funds e.g. extensive building fabric upgrades required.
- The table below provides the individual measures that are suggested for further feasibility/ implementation as part of the pilot phase for Fulton House, along with the associated costs. Solar PV upgrades for Fulton house have been included under the "BAU" scenario as part of the 2021 Wales Funding Programme application (see section 3). As such the associated savings are captured elsewhere.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
Fulton House		✓	£ 8,955,000				✓			✓	✓	✓		✓	
Haldane			£ 315,000	✓	✓							✓	✓		✓

Haldane Building

CARBON TRUST

- Haldane is home to the main information office for Human and Health Sciences, as well as Health and Social Care, Social Policy and Social Sciences. The building was constructed in 1991 with a floor area of 2,497m^2. The baseline annual electricity consumption is ~230,000kWh/year with gas consumption of ~280,000kWh/year. Whilst the total carbon emissions associated with Haldane are relatively small compared to larger consumers on Singleton, the building has a number more “complex” HVAC systems compared to others on Singleton. As such it representants a good opportunity to “test” the rollout of the core measures needed for decarbonisation requirements on a more “complex” building. Being a smaller building however, less risk is associated with carrying-out the disruptive measures needed to bring the building up to standards. Again, the building is already undergoing refurbishment and so is aligned with existing plans and allocated funds e.g. the current boiler is earmarked for renewal, which provides an opportunity to install a heat pump solution.
- The table below shows the individual measures that have been assessed for further feasibility/implementation as part of the pilot phase for Haldane, along with the associated cost breakdown. LED lighting upgrades have been included under the “BAU” scenario as part of the 2021 Wales Funding Programme application.

Building	On network	Building Performance (kWh/m2)	Total CAPEX (£)	Energy Controls Measures			Energy Efficiency Measures						Low Carbon Energy		
Fulton House		✓	£ 8,955,000				✓			✓	✓	✓		✓	
Haldane			£ 315,000	✓	✓							✓	✓		✓

Key Considerations

The University's estates staff, maintenance and contractors are vastly experienced in the installation, running and upkeep of a variety of building and M&E systems. This experience should be used to support the implementation of measures during the pilot phase. However, there is exists a range of energy efficiency standards for the variety of technologies to be procured to decarbonise SU buildings portfolio. As such, the total amount of carbon saved will be affected by the standards set and quality of products procured, alongside their proper installation, operation and maintenance. SU should look to best practice guides and standards to support the selection of optimal solutions (e.g. energy technology list). It will also be important to remain up-to-date on the emergence of new technologies, systems and protocols to facilitate effective and safe design and operation of buildings. Alongside low carbon operation, designs must always factor in the comfort, well-being and cognitive performance of the occupants.

In terms of heat decarbonisation, all-electric buildings do not need to compromise design needs, but there are important new factors that must be accounted for. As network power flows move away from a "unidirectional" model, system dynamics differ from the gas grid, and infrastructure costs need to be contained, the following headline principles apply:

- Harness passive design, enhanced building fabric and adaptive comfort to reduce demands and peaks.
- Reduce peak electricity demands.
- Size plant appropriately to meet the operational needs of the building and the grid.
- Align energy demand with supply of affordable and low carbon electricity (primarily through time shifting of loads).

Achieving consistency in the delivery of electrified heat requires a shift from more traditional system design practices in some important ways:

- *System operating temperatures will be different.*
- *Heating and cooling may be more closely coupled.*
- *Waste heat sources (coupled with heat pumps) will become more significant.*
- *Buildings may well have two-way transactions (physical and financial) with the energy network.*
- *In the past three decades design practices have shifted from ensuring peak capacities (with much over-design), to reducing annual energy consumption. This will now need to evolve further to designing for annual energy consumption AND the timing and peak of energy demand.*

Capturing Lessons

A key element of the demonstration pilot phase will be to capture lessons to inform later phases of work. This will be particularly useful to appraise any procurement, installation and operation issues faced, but should also be used as an assessment for overall performance of the buildings post-installation.

SU should allocate time and resource to properly capture and record lessons learnt. This may take the form of a case study at a high level, but it is envisaged that a high degree of detail should be documented given the complexity involved and the unfamiliar nature of certain technologies (e.g. heat pumps).

As detailed in section 9, a strategic review of the action plan as a whole is recommended following the completion of the pilot phase. A core part of the review should focus on the success and performance of the pilot buildings and include:

- An appraisal of the actual capital costs required, including development costs.
- A review of operational energy consumption and carbon emissions post installation (12 months data) in comparison to the designed energy performance versus actual operational performance.
- Consideration of thermal energy surveys pre-post installation to confirm adequacy of insulation retrofit measures.
- A view on any training required to progress further phases of work e.g. handover, operation etc.

Consideration could also be given to the development of a standard specification for the refurbishment of buildings. This would not necessarily need to be a complex document but could include minimum energy efficiency standards required such as seasonal co-efficient performance of heat pumps, and u-values of fabric insulation. Learnings from the pilot phase could be used to enhance the practical contents of the specification taking a balanced view on optimum standards versus cost.

SECTION 7

Implementation & Funding

Back to Contents Page

Section Overview

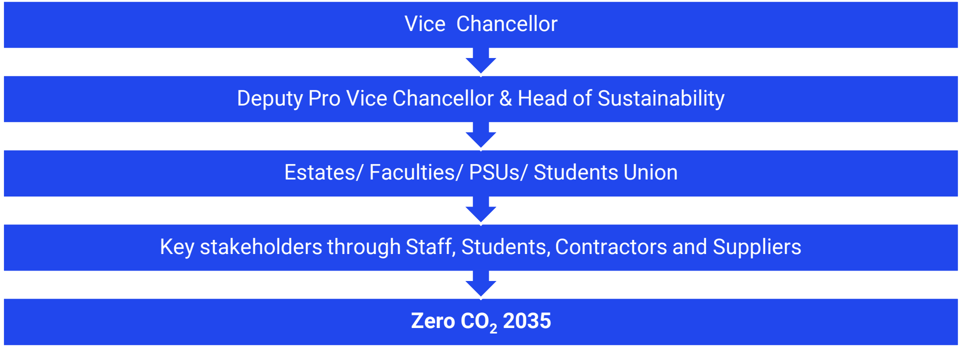
Implementation & Funding

- Section 7 outlines some key considerations for the implementation and funding of the action plan. Information included here is not intended to comprehensively cover all the considerations, given the scale of the task involved, but to indicate important factors to take on board at this juncture.
- Information provided here pertains to management structures, routes to market, examples of work elsewhere in the HE sector and considerations for the installation of heat pumps.
- It is recommended that senior board members and stakeholders are continuously engaged to keep momentum and elicit an ongoing adequate response and support to the decarbonisation plan.
- It is recognised that access to finance is critical to ensure the success of this action plan. Key sources of funding available to the University are outlined. Information on Re:fit Cymru is provided as a potential framework for implementation through an Energy Performance Contract model.
- Additional information is also provided on some of the key practical considerations of heat pump installations. This is not intended to be exhaustive given the complexity of the subject, but merely to highlight that electrification of heat requires a step change in heating system management with many new factors to consider in the transition.

Governance

To manage the implementation of this Plan it is important that organisational procedures and resources are put in place to maintain a focus on carbon reduction over time. To achieve carbon reductions that will support the ambition, SU will have to consider robust yet dynamic organisational structures to ensure that they remain flexible in the approaches being taken to reduce emissions. A successful governance structure has support and regular input from senior stakeholders (e.g., Principal-level, Governors) and buy-in from the stakeholders who influence the sustainable performance of the University (e.g., staff, students, suppliers). Ultimately, institution-wide sustainability is required to ensure successful implementation of the decarbonisation action plan.

Swansea recognises the need for strong governance and therefore has an existing governance structure in place, as summarised to the right.



Recommended key functions to focus on specifically related to carbon reduction are:

- Gaining senior endorsement of the Action Plan;
- Providing regular and ongoing oversight and monitoring of progress towards achieving the target;
- Consideration of “task and finish” groups for discrete phases of the action plan that have clear KPI’s and the remit to focus on specific tasks / projects;
- Assigning action plan leads where useful (procurement, estates, transport, student engagement);
- Managing the expectations of key stakeholders and recognising achievements on carbon reduction across the organisation.

Re:fit Cymru

Re:fit Cymru is a funding and support scheme implemented by the Welsh Government. The scheme assists public bodies and Higher Education Institutions in improving the energy efficiency of their buildings and estates, reducing overall energy use and delivering reductions in both carbon emissions and energy expenditure.

Funding from Re:fit Cymru is via an interest-free loan to be repaid through the financial savings delivered by improved energy efficiency. Savings are guaranteed through an Energy Performance Contract.

The Re:fit framework is proven and well developed, with over 250 organisations having already engaged in Re:fit. A range of energy reduction projects are supported by the scheme, with examples of supported measures shown below.

- Lighting and controls
- Heat recovery
- Variable speed drives on pumps/ fans
- PC control
- Voltage optimisation
- Building management system
- Energy management software
- Automated meter reading
- Automatic monitoring and targeting

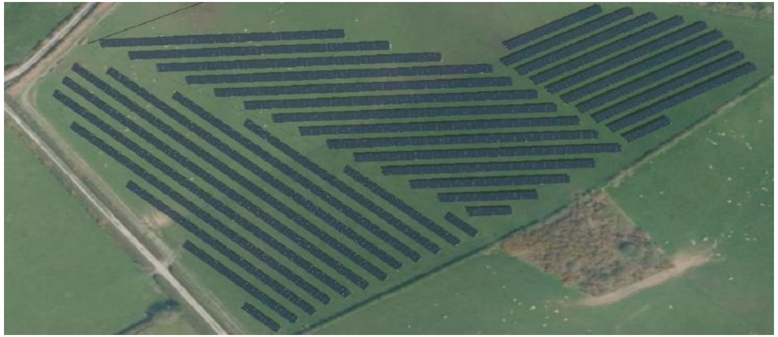
- Photovoltaic panels
- Solar thermal
- Cavity wall and loft insulation
- Insulation to pipework
- Draught proofing
- Secondary glazing
- Radiator reflector panels
- District heating
- Combined heat and power

Re:fit Cymru in practice

Generating green electricity for Aberystwyth University[1]

£2.9 million investment has been issued to Aberystwyth University, £2.6 million of which has come from Re:fit, to build a solar farm at the campus. Covering an area of 3.8 hectares, the new array will feature more than 4500 individual solar panels and is projected to reduce annual energy-related emissions by 8% across the University's entire energy portfolio. This equates to 500 tCO_2e annually, and up to 12,000 tCO_2e over its anticipated 25 year working life.

The project is expected to deliver financial savings of over £325,000 per annum and over £13m over the lifetime of the project.



[1] https://www.aber.ac.uk/en/news/archive/2022/03/title-251693-en.html

Investing in energy efficiency at Bangor University[2]

In 2018, Bangor University was awarded £2.5 million pounds from Re:fit to invest in energy efficiency. The University is expected to reduce its annual electricity and gas bill by more than £400,000, by implementing the following measures:

- LED lighting to replace fluorescent bulbs, preventing 370 tCO_2e.
- Upgrading heating and cooling systems by installing new insulated pipes and valves, cutting emissions by 730 tCO_2e per year.
- Solar PV panels on 5 buildings, generating 140,000 kWh reducing emissions by 56 tCO_2e.

[2] https://www.bangor.ac.uk/environment/refit.php.en

Additional Funding Sources

CARBON TRUST

It is recognised that access to additional resource and finance is critical to ensure the success of this Decarbonisation Action Plan.

Potential Funding	Notes
Higher Education Funding Council for Wales (HEFCW)	Capital funding is made available through HEFCW.[1] Additional funding ringfenced to support the transition to net zero has previously been made available, with £40m for the 2021/22 academic year.
Wales Funding Programme – Invest to Save	The Wales Funding Programme is supported by the Welsh Government Energy Service, with funding applications administered by Salix Finance.[2] Funding is then provided from Welsh Government on a repayable basis, with criteria limits on payback and carbon cost effectiveness.
Welsh Government – Public Sector Low Carbon Heat Grant	The Welsh Government Energy Service and Salix Finance has overseen a pilot 'Public Sector Low Carbon Heat Grant' in 2021/21, this totalled £2.4m in value. No capital grant funding is available for 2022/23, however it is planned that a funding scheme will follow in 2023/24. Development grant funding is available now (2022/23) to support projects to an investment ready position.

[1] https://www.hefcw.ac.uk/en/publications/circulars/w22-07he-additional-funding-for-academic-year-2021-22/
[2] https://www.salixfinance.co.uk/loans/welsh-loans

Case studies

Several other higher and further education providers in the UK have declared ambitious decarbonisation targets. These declarations span a range of target dates (2025–2050), terminology (carbon neutrality, net-zero, zero carbon), and scopes (scopes 1 and 2 only, inclusive of selected scope 3, full value chain, etc.); this makes comparison between targets and institutions challenging. Nonetheless, similarities exist in many of the decarbonisation challenges faced across the sector and also the initiatives required to overcome them. Some brief examples from elsewhere in the sector that are applicable to SU's main challenges are presented below:

	Organisation	Project type	Description	Approximate cost
1	**Goldsmiths, University of London**	Low-carbon heat network	The project will install a new network of insulated underground pipes around the campus and replace ageing gas boilers with an electrically powered heat pump. The scheme is also being designed so that it can be connected to a district heating scheme in Lewisham as and when this becomes available.	£5,700,000
2	**Oxford Brookes University**	Low-carbon heat network, renewable generation	A ground source heat pump to be installed to provide low carbon heating to the campus energy centre. Solar panels and complementary battery storage will also be installed to maximise the use of on-site renewable generation.	£2,350,000
3	**Cranfield University**	Low-carbon heat network, energy efficiency, renewable generation	Delivering a wide range of improvements centred on the district heating system on the university's campus. Measures include upgrades to the building management system and the installation of an air source heat pump. LED lighting upgrades will also be installed, and the solar farm will be extended to help balance the electrical system as reliance on the existing gas fired combined heat and power is reduced.	£5,000,000
4	**Sheffield University**	Advanced metering	Upgrading of heat and electricity metering across 17 University buildings.	£94,000

Heat Pumps

- To achieve the University's target, the current heat sources across the estate, including the network must be converted from gas-fired boilers and CHP, to low-carbon alternatives. Heat pumps are put forward as the main solution for SU's need (see Appendix 12/13 for further rationale).
- Based on current market costs and supply chains, a heat pump solution is likely to require significant investment. It is therefore imperative that any new low-carbon heating system runs as efficiently as possible to recoup the initial outlay through reduced running costs.
- Converting the current gas fired plant to heat pump technology will represent a step change in the way the systems are installed, run and maintained. Whilst the upgrades and installation of most technologies put forward in this plan will be familiar, a transition to heat pump solutions represents a new challenge to estates and maintenance teams.
- The pilot demonstration phase represents a starting point in which to familiarise internal teams with the set-up and running of equipment but further work will be required to fully "onboard" the technology.
- This action plan is not intended to be a manual or set of instructions on best practice design, installation and running of heat pumps. This should be sought through detailed feasibility, advised by suitably qualified engineers and informed by growing body of literature available. This includes the applications manual *AM17: Heat pumps for large non-domestic buildings* from CIBSE.
- Appendix 17 does provide some practical considerations to be aware of however in relation to sizing and operating temperatures, planning considerations, installation & commissioning and maintenance.

SECTION 8

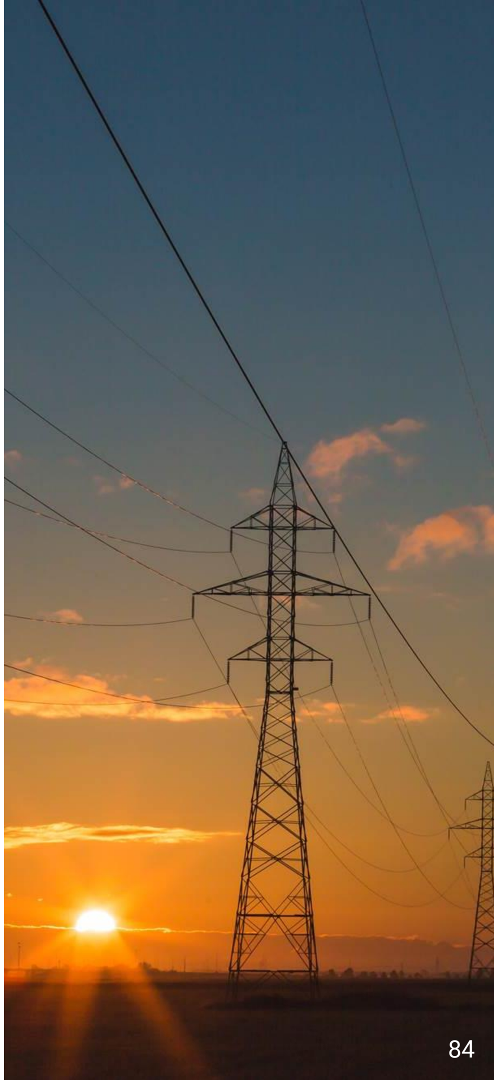
Remaining Emissions

Back to Contents Page

Section Overview

Remaining Emissions

- In section 8 we discuss the remaining emissions that are currently forecast to exist after the projects detailed in this report have been implemented.
- There always exists a degree of uncertainty when attempting to plan out carbon reduction action over long timeframes such as those assessed here. This is due to a number of variables including a reliance on “external” factors as well as those that are controlled from an “internal” perspective.
- The carbon intensity of the electricity grid and assumptions used in the calculations are key variables that are expanded on below. Regardless of the uncertainty, SU should be confident to take forward the projects presented in this report which should be seen as “no regrets” actions that will form basis of robust decarbonisation action.
- Information on carbon offsetting is also presented in this section. Whilst it is crucial that offsetting should always be secondary to all efforts for reducing emissions, there may be a future requirement for SU to consider offsets within their broader strategy. Given the uncertainty on the actual amount of emissions that will remain at the end of the target period, information provided here is generic (pertaining to current best practice) and a review of potential offsetting costs specific to SU is not included.



Gap to Target

CARBON TRUST

- The action plan focuses on known solutions that can be implemented between the present-day and 2035. However, this does not seek to imply that additional carbon reductions could not be achieved through further mitigation actions via “known” projects, or through emerging technologies.
- There exists a number of evolving technologies have not been assessed in this report e.g. below. Alongside the implementation of the core pathway projects (sections 5&6), further interventions should be investigated over the coming years to understand feasibility to help close the gap to target. In addition to the below, there may be further technologies at early stage-development, that may be viable during the latter stages of SU’s target period, which could also support further reductions towards zero.

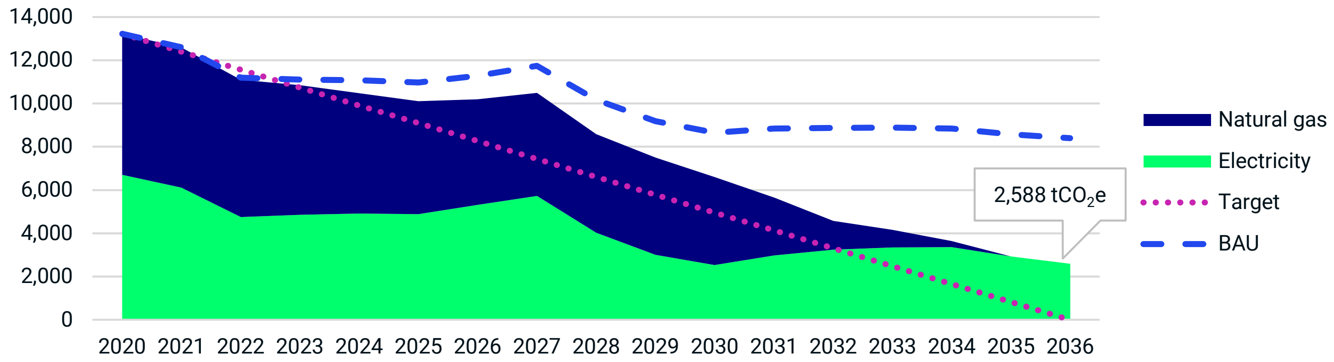
Wind Energy	Heat network options	Demand side smart energy management	Battery storage	Car park or ground mounted solar PV	Marine/Tidal Energy

- **Wind Energy:** In preparation of this report Carbon Trust were provided with an initial feasibility study for a wind turbine at Bay campus. It is understood that there is a high level of uncertainty related to the practicality of installing a turbine due to land ownership issues. However, the following page provides detail on the carbon reduction potential of the turbine in relation to the core reduction pathway.
- **Heat Network Options:** There also exists a variety of options for deeper heat decarbonisation of Singleton's heat network. Further detail on these are provided in *Swansea University Heat Strategy March 2022* produced by the Welsh Government Energy Service.
- **Other Options:** Carbon Trust are also anecdotally aware of other potential options such as work being carried out by *Carbon Track* on microgrids and battery storage options for SU. Additionally, any further sources of renewable energy systems that could provide zero carbon electricity directly to Singleton or Bay campus should be pursued. Car park/ground mounted solar PV or marine/tidal options have been suggested, for example.

Gap to Target: Bay Campus Wind Turbine and Car Park Solar PV

- In 2020, *Galatech Energy Services* provided SU with a feasibility report for a onsite wind turbine at Bay Campus. A turbine with a direct wire would offer a substantial contribution to SU's overall target. The analysis assessed the feasibility of a 1MW system with an estimated cost of ~£2.7m, simple payback of 13.8 years and an IRR of 3.67%. However, due to land ownership issues there is exists significant uncertainty as to whether the turbine could form part of SU's renewable energy portfolio. As such, it has not been included within this report a "core" reduction project (section 5&6).
- A further opportunity to install a £365k solar PV array on Margam square car park was also identified as a potential means to further mitigate the remaining emissions which could generate 476 MWh of electricity per annum.
- Due to the presence of the "remaining" emissions presented, we have included the wind turbine and car park PV array in an alternative carbon reduction pathway (below) alongside the core carbon reduction projects, to illustrate its effect on closing the gap to target. The impact on SU's overall carbon reduction pathway would be an additional 208 tCO_2e reduction (illustratively installed in 2035), **which would reduce the remaining emissions modelled in this report from 2,790 tCO_2e to 2,588 tCO_2e**.

Emissions by fuel type [tCO2e]



Gap to Target: Heat Network Options

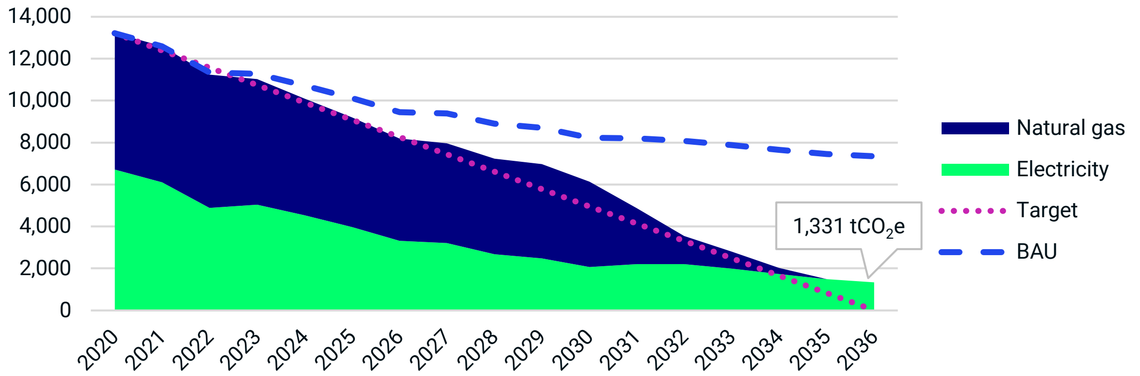
Beyond the “basic” source ground source heat pump solution to upgrade Singleton's existing heat network (as proposed in section 5&6), several “extra” options exist to enhance the low carbon operation of the network. These options should be drawn out in a detailed feasibility study on upgrade options for the network. Such options include:

- Opportunity to connect larger, low-carbon heat sources to the network.
- Potential to connect to other campus buildings and/or the hospital and WNP.
- Reducing network temperatures to increase the performance (efficiency) of a heat pump supplying the network
- Consideration of connecting significant cooling loads e.g., MRI cooling in ILS1, to the heat network.
- Exploration of the potential to extract sewer source heat from the shared sewer with the hospital.

Gap to Target

- In addition to the above, uncertainty exists in relation to the stated carbon reduction figures found in section 5&6. There are a number of variables that affect this. Key factors include uncertainty related to the carbon intensity of the electricity grid in future years, and the assumptions used as the basis of the project calculations.
- Given the proposed situation is that all building energy sources will be electrified in 2035, the carbon intensity of the grid is a crucial factor in meeting the target. As detailed in section 2, National Grid's "Steady Progression" future energy scenario forms the basis of the forecasted grid emission factors**. If the more ambitious "Consumer Transformation" were used in the model**, the remaining carbon emissions in the pathway **would be 1,331 tCO_2e in 2035/36.**
- There is no way of being sure of the grid carbon intensity in 2035/36 at this juncture, but standard procedure dictates that conservative estimates should be used. However, deeper reductions from the core pathway could be possible. The opposite could also be true however. The graph below shows the core carbon reduction project pathway under the "Consumer Transformation" scenario.
- The assumptions used for carbon reduction potential of interventions are also similarly conservative in nature. Again, this is standard practice for any feasibility analysis to avoid overstatement of potential savings. However, SU should be mindful of the fact that the actual carbon reductions could go further than initially estimated, which would close the gap to target further.

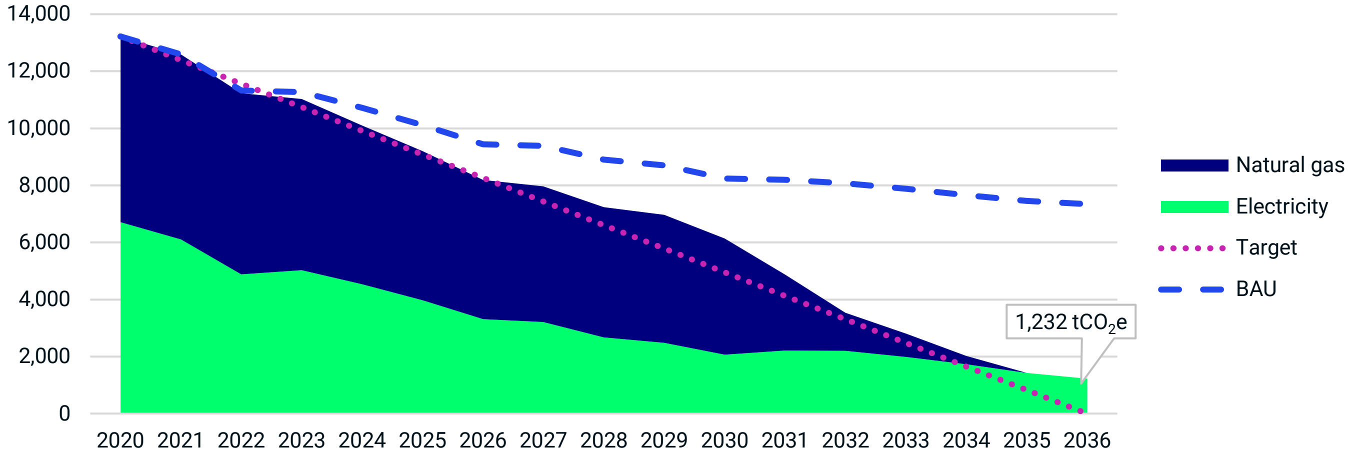
Emissions by fuel type [tCO2e]



Gap to Target

- In addition to the alternative core reduction pathways already mentioned, another alternative scenario exists which would reduce the gap to target even further. Under this additional 'best case' scenario, remaining emissions would be reduced to **1,232 tCO_2e in 2035/36.**
- The graph below shows the core reduction pathway under the "Consumer Transformation" scenario, if SU were to also invest in a 1MW turbine and large car park Solar PV system at the Bay Campus.
- However, due to uncertainties surrounding future grid decarbonisation, this emissions reduction pathway is not promised and reductions could be less, or more, than initially estimated.

Emissions by fuel type [tCO2e]



REMAINING EMISSIONS

Carbon Offsetting

- Best practice would dictate that SU should seek to take action to reduce remaining emissions as close to zero as possible. However, even by successfully following an ambitious decarbonisation pathway to 2035, a portion of emissions may be left over at the target date.
- Whilst the estimated size of these remaining emissions may shrink as SU progresses towards 2035 (impacted by emerging technologies and technology innovation that could help SU to accelerate progress), SU should be mindful that some carbon offsetting may be required to achieve the ultimate goal.
- SU have utilised "carbon zero" as the descriptive language of their target. This language is fairly unequivocal in its relation to offsetting i.e., no allowance for offsetting. However, SU should keep a watching brief on carbon offsetting best practice in relation to emerging best practice on "net zero". Net zero is more commonplace language in relation to carbon reduction targets for many organisations (alongside carbon neutrality), and although definitions are not yet universally agreed, leading actors are aligning to a common set of rules when dealing with offsets alongside any claim of net zero (see SBTi net zero standard[1]).
- The following pages provide information on carbon offsetting and current best practice to support the development of any offsetting strategy SU may consider in the future.

[1] https://sciencebasedtargets.org/net-zero

Carbon Offsetting

Carbon offsetting is a broad term that refers to the action of reducing greenhouse (GHG) emissions, or increasing carbon storage, to compensate for emissions that occur elsewhere. This involves buying/supporting projects for enhancing emissions reduction or removal outside of an organisation's own GHG inventory boundary. Offsetting can be broken down in to the four main categories shown below:

	Avoidance/reduction	Removal/sequestration
Nature-based	**Avoided nature loss** Limits the loss of nature such as forests and peatland, which currently sequester large amounts of carbon.	**Nature-based sequestration** Uses nature to sequester more carbon in the biosphere, including reforestation and restoring soil, mangroves, seagrass and peatlands
Technology-based	**'Additional' emissions avoidance/reduction** Reduces emissions from current sources that don't have the financial capacity, incentive or regulatory requirement to decarbonise (e.g., cookstoves, renewable energy and energy efficiency)	**Technology-based removal:** Removes CO_2 from the atmosphere using technological methods and stores it in the geosphere or through other secure methods such as concrete (e.g., BECCS[1], DACCS[2], construction using renewable timber)

Above: the four categories of carbon offsetting.

[1] BECCS = bioenergy with carbon capture and storage [2] DACCS = direct air carbon capture with storage

The total carbon savings of an offsetting project can be calculated and then traded as credits, each credit representing 1 tCO_2e, known as carbon or offsetting credits. A credit is a transferable instrument that can be retired from the market at any time to claim the underlying carbon reductions.

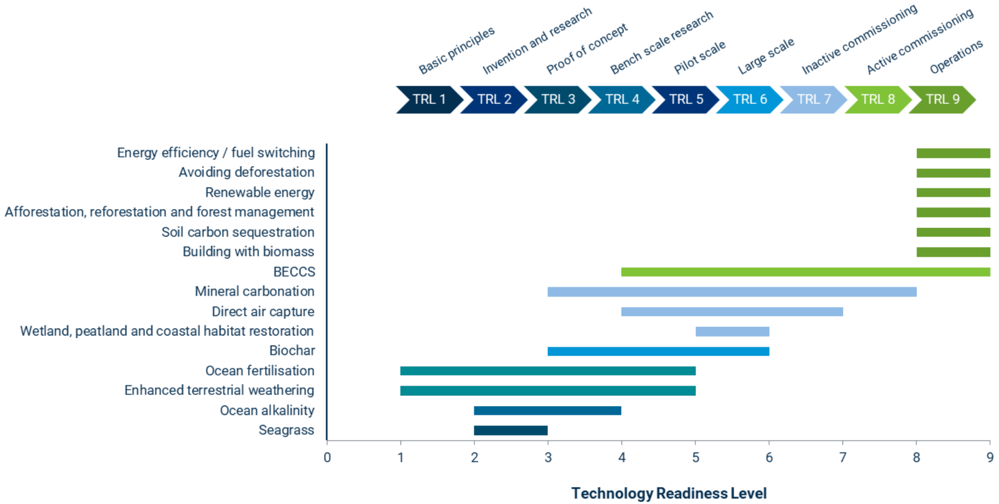
Offsetting has pertinence at a global level and is expected to play a role in curtailing the impacts of climate change globally. This report focuses at a local level and is set in the context of SU's target. The definition of net-zero is important and, although still under consultation, it is broadly accepted by climate change experts that **net-zero status will only allow offsetting of residual emissions through emissions removal/sequestration** and not through emissions avoidance/reduction. Nationally and internationally accepted definitions and standards are still in development and the SU should therefore remain informed of any changes and maintain an agile approach to offsetting.

In any event, **it is crucial that offsetting should always be secondary to all efforts for reducing emissions within the SU's own carbon emissions**.

REMAINING EMISSIONS

Carbon Offsetting

Several technologies can claim offset credits on the voluntary market, though the readiness and costs of the technologies vary substantially. Established technologies such as energy efficiency, renewable energy and nature-based solutions (the latter including reducing emissions from deforestation and forest degradation, afforestation, and soil carbon sequestration) have dominated the voluntary offset market to date, due to their commercial readiness and affordability. Almost three quarters of credits issued in 2020 were either for nature-based solutions or renewable energy. Concerns are often raised over the additionality of credits in renewable energy projects, while competing land uses for nature-based solutions have to be managed carefully, particularly as the voluntary offset market grows globally. Other technologies are emerging with high scale-up and offsetting potential, e.g., bioenergy with carbon capture and storage (BECCS), direct air carbon capture with storage (DACCS). These are currently scarce, expensive and resource intensive, and significant investment will be required to allow them to feature at scale in the future.



Soil carbon sequestration
£-7-£+2/tCO_2

Building with biomass
£0/tCO_2

Renewable energy
£1-£4/tCO_2

Energy efficiency/fuel switching
£2 - £5/tCO_2

Afforestation
£2-£25/tCO_2

Biochar
£0-£150/tCO_2

Wetland/peatland restoration
£7-£75/tCO_2

Enhanced weathering
£35-£400/tCO_2

Bioenergy CCS
£75-£250/tCO_2

Direct air CCS (DACCS)
£150-£450/tCO_2

[1] TRL Source: Adaptation from The Royal Society and Royal Academy of Engineering https://royalsociety.org/~/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf
[2] Costs Source: i) https://netzeroclimate.org/greenhouse-gas-removal/, ii) https://www.ecosystemmarketplace.com/carbon-markets/em-data-dashboard
[3] https://trove-research.com/wp-content/uploads/2021/01/Global-Carbon-Offset-Supply_11-Jan-1.pdf

Carbon Offsetting

CARBON TRUST

Market demand for voluntary offsets is expected to soar as carbon neutral/ net-zero commitments rise and global offsetting schemes (e.g. CORSIA[1]) become effective. The current market is not fit-for-purpose and many of the historic credits that exist on the market draw criticism for not meeting robust standards. There are therefore calls from market participants (e.g. the Taskforce on Scaling Voluntary Carbon Markets) to reform these carbon markets and a substantial amount of guidance is expected between now and 2030 as the sector evolves. SU should remain vigilant to these changes and if pursued create an offset strategy accordingly. In the long term, the principles set out by the University Oxford for net-zero aligned carbon offsetting are recommended as a guide:

1 **Cut emissions, use high quality offsets, and regularly revise offsetting strategy as best practice evolves**

Reductions must be prioritised in the first instance to minimise the need for offsets. Any offsets that are used should be credible and maintain environmental integrity. All reporting should be done transparently and current emissions, accounting methodology, target setting, and offsetting strategy should all be disclosed.

2 **Shift to carbon removal offsetting**

To ensure compatibility with the Paris Agreement, users of offsets should increase the portion of offsets that come from carbon removals. By 2050, 100% of offsets should be sourced from emissions removals.

3 **Shift to long-lived storage**

Transition to methods of carbon removal that have a low risk of reversal, over centuries to millennia, for example storing CO_2 in geological reservoirs or mineralising carbon into stable forms (e.g., timber used in construction).

4 **Support the development of net zero aligned offsetting**

The market for high-quality offsets that currently meet principles 2 and 3 is immature and requires early-adopters to support its evolution. This can be done through setting of long term agreements, forming sector alliances, and adopting and publicising these principles in an approach to offsetting.

[1] CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation
[2] https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf

SECTION 9

Going Forward

Back to Contents Page

Section Overview

Going Forward

- In section 9 we present next steps for SU and key considerations for the University following the development of this action plan.
- The implementation of decarbonisation action over the time scales set out in this report requires an extensive amount of planning, resource allocation and funding. This action plan can be used as basis for moving forward, but the nature of the work required is far ranging and significant.
- The University's governance approach will be critical to the successful implementation of the plan. SU should review and ensure adequate management resources are in place to progress the plan. This review should include appropriate resource to manage the ongoing need for detailed design and procurement of the projects suggested in this report.
- It is recommended that regular strategic reviews and iterations of the information contained within this plan are also conducted. This will allow SU to assess progress, review the relevance of recommendations and adjust the plan according to the latest information.

Next Steps

CARBON TRUST

- A key factor linking the action plan to on the ground implementation is a clear structure for how projects will be assessed, designed and implemented including an established “sign-off” mechanism. Carbon Trust have not investigated SU’s internal implementation mechanisms as part of this study, but it should be recognised that in order to achieve its ambitious 2035 target, SU may require additional support for the estates and sustainability teams. As such, it may be prudent to review internal processes needed to support the implementation of this plan as an immediate first step. This should include the integration of decarbonisation action within existing structures. As indicated in section 7, consideration should be given to “task and finish” groups that can support discrete projects or phases of work such as the pilot phase.
- Consideration should also be given to the development of a suite of action plan working documents. Such documents could be set up as “live” trackers and management documents that contain real time information on the development of the plan. Such documents could be created for each phase/ building and contain key info such as projects status, roles/ responsibilities, live costs, carbon reduction estimates etc. Without a well defined document management system, the detailed and complex information involved could easily become “lost” and difficult to track.
- It is anticipated that through the “pilot demonstration” phase, significant learnings can be gained regarding any unfamiliar areas of feasibility, design and implementation of projects/ technologies. These should be captured as laid out in section 6 in order to document any barriers and issues to inform future implementation of projects across SU’s building stock. SU should also assess and capture pre and post installation energy consumption/ carbon emission information as accurately as possible in order to communicate success and build the business case and gain momentum for SU’s decarbonisation action.
- As indicated on the next page, it is envisaged that SU conduct an ongoing programme of detailed design and procurement of decarbonisation technologies alongside implementation, in order to successfully implement optimal solutions for the University’s decarbonisation needs.

GOING FORWARD

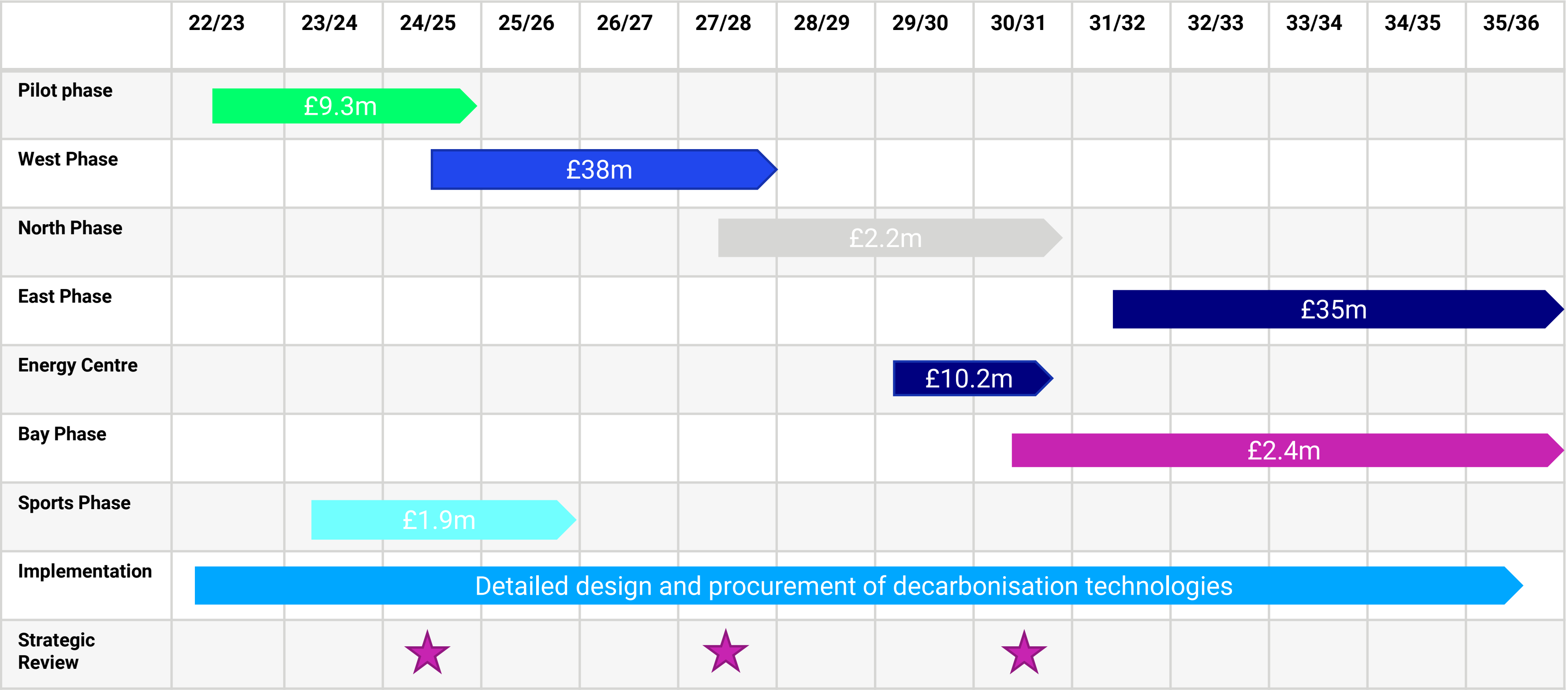
Strategic Progress Review

- In reality, there will be variations on the pathway to achieving the target in contrast to what has been surmised in this report. This includes integration of new opportunities from technology innovations that arise as the transition takes place over the coming years. The evolution of technologies and other uncertainties may lead to alternative decarbonisation pathways and therefore there are natural uncertainties in the core scenario suggested.
- It is recommended that SU plan to undertake a strategic review of this action plan at key milestones throughout the target period. In practical terms this is likely to represent an update/iteration of this plan that takes into account:
  - Progress to date from the baseline year
  - Updated future emission scenarios (if available)
  - Updated capital costs on reflection of projects implemented and up-to-date technology price estimates
  - Integration of projects not currently included in the plan (e.g. section 8)
  - Revision of the carbon reduction pathway to assess a revised gap to target
  - Review of potential offsetting requirements
- The next page provides a summary of the project phasing and budgets, which includes suggested timeframes for regular strategic reviews. These are initially suggested to take place following the *Pilot* phase, *West* phase and *North* phase.

GOING FORWARD

Estimated Budget Requirements

The total capital budget requirement for the implementation of the projects in this action plan is estimated at approximately £99m. This is broken down into budgets as illustrated in section 5 and shown below.



SECTION 10

Appendices

Back to Contents Page

Appendix 1

Carbon emissions baseline per building (19/20)

Back to Contents Page

Site Name	Site Type	Natural gas Scope 1
Abbey & Stable Block	Singleton	102.4
Amy Dillwyn	Singleton	18.4
Caswell	Singleton	47.2
Cefn Bryn	Singleton	155.4
Data Science	Singleton	40.2
Digital Technium	Singleton	64.1
Energy Centre	Singleton	159.6
Faraday Lecture Block	Singleton	123.2
Faraday Tower Block	Singleton	59.0
Finance	Singleton	159.4
Fulton House	Singleton	299.8
Glyndwr	Singleton	99.9
Grove & Grove Extension	Singleton	206.3
Haldane	Singleton	52.1
Horton	Singleton	50.8
Indoor Training Centre	Singleton	21.5
Institute of Life Science 1 (ILS1)	Singleton	64.4
Institute of Life Science 2 (ILS2)	Singleton	214.8
James Callaghan	Singleton	45.1
Keir Hardie	Singleton	44.5
Kilvey	Singleton	101.6
Langland	Singleton	48.8
Law Library (1937)	Singleton	49.6
Library & Information Centre	Singleton	122.0
Llyr Building (AQWA Culture)	Singleton	2.6
Margam	Singleton	58.2
Mosque	Singleton	0.0
Oxwich	Singleton	45.1
Penmaen	Singleton	215.2
Preseli	Singleton	195.9
Rhossili North	Singleton	10.7
Rhossili South	Singleton	8.9
Richard Price	Singleton	64.4
Talbot	Singleton	308.5
Taliesin Arts Centre	Singleton	101.1
Union House	Singleton	82.7
Vivian Tower	Singleton	186.8
Wales National Pool	Singleton	850.3
Wallace	Singleton	298.7
Centre for Integrative Semiconductor Materials (CISM)	Bay	0.0
Computational Foundry	Bay	86.2
Engineering Central (Innovation Hub)	Bay	429.4
Engineering East (Manufacturing)	Bay	413.5
Engineering North (IMPACT)	Bay	117.1
ESRI	Bay	107.8
Great Hall	Bay	102.4
Institute of Structural Materials (SMaRT)	Bay	136.3
Library (LRC)	Bay	52.1
School of Management (CBE)	Bay	163.8
Student Union/Sports Centre (Building 15/16)	Bay	31.3
Tafarn Tawe (Coffee Shop)	Bay	0.0
The College (Academic L5)	Bay	30.3
The Core (Dining & Bar)	Bay	57.3
Y Twyni	Bay	0.0

Site Name	Site Type	Uk electricity Scope 2
Abbey & Stable Block	Singleton	70.2
Amy Dillwyn	Singleton	9.2
Caswell	Singleton	18.7
Cefn Bryn	Singleton	104.9
Data Science	Singleton	23.3
Digital Technium	Singleton	32.4
Energy Centre	Singleton	105.6
Faraday Lecture Block	Singleton	70.5
Faraday Tower Block	Singleton	156.4
Finance	Singleton	5.3
Fulton House	Singleton	182.3
Glyndwr	Singleton	78.0
Grove & Grove Extension	Singleton	345.9
Haldane	Singleton	53.7
Horton	Singleton	41.9
Indoor Training Centre	Singleton	55.5
Institute of Life Science 1 (ILS1)	Singleton	343.1
Institute of Life Science 2 (ILS2)	Singleton	490.1
James Callaghan	Singleton	43.1
Keir Hardie	Singleton	55.8
Kilvey	Singleton	84.5
Langland	Singleton	20.2
Law Library (1937)	Singleton	20.3
Library & Information Centre	Singleton	209.8
Llyr Building (AQWA Culture)	Singleton	80.2
Margam	Singleton	70.0
Mosque	Singleton	0.0
Oxwich	Singleton	17.3
Penmaen	Singleton	77.5
Preseli	Singleton	66.4
Rhossili North	Singleton	11.2
Rhossili South	Singleton	10.3
Richard Price	Singleton	49.0
Talbot	Singleton	502.3
Taliesin Arts Centre	Singleton	99.1
Union House	Singleton	63.0
Vivian Tower	Singleton	211.6
Wales National Pool	Singleton	183.8
Wallace	Singleton	206.5
Centre for Integrative Semiconductor Materials (CISM)	Bay	0.0
Computational Foundry	Bay	80.6
Engineering Central (Innovation Hub)	Bay	423.4
Engineering East (Manufacturing)	Bay	446.6
Engineering North (IMPACT)	Bay	122.1
ESRI	Bay	84.1
Great Hall	Bay	153.8
Institute of Structural Materials (SMaRT)	Bay	619.6
Library (LRC)	Bay	71.3
School of Management (CBE)	Bay	170.3
Student Union/Sports Centre (Building 15/16)	Bay	14.6
Tafarn Tawe (Coffee Shop)	Bay	15.0
The College (Academic L5)	Bay	33.7
The Core (Dining & Bar)	Bay	59.4
Y Twyni	Bay	14.7

Appendix 2

BAU Assumptions

Back to Contents Page

CARBON TRUST

- Natural gas emission factors remain constant throughout the target period. Electricity emission factors follow National Grid “Steady Progression” scenario.
- No change in energy consumption as been applied to individual buildings across both campuses unless specified in section 3 i.e. for CISM, Sport Village and WNP
- Energy reductions associated with Salix projects as stated in section 3 have been reduced from the forecasted consumption for individual buildings from 22/23 subsequently. Estimated building by building energy savings applied are shown below.
- Predicted energy consumption for the Sport Village development is shown below. No gas or fossil have been included in the estimated emissions of the sports village development. Floor area data was taken from the PDF *SUSLC-AHR-XX-XX-RP-A-0001* and additional energy consumption for flood lights was factored in using data taken from the PDF *2021.062-E01*.

Boiler controls	kWh/yr
Richard Price	157,500
James Callaghan	36,823
Faraday Lecture	53,584
Glyndwr	54,312
Oxwich	47,164
Langland	56,824
Caswell	93,061

LED Lighting	kWh/yr
James Callaghan	92,804
Law Library (1937)	58,995
Richard Price	55,898
Haldane	41,917
Library & Information Centre	152,162
Grove & Grove Extension	126,116
Talbot	215,612

Solar PV	kWh/yr
Union House	39,237
Library & Information Centre	42,240
Glyndwr	94,660
Fulton House	51,830
Talbot	61,120
Engineering Central	66,434
Bay Library	94,730

SPORTS VILLAGE

	Year	Floor area	kWh/m2/yr	kWh/year	Cumualtive kWh/yr
Phase 1	2024	2,700	110	297,000	297,000
Phase 2	2025	6,000	59	354,000	651,000
Phase 3	2026	1,850	59	135,106	786,106
Phase 4	2027	2,000	64	128,000	914,106
Phase 5	2028	1,650	93	153,450	1,067,556

Appendix 3

Proactive Maintenance

Back to Contents Page

CARBON TRUST

Planned preventative - This approach uses regular, time-based maintenance activities carried out in accordance with a planned maintenance schedule. It's effectiveness relies upon the correct maintenance activities being identified, the correct time interval being chosen and the work being carried out as per schedule. This approach significantly reduces failure rates and keeps machinery in good energy efficient operating conditions.

Condition monitoring (Predictive maintenance): Utilises a number of tools and techniques to monitor the 'health' of plant, machinery, vehicles and building elements. The basic approach is to identify 'normal' operating conditions so that variation can be used to signify abnormal operating conditions. These can then be reported and corrective action taken before breakdown occurs or increased energy use becomes significant.

Total productive maintenance (TPM): Essentially relies on team work bringing together maintenance and other support personnel to develop and operate a structured approach to maintaining and improving machinery, the works place and working methods.

Reliability centred maintenance (RCM): This is a technique that can be used to analyse the machinery and its elements and assess the risk associated with each one. The high risk items can then be highlighted and maintenance effort focused upon them so that the risk of failure is minimised. One or more of the maintenance approaches described can then be applied to the machinery commensurate with the risk highlighted by the RCM analysis.

Appendix 4

BMS Improvements Modelling Assumptions

Back to Contents Page

Building name	Details	% Gas Saving	No Splits	Electricity Saving kWh.pa	£/m2	£ Capex
Finance	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 15,631.55
Abbey & Stable Block	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 57,182.16
James Callaghan	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 46,897.82
Law Library (1937)	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 41,447.15
Mosque	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 4,546.55
Amy Dillwyn	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 8,575.14
Haldane	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 39,506.81
Union House	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 55,546.36
Rhossili North	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 6,494.32
Rhossili South	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 5,821.81
Taliesin Arts Centre	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 65,864.88
Llyr Building (AQWA Culture)	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 11,865.10
Indoor Training Centre	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 34,582.80
Keir Hardie	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 89,281.68
Wallace	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 139,972.05
Margam	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 59,988.97
Glyndwr	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 82,461.30
Vivian Tower	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 156,377.84
Grove & Grove Extension	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 148,728.18
Fulton House	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 131,706.19
Preseli	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 60,888.82
Cefn Bryn	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 59,288.61
Faraday Lecture Block	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 57,087.09
Faraday Tower Block	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 74,779.05
Kilvey	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 61,872.52
Penmaen	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 125,262.50
Horton	New outstation & occupancy detection with set back mode	10			£ 15.82	£ 32,594.84
Wales National Pool	New outstations and control panels	10			£ 15.82	£ 92,800.86
Engineering Central (Innovation Hub)	Integrate DX cooling onto BMS c/w occupancy sensing x 2 splits	0	2	2,080		£ 1,400.00
Institute of Structural Materials (SMaRT)	Integrate DX cooling onto BMS c/w occupancy sensing x 33 splits	0	33	34,320		£ 23,100.00
Engineering East (Manufacturing)	Integrate DX cooling onto BMS c/w occupancy sensing x 30 splits		30	31,200		£ 21,000.00
School of Management (CBE)	Integrate DX cooling onto BMS c/w occupancy sensing x 6 splits	0	6	6,240		£ 4,200.00
				73840		£ 1,816,752.95

Appendix 4

BMS Improvements Modelling Assumptions

Back to Contents Page

Building name	Details	% Gas Saving	% Electricity Saving	£/m2	£ Capex
Haldane	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 12,486.25
Digital Technium	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 16,749.85
Llyr Building (AQWA Culture)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 3,750.00
Data Science	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 14,983.50
Institute of Life Science 2 (ILS2)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 40,380.78
Institute of Life Science 1 (ILS1)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 34,157.10
Engineering Central (Innovation Hub)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 53,952.00
Institute of Structural Materials (SMaRT)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 18,756.00
Engineering East (Manufacturing)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 61,704.00
Great Hall	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 19,145.00
School of Management (CBE)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 33,340.00
Library (LRC)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 12,250.00
Engineering North (IMPACT)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 42,756.00
ESRI	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 6.00	£ 22,074.00
The College (Academic L5)	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 19,355.00
Computational Foundry	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 38,850.00
Y Twyni	Continuous commissioning, establish design flow rates, recommission (inc VSD), monitor and target	5%	10%	£ 5.00	£ 13,055.00
Totals					£ 457,744.48

Appendix 5

Voltage Trim Improvements Modelling Assumptions

Back to Contents Page

CARBON TRUST

Building name	Floor area m2	Current Voltage	% Over-voltage (reference to 230V)	Est % Inductive Loads	% Electrical Energy Saving	Capex £
Finance	988	234	1.7%	15%	0.26%	£1,500.00
Abbey & Stable Block	3,615	233	1.3%	15%	0.20%	£1,500.00
James Callaghan	2,964	234	1.7%	15%	0.26%	£1,500.00
Richard Price	2,818	235	2.2%	25%	0.54%	£1,500.00
Haldane	2,497	238	3.5%	35%	1.22%	£1,500.00
Digital Technium	3,350	234	1.7%	25%	0.43%	£1,500.00
Keir Hardie	5,644	234	1.7%	15%	0.26%	£1,500.00
Wallace	8,848	235	2.2%	25%	0.54%	£1,500.00
Margam	3,792	238	3.5%	15%	0.52%	£1,500.00
Glyndwr	5,212	241	4.8%	25%	1.20%	£1,500.00
Vivian Tower	9,885	237	3.0%	25%	0.76%	£1,500.00
Data Science	2,997	242	5.2%	15%	0.78%	£1,500.00
Grove & Grove Extension	9,401	236	2.6%	25%	0.65%	£1,500.00
Institute of Life Science 2 (ILS2)	6,730	238	3.5%	35%	1.22%	£1,500.00
Institute of Life Science 1 (ILS1)	5,693	240	4.3%	35%	1.52%	£1,500.00
Wales National Pool	5,866	240	4.3%	35%	1.52%	£1,500.00
Engineering Central (Innovation Hub)	8,992	239	3.9%	35%	1.37%	£1,500.00
Institute of Structural Materials (SMaRT)	3,126	236	2.6%	35%	0.91%	£1,500.00
Engineering East (Manufacturing)	10,284	240	4.3%	35%	1.52%	£1,500.00
Great Hall	3,829	239	3.9%	35%	1.37%	£1,500.00
School of Management (CBE)	6,668	239	3.9%	35%	1.37%	£1,500.00
Library (LRC)	2,450	239	3.9%	35%	1.37%	£1,500.00
Engineering North (IMPACT)	7,126	238	3.5%	35%	1.22%	£1,500.00
ESRI	3,679	239	3.9%	35%	1.37%	£1,500.00
The College (Academic L5)	3,871	239	3.9%	35%	1.37%	£1,500.00
Computational Foundry	7,770	239	3.9%	35%	1.37%	£1,500.00
Y Twyni	2,611	242	5.2%	35%	1.83%	£1,500.00
Totals						£40,500.00

Appendix 6

Back to Contents Page

Ventilation System Improvements Modelling Assumptions

Building name	Approx Number of Air Handling Units	Description	Approx Duct Size	Est Total kWe	Run Hours	Estimated Annual Energy Consumption kWh.pa (Elec)	% Saving (Elec) via modern EC Drives etc	Electrical Saving kWh.pa	Typical air changes per hour	Est Air change volume	Est M3/S	Peak Heat Rejected kW	Heating Diversity	Heating Hours	Estimated Annual Energy Consumption kWh.pa (Gas)	% Saving	Estimated Annual Savings kWh.pa (Gas)	Capex £ AHU, VHR Duct and terminals
Law Library (1937)	1	1960's belt driven AHU 1 kW no VHR	700*700mm Duct	2	8736	17,472	40%	6,989	6	873	1.46	35	0.35	5,040	61,622	80%	49,298	73,357
Union House	2	1960's belt driven AHU each with 1 kW motor - no VHR	400*400mm Duct	4	4368	17,472	40%	6,989	6	702	1.17	28	0.35	5,040	49,549	80%	39,639	98,311
Taliesin Arts Centre	2	Old belt driven AHU's no VHR say 3kW motors	900*900mm duct (guess)	12	6552	78,624	40%	31,450	10	2,082	5.78	139	0.35	5,040	244,806	80%	195,844	116,574
Library & Information Centre	2	1958 Library AHU no extract & reading room. Say 4.5kW motors	5600 CFM (Library)	18	8736	157,248	40%	62,899	8	3,328	7.40	178	0.35	5,040	313,111	80%	250,489	232,970
Vivian Tower	2	Large 1960's belt drive fans without heat recovery	3kW drives?	12	8736	104,832	40%	41,933	6	3,954	6.59	158	0.35	5,040	278,987	80%	223,190	276,773
Grove & Grove Extension	1	Large lecture hall - old AHU - not surveyed - suspect no heat recovery	7.5kW drives?	15	8736	131,040	40%	52,416	10	1,880	5.22	125	0.35	5,040	221,116	80%	176,893	263,234
Fulton House	6	1960's supply and extract fans - no heat recovery - large drives	3kw drives?	36	6552	235,872	40%	94,349	10	3,330	9.25	222	0.35	5,040	391,619	80%	313,295	233,106
Faraday Lecture Block	9	Life expired Trane air handling units	Belt driven 1kW each?	18	4368	78,624	40%	31,450	10	2,706	7.52	180	0.35	5,040	318,271	80%	254,616	101,038
Totals								328,474									1,503,264	1,395,363

Appendix 7

Cooling Efficiency Modelling Assumptions

Back to Contents Page

Building name	Existing cooling load kW	Existing CoP	Run Hours (est) pa.	Diversity	Annual Cooling kwh.pa	Potential CoP	Annual cooling energy kwh.pa (improved)	Annual electricity saving kWh.pa	Cap EX £
Llyr Building (AQWA Culture)	340	2.5	5040	20%	137,088	3.5	97,920	39,168	£ 122,981
Institute of Life Science 2 (ILS2)	480	2.5	5040	20%	193,536	3.5	138,240	55,296	£ 173,621
Faraday Lecture Block	300	2.5	2520	20%	60,480	3.5	43,200	17,280	£ 108,513
Institute of Life Science 1 (ILS1)	263	2.5	5040	20%	106,042	3.5	75,744	30,298	£ 95,130
total	1383							142,042	£ 500,245

Appendix 8

Air Leakage Modelling Assumptions

Back to Contents Page

Building name	Number of doors (approximate)	Gas Energy Saving Per door kWh.pa	Gas Energy Savings kWh.pa	£ Cost per door	£ Capex
Engineering Central (Innovation Hub)	8	660	5,280	£ 500	£ 4,000
Institute of Structural Materials (SMaRT)	4	660	2,640	£ 500	£ 2,000
Engineering East (Manufacturing)	8	660	5,280	£ 500	£ 4,000
Great Hall	8	660	5,280	£ 500	£ 4,000
School of Management (CBE)	8	660	5,280	£ 500	£ 4,000
Library (LRC)	8	660	5,280	£ 500	£ 4,000
Engineering North (IMPACT)	6	660	3,960	£ 500	£ 3,000
ESRI	4	660	2,640	£ 500	£ 2,000
The College (Academic L5)	6	660	3,960	£ 500	£ 3,000
Computational Foundry	8	660	5,280	£ 500	£ 4,000
Y Twyni	4	660	2,640	£ 500	£ 2,000
Total			47,520		£ 36,000.00

Appendix 9

Fabric & Insulation Improvements Modelling Assumptions

Back to Contents Page

Building name	Glazing only	Roof Insulation only	New cladding/glazing & roof insulation	Energy Saving % (Gas)	CAPEX Rate £/m2	CAPEX £
Abbey & Stable Block	Y	Y		20%	£ 371.41	£ 1,342,465
Law Library (1937)			Y	60%	£ 990.71	£ 2,595,571
Mosque			Y	60%	£ 990.71	£ 284,721
Richard Price		Y		10%	£ 62.91	£ 177,262
Amy Dillwyn			Y	60%	£ 990.71	£ 537,006
Union House			Y	60%	£ 990.71	£ 3,478,514
Library & Information Centre			Y	60%	£ 990.71	£ 8,243,074
Margam			Y	60%	£ 990.71	£ 3,756,727
Glyndwr			Y	60%	£ 990.71	£ 5,164,025
Vivian Tower			Y	60%	£ 990.71	£ 9,792,947
Grove & Grove Extension			Y	60%	£ 990.71	£ 9,313,897
Fulton House			Y	60%	£ 990.71	£ 8,247,919
Talbot			Y	60%	£ 990.71	£ 17,029,981
Total						£ 69,964,108

Building name	No Valves, Flanges and metres of exposed pipework (estimated)	Heat Saved Per Count kWh.pa per item	Unit Cost Capex £	No of exposed Plate Heat Exchangers	Heat Saving per plate HX kwh.pa	Unit Cost Capex £	Total Heat Saving kWh.pa	Total Capex £
Finance	2	223.49	125				447	£ 250.00
Mosque	4	128.149	85				513	£ 340.00
Richard Price	12	223.49	125				2,682	£ 1,500.00
Haldane	16	128.149	85				2,050	£ 1,360.00
Union House	8	128.149	85				1,025	£ 680.00
Taliesin Arts Centre	14	128.149	85				1,794	£ 1,190.00
Keir Hardie	6	128.149	85				769	£ 510.00
Library & Information Centre	12	223.49	125				2,682	£ 1,500.00
Wallace	8	223.49	125	2	10920	150	23,628	£ 1,300.00
Glyndwr	6	223.49	125				1,341	£ 750.00
Vivian Tower	6	223.49	125				1,341	£ 750.00
Grove & Grove Extension				1	43680	250	43,680	£ 250.00
Fulton House	10	128.149	85				1,281	£ 850.00
Faraday Lecture Block	20	223.49	125				4,470	£ 2,500.00
Wales National Pool	8	223.49	125				1,788	£ 1,000.00
Engineering Central (Innovation Hub)	8	223.49	125	1	21840	175	23,628	£ 1,175.00
ESRI	1	223.49	125	1	10920	150	11,143	£ 275.00
The College (Academic L5)	6	223.49	125				1,341	£ 750.00
Total							125,603	£ 16,930.00

Appendix 10

LED Lighting Modelling Assumptions

Back to Contents Page

CARBON TRUST

Building name	Existing Lighting Type (non LED)	% Floor area to Upgrade to LED (approximate)	Floor area for LED Upgrade	£/m2 for LED	Cap Ex £	Energy Saving kWh.pa/m2	Annual energy saving kWh.pa
Finance	600*600 T8 and 2D CFL	20%	198	28.34	£5,601	20.22	3,997
Abbey & Stable Block	T8 Cat 2, CFL and T5	75%	2,711	28.34	£76,833	20.22	54,826
Mosque	T8 Fluorescent	50%	144	28.34	£4,073	20.22	2,906
Amy Dillwyn	T8 fluorescent	50%	271	28.34	£7,681	20.22	5,481
Union House	T8 fluorescent	25%	878	28.34	£24,878	20.22	17,752
Rhossili North	CFL	10%	41	28.34	£1,163	20.22	830
Rhossili South	CFL	10%	37	28.34	£1,043	20.22	744
Digital Technium	CFL	30%	1,005	28.34	£28,484	20.22	20,325
Taliesin Arts Centre	CFL and T8 Fluorescent	50%	2,082	28.34	£58,999	20.22	42,100
Llyr Building (AQWA Culture)	CFL and Halogen	5%	38	28.34	£1,063	20.22	758
Keir Hardie	T8 Fluorescent	25%	1,411	28.34	£39,988	20.22	28,534
Wallace	CFL and T8 Fluorescent	75%	6,636	28.34	£188,073	20.22	134,204
Margam	CFL and T5 Fluorescent	75%	2,844	28.34	£80,604	20.22	57,517
Glyndwr	T8 Fluorescent & CFL	60%	3,127	28.34	£88,639	20.22	63,250
Vivian Tower	T8 & T5 Fluorescent	50%	4,942	28.34	£140,078	20.22	99,956
Fulton House	T5, T12 and CFL Fluorescent	50%	4,163	28.34	£117,978	20.22	84,186
Preseli	CFL	10%	385	28.34	£10,908	20.22	7,784
Cefn Bryn	CFL	10%	375	28.34	£10,622	20.22	7,579
Institute of Life Science 2 (ILS2)	CFL	50%	3,365	28.34	£95,373	20.22	68,056
Faraday Lecture Block	T5, T8 Fluorescent	75%	2,706	28.34	£76,705	20.22	54,735
Faraday Tower Block	T5, T8 Fluorescent	50%	2,363	28.34	£66,984	20.22	47,798
Institute of Life Science 1 (ILS1)	CFL	70%	3,985	28.34	£112,944	20.22	80,593
Kilvey	CFL	10%	391	28.34	£11,085	20.22	7,910
Penmaen	CFL	10%	792	28.34	£22,441	20.22	16,013
Horton	CFL	10%	206	28.34	£5,839	20.22	4,167
Oxwich	CFL	10%	173	28.34	£4,900	20.22	3,497
Langland	CFL	10%	207	28.34	£5,880	20.22	4,196
Caswell	CFL	10%	207	28.34	£5,880	20.22	4,196
Wales National Pool	T8 & CFL in plantrooms	10%	587	28.34	£16,626	20.22	11,864
Engineering Central (Innovation Hub)	T5 Fluorescent	75%	6,744	28.34	£191,140	16.99	114,569
Institute of Structural Materials (SMaRT)	T5 Fluorescent	10%	313	28.34	£8,860	16.99	5,311
Engineering East (Manufacturing)	T5 Fluorescent	10%	1,028	28.34	£29,147	16.99	17,471
Great Hall	T5 & CFL Fluorescent	60%	2,297	28.34	£65,113	16.99	39,029
School of Management (CBE)	T5 & CFL Fluorescent	100%	6,668	28.34	£188,986	16.99	113,278
Library (LRC)	T5 & CFL Fluorescent	100%	2,450	28.34	£69,438	16.99	41,621
ESRI	T5 Fluorescent	20%	736	28.34	£20,854	16.99	12,500
Student Union/Sports Centre (Building 15/16)	CFL Fluorescent	100%	500	28.34	£14,171	16.99	8,494
Total					£1,899,075		1,288,028

Appendix 11

EC drives and IE5 motors Modelling Assumptions

Back to Contents Page

CARBON TRUST

Building name	No Air Handling Units (estimate)	No Fans (Estimate)	Typical Fan Power kW per Fan (Estimate)	Run Hours (Estimate)	Annual kWh.pa	EC Fan Energy Saving (estimate)	Energy Saving kWh.pa	Cost per fan	Capex £
James Callaghan	2	4	1.1	8736	38,438	35%	13,453	£ 3,500	£ 14,000
Richard Price	1	2	2.5	8736	43,680	20%	8,736	£ 4,500	£ 9,000
Haldane	1	2	2.2	8736	38,438	20%	7,688	£ 4,500	£ 9,000
Keir Hardie	1	2	1.8	8736	31,450	20%	6,290	£ 4,500	£ 9,000
Institute of Life Science 2 (ILS2)	4	8	3	8736	209,664	20%	41,933	£ 4,500	£ 36,000
Institute of Life Science 1 (ILS1)	4	8	3	8736	209,664	20%	41,933	£ 4,500	£ 36,000
Wales National Pool	4	8	7.5	8736	524,160	20%	104,832	£ 7,000	£ 56,000
Engineering Central (Innovation Hub)	3	6	5	4368	131,040	20%	26,208	£ 6,000	£ 36,000
Institute of Structural Materials (SMaRT)	4	8	5	4368	174,720	20%	34,944	£ 6,000	£ 48,000
Engineering East (Manufacturing)	7	14	3	4368	183,456	20%	36,691	£ 4,500	£ 63,000
Great Hall	6	12	7.5	4368	393,120	20%	78,624	£ 7,000	£ 84,000
School of Management (CBE)	2	4	3	4368	52,416	20%	10,483	£ 4,500	£ 18,000
Library (LRC)	3	2	3	4368	26,208	20%	5,242	£ 4,500	£ 9,000
ESRI	5	2	5	4368	43,680	20%	8,736	£ 6,000	£ 12,000
The College (Academic L5)	2	2	1	4368	8,736	20%	1,747	£ 3,500	£ 7,000
Total							427,540		£ 446,000.00

Building name	Approx QTY Motors (estimate)	Average kW Rating (Estimate)	Run Hours (estimate)	kWh.pa (estimate)	% Motor Upgrade saving (estmate)	Electrical kWh.pa Saving	Unit rate £	CapEX
Finance	3	1.5	5,040	22680	20%	4536	£ 8,607.00	£ 25,821
James Callaghan	2	1.5	5,040	15120	20%	3024	£ 8,607.00	£ 17,214
Law Library (1937)	4	1.5	5,040	30240	20%	6048	£ 8,607.00	£ 34,428
Richard Price	2	1.5	5,040	15120	20%	3024	£ 8,607.00	£ 17,214
Amy Dillwyn	3	1	5,040	15120	20%	3024	£ 8,607.00	£ 25,821
Haldane	4	2	5,040	40320	20%	8064	£ 8,607.00	£ 34,428
Digital Technium	2	1.5	5,040	15120	20%	3024	£ 8,607.00	£ 17,214
Taliesin Arts Centre	1	3	5,040	15120	30%	4536	£ 8,607.00	£ 8,607
Keir Hardie	2	1.5	5,040	15120	20%	3024	£ 8,607.00	£ 17,214
Library & Information Centre	2	1.5	5,040	15120	20%	3024	£ 8,607.00	£ 17,214
Wallace	4	2.2	5,040	44352	20%	8870.4	£ 8,607.00	£ 34,428
Glyndwr	3	1.5	5,040	22680	20%	4536	£ 8,607.00	£ 25,821
Vivian Tower	6	1.5	5,040	45360	20%	9072	£ 8,607.00	£ 51,642
Grove & Grove Extension	3	1.5	5,040	22680	20%	4536	£ 8,607.00	£ 25,821
Fulton House	4	1.5	5,040	30240	20%	6048	£ 8,607.00	£ 34,428
Faraday Lecture Block	2	2.2	5,040	22176	20%	4435.2	£ 8,607.00	£ 17,214
Talbot	2	3	5,040	30240	20%	6048	£ 8,607.00	£ 17,214
Wales National Pool	3	22	5,040	332640	20%	66528	£ 19,488.00	£ 58,464
Engineering Central (Innovation Hub)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
Institute of Structural Materials (SMaRT)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
Engineering East (Manufacturing)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
Great Hall	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
School of Management (CBE)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
Library (LRC)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
ESRI	5	1.5	5,040	37800	10%	3780	£ 8,607.00	£ 43,035
The College (Academic L5)	3	1.5	5,040	22680	10%	2268	£ 8,607.00	£ 25,821
Total						171,058		£ 703,989

Appendix 12

Back to Contents Page

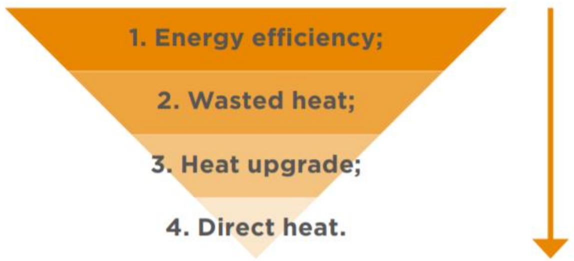
Heat Hierarchy: a strategic approach to heat decarbonisation

Gas consumption for space and water heating in buildings accounts for 50% of SU's scope 1 and 2 carbon emissions. Compared to electricity, the emissions factor for natural gas is less sensitive to policy and technology changes and is expected to remain largely constant between now and 2030. In order to achieve their decarbonisation targets SU will therefore have to be proactive in targeting a significant reduction in natural gas use across the estate and transition from gas to low-carbon fuels.

The challenge of heat decarbonisation is multi-faceted and there is no 'one-size-fits-all' solution that can be implemented across SU's estate. We recommend that any approach to heat decarbonisation should consider the heat hierarchy outlined below. The hierarchy has four key stages, which should be addressed in chronological order:

- **Energy efficiency.** Reduce the heating demand of buildings by improving their thermal performance through fabric upgrades (e.g. insulation, draught proofing). As the initial step, this is referred to as a 'fabric-first' approach and should be maximised for each building, within the bounds of reasonable viability (i.e. respecting technical and financial constraints), regardless of the heat source.
- **Wasted heat.** Utilise any heat that is already being produced in other processes and wasted.
- **Heat upgrade (i.e. heat pumps).** 'Upgrading' heat refers to the process of raising a low-temperature heat source to a higher temperature that can be utilised in heating system. This process requires an energy input (e.g. electricity) and is the function of heat pumps.
- **Direct heat.** This is where energy is directly inputted for the *generation* of heat (e.g. fuel into a boiler). This should be restricted to when wasted heat is not available and the use of a heat pump is not technically or financially feasible.

The solution will likely involve a combination of these measures, in varying proportions. The appropriateness of each option needs to be assessed in the context of the fabric and efficiency of each building to ensure that space can be adequately heated. Following our remote initial assessment, the University should look to consolidate this work with further site-specific investigations, using the heat hierarchy as a foundation.



Above: the heat hierarchy

Source: ADE, A framework for net-zero for new and existing buildings.

Appendix 13

Electrification the preferred route to decarbonisation

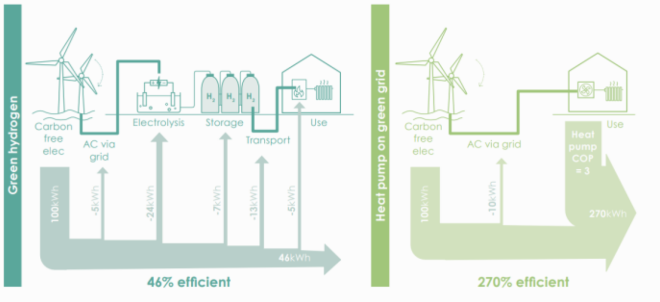
Back to Contents Page

CARBON TRUST

Electrifying heat through the installation of high efficiency heat pumps (either air-source or ground-source) is recommended as the primary route to decarbonising the University's heat demand. **Feasibility studies to confirm the viability of heat pumps across SU's estate are a firm recommendation of this report and should be commissioned as a priority** in advance of every heating system replacement. Rationale is included below for excluding hydrogen and biomass heating (often cited alongside heat pumps as potential low-carbon heat sources). While excluded from analysis at this stage, it should be noted that both of these options would be preferred over continued use of natural gas, should further studies deem heat pumps an inappropriate solution. **It is also re-emphasised that energy efficiency to reduce end heat must be maximised, regardless of the ultimate heat source.**

- **Hydrogen:** The preliminary exclusion of hydrogen for heating is consistent with recommendations made by the UK's Climate Change Committee (CCC), which views hydrogen as important for hard-to-abate areas of the economy but *only* for use where you cannot feasibly electrify. They view the mid-2020s as critical for making decisions on hydrogen for heating, and the UK Government has recently announced trials for hydrogen heating in the Hydrogen Strategy; these trials are 'pioneering' and widespread use of hydrogen for heating, if it ever comes, should not be expected until later this decade. Due to it's readiness level, it is our opinion that waiting on hydrogen-for-heating risks stagnating climate action and prolonging the use of fossil fuels. From a technical perspective, the efficiency of heat pumps powered by renewable electricity vs. hydrogen produced using renewable electricity is also far greater and requires significantly less infrastructure (*see inset below*), which can be expected to translate into financial savings.
- **Biomass:** Biomass for heating has provisionally been excluded due to the associated 'outside of scope' emissions. The unabated combustion of biomass can legitimately be considered a low-carbon fuel since the fuel source absorbs an equivalent amount of CO_2 during its growth phase as it releases during combustion. Biomass can also be a net carbon sink if either (a) the carbon released during combustion is captured (e.g. BECCS), or (b) the biomass is not combusted and is maintained for other long-term uses (e.g. construction). Biomass as a carbon sink has a meaningful contribution to the UK's overall net-zero pathway and sustainable biomass reserves should be prioritised for net-negative operations or where other low-carbon heating solutions are not possible. Particulate emissions from biomass combustion are also significant, and substantial abatement (e.g. filtering) would be required to protect air quality.

Heat pump efficiency vs. hydrogen *(source: LETI)*



Appendix 14

Electrified heat modelling assumptions

Back to Contents Page

CARBON TRUST

- Costs and carbon savings for emitter upgrades are based on upgrading to large radiators, with the exception of Law Library (underfloor heating), Cefn Bryn, Preseli and Kilvey (hot water cylinders). Further feasibility and detailed design are needed to establish the most suitable emitters for each building.
- Heat emitter upgrades have been based on estimated percentages of Gross Internal Area where heating is provided by VT and CT circuits.
- Any enabling works specific to the building have not been accounted for and therefore an additional 10% capital cost has been added.
- Annual O&M costs for gas boilers have been accounted for using gas boiler service costs provided by the University.
- ASHP and electric boiler peaking plant may not be suitable for all buildings, and further feasibility and detailed design is needed to identify alternative solutions where more appropriate e.g., thermal storage.
- 6% inflation has been applied to the unit cost of natural gas and 4% to electricity prices based on discussion with Swansea University. Real inflation rates may vary significantly.
- Gas and electricity prices taken to be 6 p/kWh and 16 p/kWh respectively
- Heat pump equipment costs taken to be 900-1100 £/kW excluding ancillary costs such as emitter upgrades.
- No additional costs have been included for insulation or localised thermostat control.
- Heat pump costs include purchase and installation cost for heat pump and buffer tank.
- Under floor heating costs (for Law Library) have been approximated as 14 £/m2 with an additional cost for enabling works.
- Reference year of 2019 (pre-pandemic) was taken as a baseline for buildings’ energy consumption, with the exception of WNP which was 2021 – reflective of the out-of-service CHP.
- Average tariffs were provided by Swansea University including all taxes, levies and charges.
- Plant room space requirements have not been considered and should be investigated on an individual basis for each building.
- A 20% overall contingency has been added onto the capital cost to reflect market uncertainty and inflation.

Appendix 15

Electrified Heat: Heat network modelling assumptions

Back to Contents Page

CARBON TRUST

- Annual heat demand found from monthly gas consumption at the energy centre multiplied by thermal efficiencies of gas boilers and CHP engine, and accounting for system losses.
- Heat demand is normalised by comparing base year degree-day data to the most recent 5-year average
- Hourly heat demand profiles of buildings with individual gas supplies combined and proportioned over the year to create an annual heat demand profile
- Heat demand profile multiplied by annual heat consumption of the heat network (with the addition of constant systems losses throughout the year)
- Annual heat demand ordered largest to smallest to produce a load duration curve
- Heat pump maximum output found from 1,500 annual run hour threshold
- Cost assumption applied to estimate capital costs:

Cascade (ASHP & WSHP)	1800	£/kW
GSHP (80 ºC)	1900	£/kW
Power & Controls	100	£/kW
Thermal Storage	1000	£/m3
LTHW Pipework	800	£/m
Heat transfer station	~35	£/kW

Appendix 16

Solar PV modelling assumptions

Back to Contents Page

CARBON TRUST

Building name	Roof Area Available for PV M2	No Panels (at 1.52m2)	kWh per Panel	kWh Total	Cost per panel £	Capex £
Finance	74	48	301.21	14,565	£ 231	£ 11,185.06
James Callaghan	188	123	301.21	37,156	£ 231	£ 28,533.30
Law Library (1937)	150	99	301.21	29,725	£ 231	£ 22,826.64
Richard Price	228	150	301.21	45,182	£ 231	£ 34,696.50
Haldane	188	123	301.21	37,156	£ 231	£ 28,533.30
Rhossili North	53	35	301.21	10,404	£ 231	£ 7,989.33
Rhossili South	53	35	301.21	10,404	£ 231	£ 7,989.33
Llyr Building (AQWA Culture)	72	47	301.21	14,268	£ 231	£ 10,956.79
Wallace	480	316	301.21	95,119	£ 231	£ 73,045.26
Grove & Grove Extension	120	79	301.21	23,780	£ 231	£ 18,261.31
Institute of Life Science 2 (ILS2)	325	214	301.21	64,403	£ 231	£ 49,457.73
Faraday Tower Block	150	99	301.21	29,725	£ 231	£ 22,826.64
Institute of Life Science 1 (ILS1)	192	126	301.21	38,048	£ 231	£ 29,218.10
Penmaen	256	168	301.21	50,730	£ 231	£ 38,957.47
Horton	162	107	301.21	32,103	£ 231	£ 24,652.77
Oxwich	100	66	301.21	19,816	£ 231	£ 15,217.76
Langland	100	66	301.21	19,816	£ 231	£ 15,217.76
Caswell	100	66	301.21	19,816	£ 231	£ 15,217.76
Wales National Pool	1575	1036	301.21	312,109	£ 231	£ 239,679.75
The College (Academic L5)	100	66	301.21	19,816	£ 231	£ 15,217.76

Appendix 17

Heat Pumps

Back to Contents Page

CARBON TRUST

Sizing & Operating Temperatures

Sizing heat pumps: correctly is of paramount importance. A growing body of evidence is now available that shows accurate sizing is needed to maintain efficiency. Heat pumps should be selected as closely as possible to the design heat demands. The Microgeneration Certification Scheme Standard MIS 3005, requires units to achieve 100% of the duty at an external temperature condition exceeded for 99.6% of the year, *if reasonably practicable*. It also stipulates that supplementary heat is not permitted from direct electric at external temperatures *above the design external temperature* ("bi-valent point" or "balance point"), but other alternative auxiliary sources of heat are permitted where this is not reasonable practicable (e.g. 'hybrid' systems). Although additional supplementary heat may be required when the external temperature drops below the bi-valent/balance point, this will occur for very short periods of the year and therefore should not significantly affect overall seasonal efficiency even when direct electric heat is utilised.

Operating temperatures: Most buildings with wet heating systems have been designed to deliver 82°C/71°C (flow and return), however these higher temperatures aren't necessarily required to heat a space. Many buildings can operate at lower temperatures. Low temperature systems (standards heat pumps) will operate between 35-60°C (flow). This is usually the case for air source heat pumps (where ground source or water source aren't possible). Lower temperatures may require emitter changes, depending on the age of the building/standard of fabric etc. Higher temperature heat pumps operate at 60°C flow upwards. High temperature heat pumps are becoming more readily available and such solutions can be used in conjunction with existing gas boilers, or used as a staged system. It's important to remember that although the higher temperature options may be less intrusive initially (without the need for building fabric upgrades), the efficiencies will not be as good as the lower temperature options.

***Warning:** It has been normal practice with gas fired heating systems to use rules of thumb for design. This is not good practice for detailed design (e.g. selecting heat emitters) and final selection of the heat generator and should NEVER be used for this purpose. MIS 3005 follows existing Standards to deliver good practice in design and selection. Rules of thumb (i.e. W/m2 or W/m3 covering all elements) or 'whole building' calculations may be used for approximate sizing and overall project feasibility but should NOT be used for the final design and selection of the heating system.*

Appendix 17

Heat Pumps

Back to Contents Page

CARBON TRUST

Planning Considerations

Building electrical supply connections may need to be upgraded for the installation of heat pumps to buildings. In addition to the extra kVA capacity required, the district network operator (DNO) may require information on the starting method of the heat pumps – for example, direct-on-line, soft-start – as this can impact the electrical infrastructure.

Noise from air source heat pumps and outdoor units can be greatest during a 'blowdown' operation, when fans run at maximum speed to dry the evaporator after a defrost cycle. **Meltwater and pluming** from air source heat pumps can be produced both during and after defrosting cycles. This should be considered carefully when locating such units, as run-off water is likely to refreeze, presenting a slip hazard. **Refrigerant selection** is key to the long-term low carbon operation of new heat pump systems. The trade-offs between performance and environmental impact of different refrigerants should be considered, including a review of CO_2 heat pumps potential.

Spatial needs: can be quite different to standard boilers. The "shell" of a heat pump can house different capacities so there isn't a clear rule of thumb on space requirements. However the below diagrams show some typical diameters for common units and other considerations.

Example Small Heat Pumps (around 20kW)

- 20 kW Heating Capacity – 1807 x 779 x 1687 mm
- 35 kW Heating Capacity – 2061 x 898 x 2087 mm

Example Large Heat Pumps (>200 kW)

- 230 kW Heating Capacity – 4520 x 2200 x 2530 mm
- 575 kW Heating Capacity – 10400 x 2260 x 2530 mm

SPACE CONSIDERATIONS

- Smaller units can be modular to make up a larger capacities (e.g., 100 kW = 5 x 20 kW).
- Smaller units with front facing fans need at least 1m clearing in front, and vertical fan setups need 1m all around, to allow for airflow.
- High temperature or low noise units are generally larger than standards sizes.
- Ideally, heat pumps should be located away from windows and residential areas due to noise; acoustic fencing may need to be considered as a result of location.
- Most suppliers will recommend a buffer vessel. These can be sited outside by the heat pump or inside the plant room.

Installation and Commissioning

Manufacturers' instructions and those of any designer employed should be rigorously followed. If in doubt a query should be raised with the appropriate party. A number of manufacturers and installation best practice schemes (e.g. Benchmark), provide an installations checklist and it is recommended these are used where possible.

Typical areas which need the most attention are:

- Ensuring adequate space for access for maintenance, servicing, adjusting set points and/or flow valves, reading meters etc.
- Ensuring pipe runs are the correct size, routed to minimise unnecessary bends or changes of direction, and are well supported and insulated where required.
- Ensuring that hydraulic systems are properly pressure tested, have water treatment added as directed, and are adequately vented and flow rates checked.
- Ensuring that heat emitters are hydraulically balanced using appropriate valves (lock-shield on radiators, flow control valves on under floor heating circuits) to provide the desired flow rate to provide a similar temperature difference across the emitter.
- Provision of clear operating and maintenance manual including any recommended spares, plus contact details, for all relevant parties and major equipment suppliers.
- Care must be taken in the siting of the outdoor unit of an air source heat pump to ensure adequate air flow and that the unit does not cause a noise problem to occupants. Most modern heat pump units emit very low levels of sound however.

Appendix 17

Heat Pumps

Back to Contents Page

CARBON TRUST

Maintenance Considerations

There is a degree of uncertainty and inconsistency in advice on maintenance of heat pump systems. This is because the heat pump unit itself is most often a contained unit sealed during manufacture, similar to a domestic refrigerator which requires minimal maintenance. However, the system to which they are attached often needs periodic servicing. Therefore, it is important to differentiate between maintenance of the heat pump itself and the overall heating and/or hot water system. The recommendations of the manufacturer should always be followed. It is unlikely that more than one service inspection per year will be required however.

Air source Heat Pumps: In general, all air source, outdoor units should be checked to ensure the airflow through them is not impeded in anyway by the build-up of matter blown in by the wind (e.g. leaves and general debris) or from the growth of vegetation. This does not necessarily need to be performed by a specialist.

GSHP Systems: Closed loop (ground or water): It is important to ensure that the closed loop circuit is clean, free of any biofouling build up, free of leaks/fully filled and the Thermal Transfer Fluid (TTF) contains adequate anti-freeze to prevent freezing. Leaks can be detected by:

- Visual check of the array
- Monitoring of any automatic refill systems, for instance via a dedicated water meter
- Checking the concentration of anti-freeze chemical (chemical must be identified)

***Warning:** Buffer vessels can perform important functions if incorporated correctly, however they can also increase heat loss from the system and add additional parasitic load from additional circulation pumps, which may also have to work in continuous operation. Therefore, their inclusion should be carefully considered and the advice of the manufacturer or a specialist sought.*

***Warning:** It is vital that the system does not cycle on and off repeatedly as this will lead to excessive wear on the components, poor comfort control and reduced system efficiency.*

Appendix 17

Heat Pumps: Heat Network Upgrade

Back to Contents Page

Due to the large scale of works for any heat network upgrade considered, The University should consider a multi-stage procurement with inclusion of a “breakpoint” after the initial design. This breakpoint will allow SU to consider the final costs and implications of the proposed design by a contractor.

The heat network upgrade may be procured under the same contract, although may be more suitably procured separately at a later date depending on successful application for potential funding (from HNDU) and the results of a funded feasibility study.

Below are example stages of procurement for a large campus upgrade programme.

- Stage 1: Initial proposal and design options (Consultation and pre-qualification)
- Stage 2: Detailed design and costing (Detailed design and breakpoint)
- Stage 3: Delivery (Delivery, Commissioning and breakpoint)
- Stage 4: Operations & Maintenance (optional) (Maintenance and Performance Monitoring)

Further detail on the prosed stages above can be located in *Swansea University Heat Strategy March 2022* produced by the Welsh Government Energy Service.

Appendix 18

Abbreviations

[Back to Contents Page]

SU	Swansea University
GHG	Green House Gas
SBTi	Science Based Target Initiative
tCO_2e	Tonnes of carbon dioxide equivalent
BAU	Business As Usual
WTT	Well to Tank
T&D	Transmission & Distribution
kWh	Kilowatt Hour
LED	Light Emitting Diode
HVAC	Heating Ventilation and Air Conditioning
AHU	Air Handling Unit
COP	Co-efficient of Performance
SCOP	Seasonal Co-efficient of Performance
SEER	Seasonal Energy Efficiency Ratio
M&E	Mechanical and Electrical
EC	Electrically Commutated

DX	Direct Expansion
FES	Future Energy Scenarios
A/GSHP	Air/Ground source heat pump
BECCS	Bioenergy and carbon capture and storage
BMS	Building Management System
PV	PV
CHP	CHP
CIBSE	Chartered Institute of Building Service Engineers

The Carbon Trust is a company limited by guarantee and registered in England and Wales under company number 4190230 with its registered office at 4th Floor Dorset House, Stamford Street, London SE1 9NT.