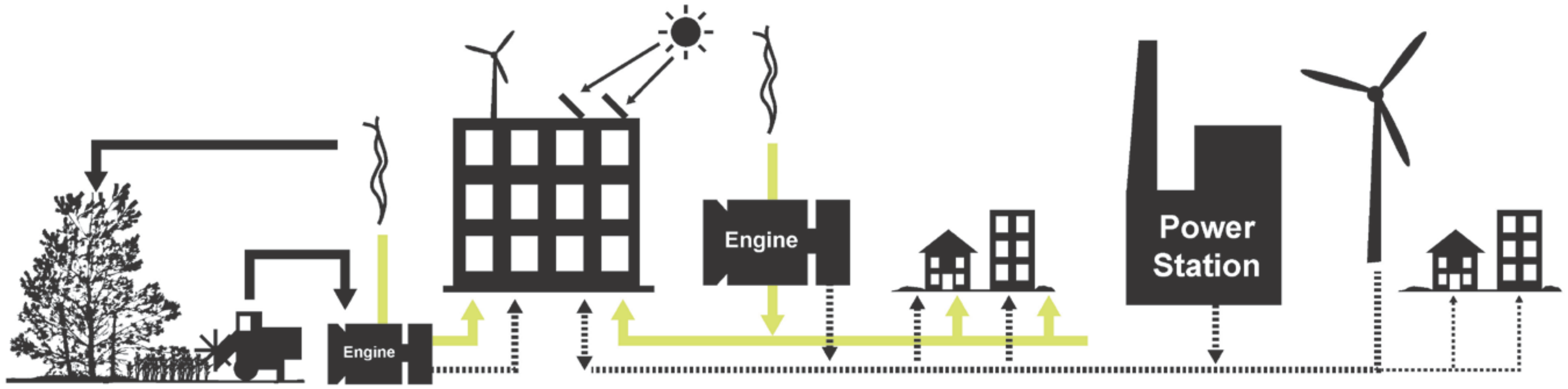
The University of Sheffield

Energy Strategy

May 2012



ARUP

The University of Sheffield
Energy Strategy
Report

218999-00

Issue | 1 June 2012

Ove Arup & Partners Ltd
New Oxford House
30 Barkers Pool
Sheffield
S1 2HB
United Kingdom
arup.com

Job number 218999-00

ARUP

Contents

Executive Summary

The University have clear commercially viable strategic opportunities to reduce carbon and improve business continuity through behaviour change, building services upgrades and self generation low and zero carbon interventions. It is recommended that to deliver the interventions identified by this study the University address a number of constraining factors. The constraints are not unusual and given the right commitment can easily be addressed as enabling activities.

For the University to achieve the HEFCE 2020 carbon reduction target requirements, by far the greatest carbon reduction will be achieved by the introduction of self generation infrastructure. It is recommended that the University embark on the development of integrating CHP energy centres with elements of renewable boiler fuel at strategically appropriate locations, along with the application of off-site wind turbines and building integrated solar photovoltaics in a pragmatic and appropriate manner. CHP and renewable intervention capacities have been modelled against demand data and selected accordingly. The maximum benefit gained from CHP can be achieved by interconnecting these energy centres with the Veolia district heat network.

The Veolia network offers the University a greater advantage in terms of carbon reduction opportunities than are available to other less fortunate Universities without city district networks. To enable heat interconnection between developed University energy centres and the Veolia network a greater level of collaboration and understanding between the parties will be required. However, there is been a reticence to either party driving this, primarily due to a lack of Veolia customer service and relationship management over a number of years. Fortunately, new management and impetus in both parties has created more willingness to improve the relationship. Veolia are now responding to University customer requirements and have thoroughly engaged in working sessions over the course of this strategy development, exploring possible carbon and continuity interventions. It is recommended that to enable the development of University CHP energy centres a memorandum of understanding (MoU) be drawn-up and agreed upon by the University and Veolia. Such an MoU would be designed to address other intervention recommendations requiring enabling works and to foster an improvement in the long term relationship.

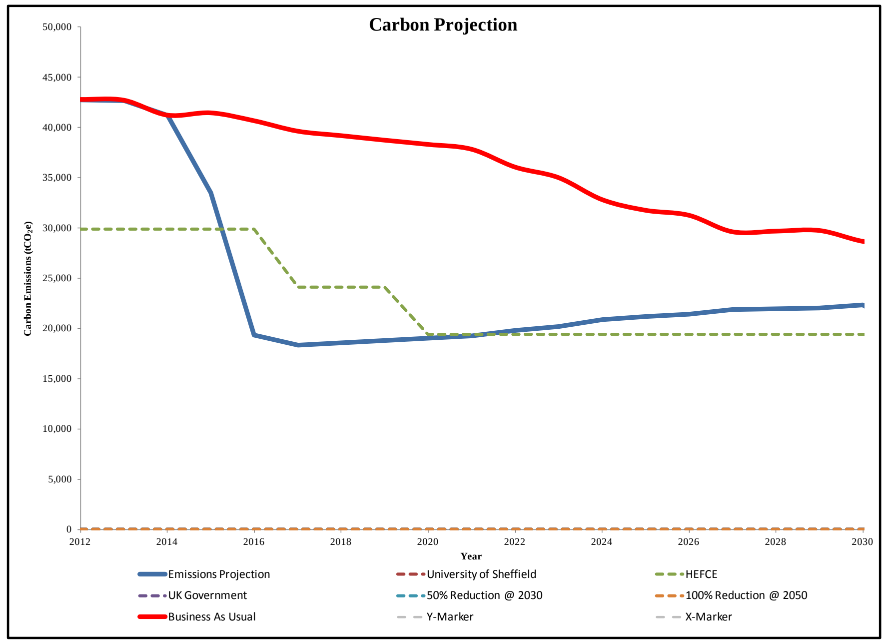
A long term relationship with Veolia is essential for improved University business continuity planning and energy system resilience. Planned preventative maintenance (PPM) regimes of both parties need to be developed in collaboration, along with agreed method statements of work and reporting when dealing with system failures and emergency repair. It is further recommended that the University explore the purchase of renewable electricity from Veolia's Bernard Road EfW facility which will become available towards the end of 2013 when their existing Non-Fossil Fuel Obligation agreement with the Non-Fossil Fuel Purchasing Agency ceases.

The dashboard model produced for the strategy combines gathered estate data with energy and carbon inventories to manipulate selected behavioural, buildings and self-generation interventions to produce carbon, financial and marginal abatement cost curves in a dashboard format. The model permits the creation and selection of intervention scenarios and adjustment of key variables. Recommendations have been produced using the model outputs combined with an understanding of interventions bearing on risk to the University Estate.

It is recommended that along with the self generation interventions, a roll-out of behavioural change management be undertaken consisting of faculty and departmental end user engagement and assignment of 'champions'. Behavioural champions within faculties and departments should be made responsible for communicating the need for change to the building users through stakeholder meetings and activity assignment to users. Communicating the energy and carbon performance of University buildings by effective use of the University's metered data in reports, building foyer read-out displays and smart phone applications are recommended as important behaviour changing interventions to be undertaken by the Estates team.

Building services refurbishment has been targeted by building use and service type, utilising available data and survey findings. The overall University stock was found to be performing to a good standard of energy and carbon. Where resolution of available data did not permit a fine granularity of examination, aggregated performance was proportionally derived and compared with best practice benchmarks. A series of commercially viable building interventions are recommended including heating, cooling, ventilation, lighting and building fabric improvements. However, constraints to plant room accessibility are extensive due to the managed asbestos presence across the University. Greater levels of energy and carbon saving than current ease of access permits are anticipated from plant room interventions. The presence of asbestos across the University is a significant obstacle to energy and carbon reduction, metering and effective maintenance. It is therefore recommended that building services plant room interventions are enabled by a commitment to remove all asbestos.

Modelled carbon reduction trajectories illustrate an achievable plan of action to meet the 2020 HEFCE target. Reductions over the business as usual trajectory will be around 19,000 Tonnes of CO_2 equivalent by 2020 made by the recommended behavioural, buildings and self-generation interventions delivery programme.



The self generation capacity, responsible for the larger part of carbon reduction as modelled with the Dashboard tool include the following technology capacities:

Intervention	MW capacity
PV	0.1
Gas CHP	6
Biomass Boilers	4
Wind	7.5

Counteracting University growth projections, decarbonisation of grid supplied electricity results in a gradual reduction in carbon even for the business as usual case.

The intervention delivery investment plan will amount to around £40M over a development programme running from 2012 to 2017.

The University has a clear route map to cost effective carbon reduction aligned where possible with City and neighbourhood initiatives. The recommendations presented position the University at the forefront of carbon reduction initiative within the City and will elevate the University's position in the higher education sector carbon reduction challenge, reportable through an updated Carbon Management Plan.

1 Introduction

1.1 Brief

Arup has been commissioned by the Estates and Facilities Management (E&FM) department of the University of Sheffield (”the University”) to produce an energy strategy covering the current and future estate portfolio. The strategy is intended to cover buildings, behaviour and self-generation opportunities and initiatives across the University estate.

The aim of the study is to understand the existing energy supply and consumption position of the University alongside the future requirements of the estate to ensure that the University is operating to the best of its ability.

Figure 1 - University of Sheffield Estate

1.2 Methodology

The following methodology has been used in order to complete the brief set out as part of the study.

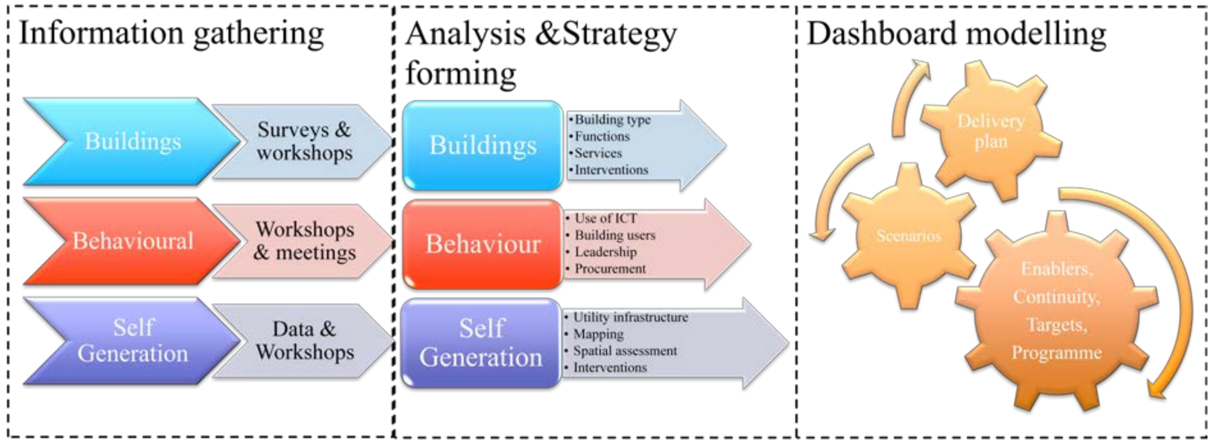


Figure 2 - Methodology Illustration

Data Gathering & Site Assessments

The first stage in developing an energy strategy is to understand the current position of the University.

A review of the data currently held by the University has been undertaken and where possible quantification of the University’s estate and faculty development plans has been produced. This has included taking a view on proposed projects and future aims and objectives for the University.

Energy management data has been utilised to understand the current energy demands and consumptions across the estate. Site surveys have been completed to fully appreciate the current condition of buildings and associated services and infrastructure across the estate.

Stakeholder Workshops

In addition to engaging directly with the University, consideration has also been given to a range of other stakeholders who may potentially be impacted upon or be interested in opportunities associated with the development of an energy strategy for the University.

Interactive workshops have been held with the major stakeholders, these have included;

- Sheffield City Council (SCC).
- Veolia Environmental Services (Veolia).
- Local Stakeholders.
- University Faculties.
- University Estates and Facilities Management (E&FM).

Behavioural Change

Behavioural change initiatives are currently considered to be an integral part of any future energy strategy. Deployment of behavioural initiatives can provide cost effective methods of reducing energy demand and carbon emissions across a range of operations.

Opportunities for deploying behavioural change initiatives and the potential impact of these initiatives has been undertaken making reference to both best practice operations, potential future innovations and in ensuring communication of an evolving energy strategy for the University.

Existing Buildings

Based on the data made available for the University and the site surveys completed as part of the study guidance associated with the existing building stock across the University's estate has been provided.

This guidance has focussed upon energy and carbon savings and, where appropriate, the impacts that building based opportunities and initiatives may have on business continuity. This work has been undertaken while paying due consideration to the current plans for redevelopment and refurbishment of buildings, facilities and associated services across the University's estate.

Self Generation

Self generation provides a major opportunity for the University to increase its control over energy supply and therefore the potential risks and impacts on business operations as well as providing opportunities for investment and reducing the overall cost and carbon intensity of energy consumed across the University's estate.

Based on the energy data made available and the details of the estate, an exercise has been completed with the aim of identifying potential technology options and projects for deployment across the University's estate. This exercise has taken into consideration the local and wider infrastructure and the impact and opportunities this has on self generation opportunities.

Reporting

The results of the energy strategy study undertaken by Arup on behalf of the University are presented within this technical report. In addition, an update of University's carbon management plan has been produced based on the recommendations of the study. These two documents have been provided alongside the modelling tool and all associated documentation.

Modelling

In addition to the energy strategy report being produced as part of the study, a modelling tool has also been developed. The aim of this tool is to allow for the University to undertake quick and easy assessments of the relative impact of a range of interventions and opportunities across the estate. The tool has been designed to allow for multiple scenarios to be easily compared and outputs produced in graphical format.

The key outputs from the tool include a projection of carbon emissions associated with University activities and a marginal abatement cost curve (MACC) allowing easy comparison of the relative cost effectiveness of opportunities and interventions.

2 University of Sheffield Estate Overview

The following information forms the foundations of the energy strategy developed by Arup on behalf of the University. This information has been used in assessing the opportunities and interventions under consideration and to develop all of the recommendations presented at the conclusion of this report.

The University, established in 1905, is a leading teaching and research based University located in the north of England. The main campus area, covering the Western Bank, St George's and North Campus sites, is located approximately one mile west of Sheffield city centre. In addition to the main campus the University also has several other satellite buildings and sites across the city, primarily located in the west of Sheffield.

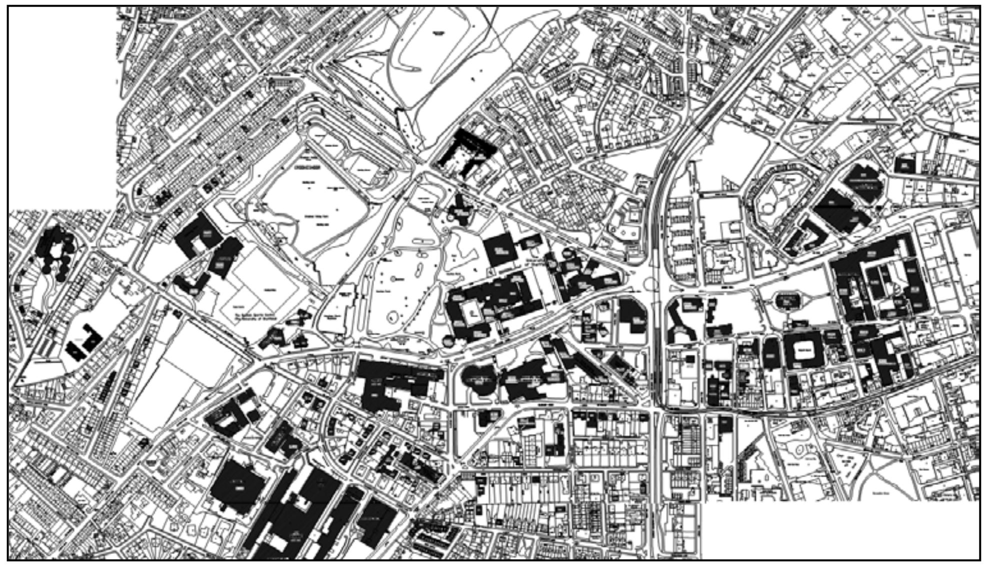


Figure 3 – University of Sheffield Estate

The estate comprises a total of 340,000m^2 of buildings and infrastructure across a total area of 40 hectares. The University also has a significant presence at the Advanced Manufacturing Park (AMRC) in Rotherham, where it has invested substantial capital in developing facilities over recent years.

2.1 Operations

The University is split into five faculties across the Sheffield estate;

- Faculty of Arts & Humanities.
- Faculty of Engineering.
- Faculty of Medicine, Dentistry and Health.
- Faculty of Pure Science.
- Faculty of Social Science.

In addition to these five faculties a number of support services operate across the estate. The E&FM department are responsible for maintaining the University's buildings and gardens, managing its property and facilities and procuring new buildings.

2.2 Estate Strategy

An overall estate strategy was developed by the E&FM department covering the period 2010 – 2015 and focuses on;

- Improvements to the general estate condition including buildings, services, public realm and physical environment.
- A reduction in the University's carbon footprint.
- Reducing operating costs through maximising efficiency of use of the estate.
- Provision for targeted growth in student numbers and research activities.

All of these items will directly impact upon energy supply and consumption across the estate and deploying an effective energy strategy will ensure that any major impacts of these changes can be mitigated while the University takes advantage of available opportunities. The four items outlined above also clearly fit within the three overarching topics of the proposed energy strategy; business continuity, cost and carbon.

2.3 Masterplan

Although no masterplan is in place for the University estate, a number of aims are set out within the estate strategy. The table below provides a summary of the information set out within the estate strategy and the likely impact on energy across the University's estate.

Faculty	Description	Impact on Energy
Engineering	Refurbishment of the St George's campus including a new building on the corner of the St George's complex, a major refurbishment of the Mining Block and further expansion of the Jessop East site. Expansion of the AMRC site.	Significant increase in energy demands over the short-medium term as the faculty continues to expand. Increased demand placed on existing infrastructure and potential requirement to find alternative options for energy supply and minimising impact of increased demand.
Social Sciences	Relocation of the Management School from the St George's campus to the Crookesmoor site. Consolidation of a number of departments into the current Management School building.	Net impact likely to be minimal in the short-term. Energy demands likely to increase in line with the anticipated growth of the management school. Potential impact on carbon associated with moving management school off the district heating network.
Science	Opportunities identified to reduce its overall space requirements primarily through the relocation of the Psychology department.	Potential reduction in overall energy demands associated with faculty but likely increase in energy demand density associated with consolidating overall space requirements.
Medicine, Dentistry and Health	Investment in a Clinical Skills Training facility at the Northern General Hospital and relocation of the Nursing department from the Northern General Hospital close to the Hallamshire Hospital.	Impact on energy associated with University expected to be low due to current agreements in place with local NHS trusts.
Arts & Humanities	Little to no development following the success of Jessop West.	No significant future changes expected.
Other	Expansion of the Information Commons, redevelopment of Brunswick Street for CiCS and reconfiguration of New Spring House for Academic Services.	Potential increased demand around centre of Western Bank campus.

2.3.1 Short to Medium Term

The information made available within the Estates Strategy and collated through discussions with E&FM personnel have been summarised in an estate development plan shown in the figure below. This information has been used as part of the modelling work to estimate future estate emissions.

	2013	2014	2015	2016	2017
Fredrick Mappin	1,468			2,783	
Broad Lane Block					2,568
Central Wing			3,294		
Mining Block					2,229
Amy Johnson Building					
Chemical Engineering Building	685				
Sir Robert Hadfield Building	896	1,065			
Amy Johnson Annexe					618
New Caledonia Workshop					427
Engineering New Build Phase 1	5,000				
Engineering New Build Phase 3			2,800		
Jessop East			19,500		
Crookesmoor Building					500
Brunswick Street					182
New Spring House					970
New Build	5,000	0	22,300	0	500
Refurbishment	3,049	1,065	3,294	2,783	3,720
Demolition	0	0	0	0	3,274

Figure 4 –Estate Development Plan

The main development across the estate in the short to medium term appears to be focussed in and around the St George’s campus with significant redevelopment and expansions of the Engineering Faculty facilities and construction of the Jessop East building. These proposed works are likely to have a significant impact upon the energy supply arrangements particularly with regard to the supply of heat.

2.3.2 Long Term

Due to the lack of long-term development information made available three development scenarios have also been considered in order to assess the future potential energy demands and carbon emissions associated with the University’s estate. These three scenarios are detailed below. These scenarios have been used to project the future carbon emissions of the University in the long-term.

Scenario	Description
1 – High Growth	Total floor area of University estate grows at 5.0% per annum post 2017.
2 – Central Growth	Total floor area of University estate grows at 2.5% per annum post 2017
3 – Low Growth	Total floor area of University estate grows at 1.0% per annum post 2017.

2.4 Carbon Management Plan

The University of Sheffield Carbon Management Programme Strategy and Implementation Plan (SIP), was published February 2008. It sets a carbon emissions target of 20% below the 2005-6 baseline Academic year by 2016-17. Under this reduced emissions scenario, this equates to annual carbon emissions savings of about 20,000 tCO_2e and reduction in annual costs by £6m by 2016-17.

2.4.1 Completed actions

The SIP outlined past actions completed to reduce carbon emissions from energy use. These included:

- the development and extension of the local energy from waste district heating scheme
- installation of M&T systems
- procurement of low energy equipment
- improved HVAC controls
- installation of insulation
- relighting
- reduced PC power wastage and,
- improved BEMS controls.

2.4.2 Planned actions

The SIP outlines emission reduction opportunities split into three areas: Long-term enablement actions; No- and low-cost actions; and Actions requiring investment.

Long-term enablement actions include: budget devolution, Sustainability Policy development, web site promotion, Green Purchasing Policy implantation; Carbon Offsetting; increased use of teleconferencing; the appointment of Energy Engineer and Environmental Controls Engineer; and replacing of sub-meters at the end of their useful life.

No- and low-cost actions include: awareness raising; energy efficient procurement; use of IT power efficiency features; priority to maintenance that reduces energy use; and the adjustment of BMS set points and time schedules.

Actions requiring investment include: improving building fabric; improving lighting controls; use of standalone controls such as TRVs, presence sensors and time switches; use of BMS outstations; motor controllers for refrigerators; water boilers in kitchenettes; time switches to control point of use electric domestic water heaters.

Actions identified but not considered in as much detail include: installing a chilled water distribution system; installing voltage controllers; further BEMS upgrades; boiler replacements; motor replacements and inverters; lighting upgrades; improving heating controls; and installing dedicated chillers.

3 Buildings Strategy Approach

The diverse nature of the estate consists of a wide and varied range of buildings. It is therefore likely to result in a range of challenges particularly with respect to energy.

The University Estate consists of 324 buildings that vary in age, condition and usage. The Buildings are occupied by five faculties, residential accommodation and a variety of services and facilities. The occupiers of the Estate can be split into 9 main user groups:

1. **Faculty of Engineering:** Occupying 17% (by area) of the estate, the Faculty of Engineering encompassing departments of Automatic Control and Systems Engineering, Civil and Structural Engineering, Chemical and Biological Engineering, Computer Science, Electronic and Electrical Engineering, Materials Science and Engineering, Mechanical Engineering.

2. **Faculty of Arts and Humanities**: Encompassing departments of Archaeology, Biblical Studies, History, Philosophy, Music, the School of English Literature, Language and Linguistics and the SoMLaL (School of Modern Languages and Linguistics), the Faculty of Arts and Humanities occupies the smallest share of the estate (4%).

3. **Faculty of Medicine, Dentistry and Health:** The Faculty occupies 13% of the Estate and is located predominantly around the Royal Hallamshire Hospital and Northern General Hospital.

4. **Faculty of Science:** The Faculty is comprised the following departments; Animal and Plant Sciences, School of Mathematics and Statistics (SoMaS), Biomedical Science, Chemistry, Molecular Biology and Biotechnology, Physics and Astronomy and Psychology and occupies 11% of the total estate.

5. **Faculty of Social Sciences:** Includes the departments of Architecture, East Asian Studies, Economics, Education, Geography, Information School, Law, Journalism, Landscape, Management School, Politics, Sociological Studies, Town and Regional Planning., The Faculty of Social Sciences occupies 9% of the estate.

6. **Professional Services**: They occupy the majority of the University Estate with a 20% share and include Academic Services, Student Services, Library, Development and Alumni Relations, and External Relations alongside the supporting departments of Finance, CiCS, HR and Estates and Facilities Management.

7. **Learning Infrastructure**: Occupying 12% of the Estate, the Learning Infrastructure accommodation comprises of self learning areas including Libraries and the Information Commons, and Pool Teaching facilities including specialist and pool lecture theatres, seminar spaces, IT suites and laboratories and specialist support services including Dyslexia support services and the English Language Teaching Centre.

8. **Residential Accommodation:** Residential buildings, predominantly located within the Broomhill and Ranmoor area of Sheffield occupy 5% of the Estate.

9. **Social/Commercial:** Activities within these types of building include Catering and Retail, Conferencing, Ceremonial, Performance, Sport, Public Realm, and the Students' Union. These buildings account for 9% of the University Estate.

The area breakdown between the Building Usage types is summarised within Figure 5 below.

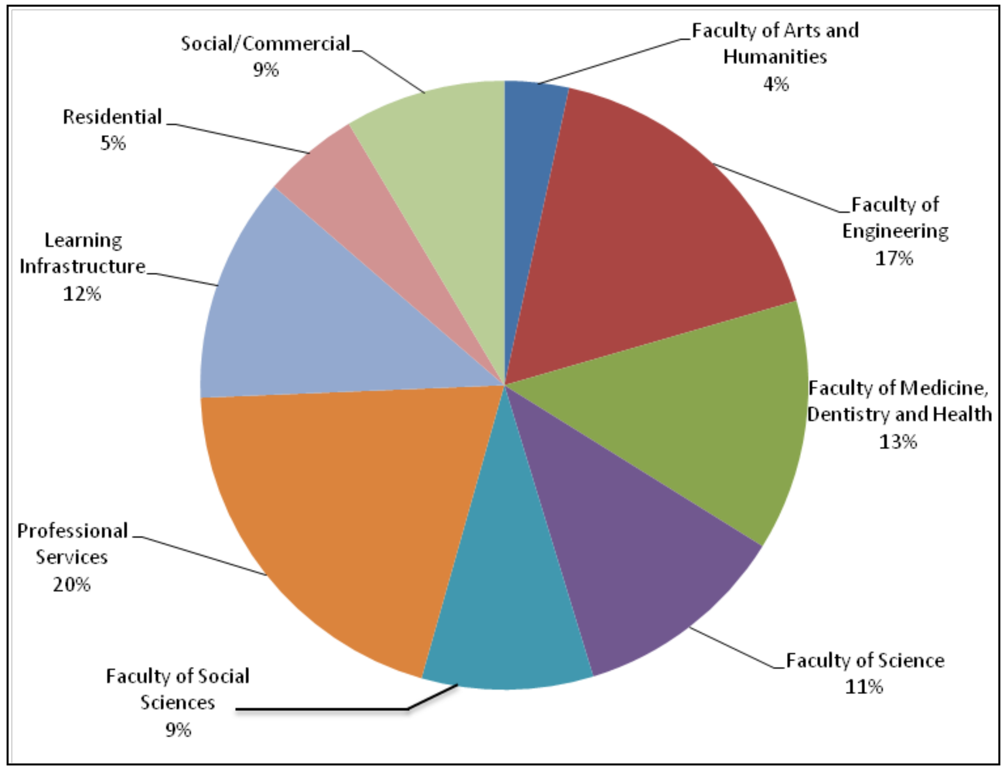


Figure 5: Breakdown of Estate Area (m^2) by Faculty/Service

3.1 Condition

The condition of the University Estate has improved over recent years in response to the 2007/08 TRAC group survey undertaken by HEFCE. The University has committed to increasing the proportion of buildings in HEFCE condition 'A/B' to a minimum of 65%[1] by 2016.

The HEFCE condition rating provides a sound indication of the energy performance of each building. An 'A/B' rating indicates that the building has been typically built or refurbished within the last five years, and/or the building fabric and building services are maintained such that they comply with good statutory requirements. This can be interpreted as the building

[1] The University of Sheffield Estates Strategy 2010-2015, Jan 2011

operating in an effective and energy efficient manner from a building fabric and building services perspective.

A 'C/D' rating indicates that replacement or upgrade of the building fabric or services is required in the short-medium term. A 'C' rated building is still operational but suffers from major operational inefficiencies. A 'D' rated building is deemed inoperable or likely to become inoperable. A 'C/D' rating can be interpreted as the building operating in an energy inefficient manner from a building fabric and building services perspective.

Table 1 below provides a summary of the HEFCE Condition Ratings across the Estate as recorded in the University's Condition Register.

HEFCE Condition	HEFCE Condition Definition	% (m^2) of Estate
A	As new condition	24
B	Sound, operationally safe and exhibiting only minor deterioration	42
C	Operational, but major repair or replacement needed in the short to medium-term (generally 3 years)	27
D	Inoperable or serious risk of major failure or breakdown.	7

Table 1: Current HEFCE Condition of Estate

As shown in Table 1 the University has reached its 2016 target where 66% of the University Estate has been rated A/B. This shows that the vast majority of the buildings are operating in an efficient way.

Although this conclusion suggests that the building interventions discussed in this Strategy are predominately applicable to the remaining 34% of the Estate, there is still scope to integrate many into A/B rated buildings.

Furthermore, although the building fabric and services may be operating effectively in many cases, there may be scope to change the behaviour and habits of the occupants such that the building is used in a more energy efficient way.

3.2 Age and Heritage

The University of Sheffield was established in 1905 and has grown and developed over the past century. Table 2provides an indication of the various ages of buildings across the Estate and the respective proportion of estate floor area.

Age	% (m^2) of Estate
1940-1959	9
pre-1840	1
1840-1913	18
1914-1939	6
1960-1979	42
1980+	24

Table 2: Age of buildings within Estate

Energy efficiency does not necessarily correlate with the age of a building however a building's age will assist in highlighting where building interventions, such as fabric upgrades, are more likely to be applicable.

The University occupies 46 listed buildings. The feasibility of introducing energy saving interventions such as installing cavity insulation or double glazing may be difficult where the conservation of the building heritage is priority.

Figure 6: The Jessop Building and Edwardian Block at the Western Bank are listed buildings.

3.3 Buildings considered as part of the Energy Strategy

To understand the scope for energy saving building interventions across the University, 38 buildings are selected as a sample of the Estate. These buildings and are deemed to represent the various building and occupant characteristics that dictate energy consumption and scope for intervention. These characteristics include:

- University Faculty
- Building Use,
- HEFCE Condition,
- DEC Rating and;
- Year of Construction

A survey of each building was completed considering the condition and control of the heating, cooling, ventilation and lighting building services installations in addition to the condition of the building fabric. A list of the buildings surveyed along with the recommended energy saving interventions is contained within Appendix A.

Due to the lack of energy data available at suitable resolutions, it was deemed necessary to focus the building element of the Energy Strategy upon those buildings where energy data exists and those located within highest energy consuming campus areas. Following assessment of the available energy data, these areas include the Western Bank, St George's and Northern Campuses. The survey work also considered a sample of the older accommodation properties at Broomhill, including Stephenson Hall and a sample building of the Accommodation Services retained estate.

Assessment of the data showed that 91 buildings would form the basis of the Dashboard model and Energy Strategy. These buildings account for 188,000m^2 (45%) of the University's Estate and over 60% of the University's total energy consumption.

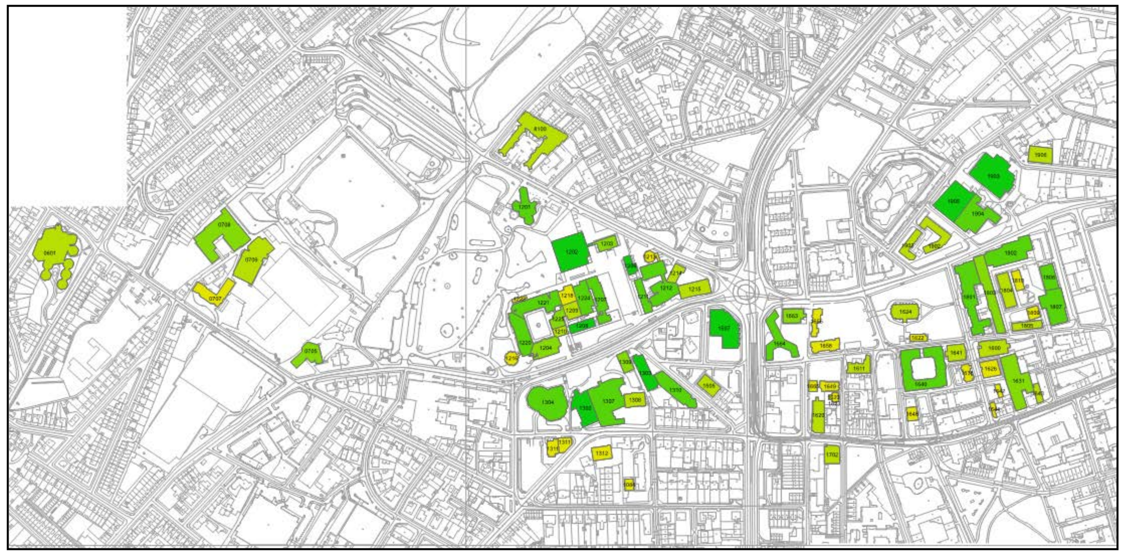


Figure 7 – Distribution of electricity consumption across University estate.

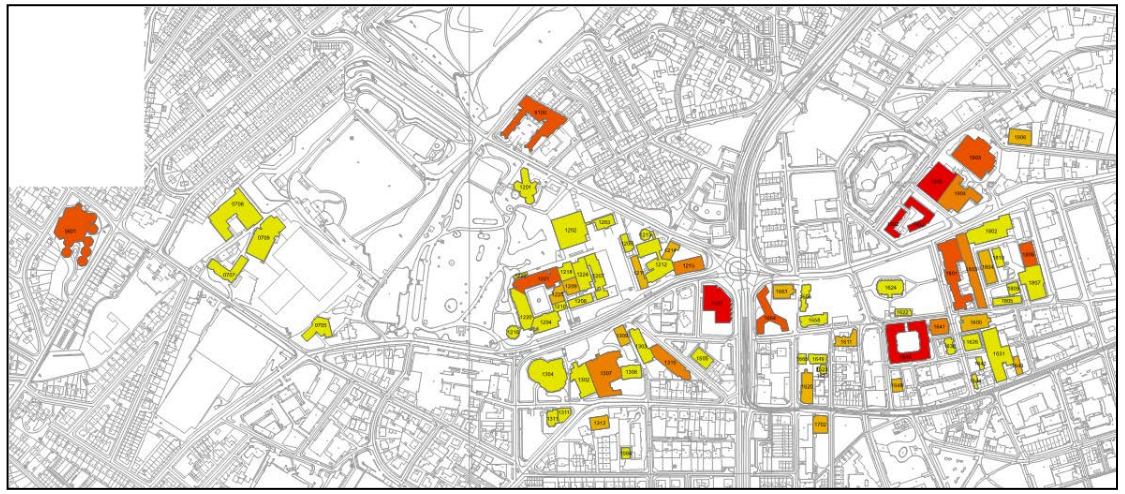


Figure 8 – Distribution of Natural Gas consumption across University estate.

Figure 9 – Distribution of Veolia Heat consumption across University estate.

In addition to the 38 building types, there are a number of buildings across the University Estate that have recently been built or refurbished. In this instance, it was assumed that no interventions are necessary. Furthermore, it is proposed that many of the Faculty of Engineering buildings located within the St George's campus are to undergo a major refurbishment. The proposed refurbishment work as outlined within initial work completed by Arup will be accounted for within the Dashboard Model, including those buildings that are to be demolished.

3.3.1 Survey Constraints

The survey work was limited in many instances by the presence of asbestos. The University manages spaces with asbestos through a traffic light signage system. Asbestos was generally found within plant areas and those areas demarcated by either a yellow or red sign was deemed unsafe. As such, the scope for many of the interventions relating to plant rooms including central plant upgrades or weather compensation have not been determined in detail.

3.4 Space Types

The diverse nature of the University's research, teaching and operational activities means that the range of energy-consuming activities across the Estate are most reliably differentiated by categorising in terms of common space-type functions. For the purposes of this strategy, 15 space types are determined to categorise the use of all spaces across the 91 buildings, these form the basis of the building elements of the Energy Strategy and include:

Room Type	Room Type
Lecture Theatres	Low Energy Usage Laboratory:
General Offices	Clean room Laboratory
Classrooms/Seminars Rooms	Circulation/Lobby spaces
ICT Suite	Back of House Areas
Retail and Leisure	Accommodation
Kitchen	Library
High Energy Usage Laboratory:	Toilets and Changing Areas
Cold Rooms	

The split of room types across the Estate are summarised in figure 9 below:

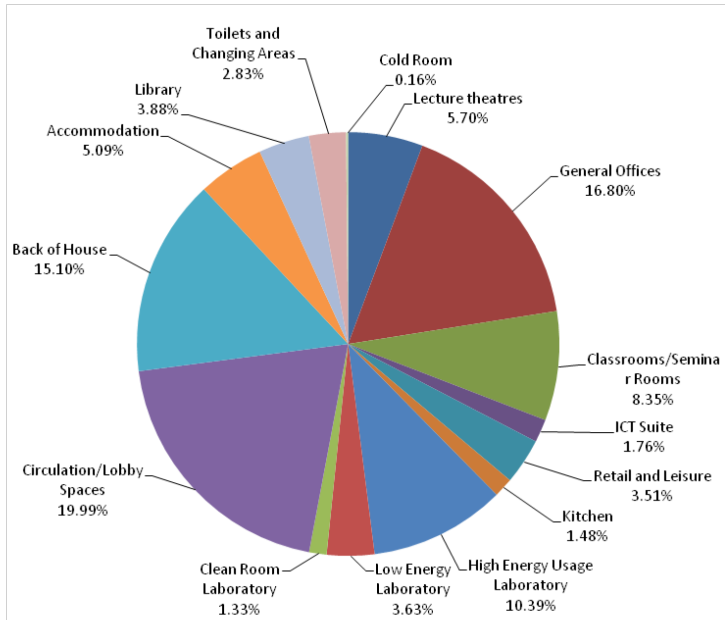


Figure 10: Space Types - % area of Estate

3.5 Energy Performance

To understand how well the University Estate is performing in terms of energy consumption, the annual heating energy consumption figures are compared to benchmarks of typical buildings of that type. The benchmark data is based upon that contained within CIBSE TM 46 guidance document. This assessment was limited to 65 buildings by virtue of them having display energy certificates (DECs) and therefore a full set of data.

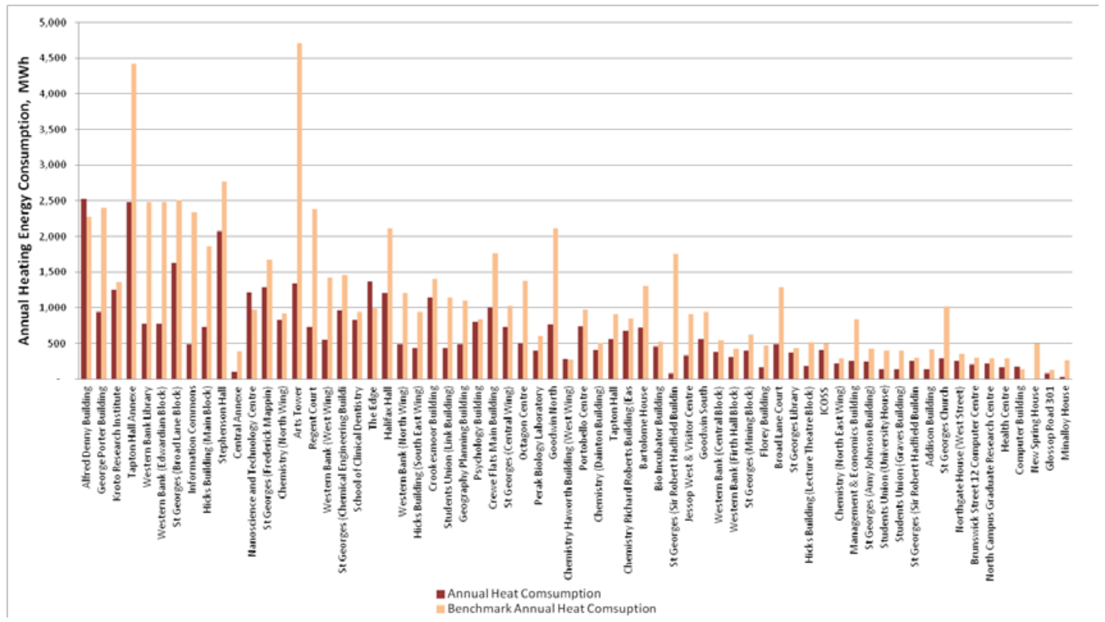


Figure 11: Comparison of annual heating consumption of DEC rated buildings with heat consumption benchmarks

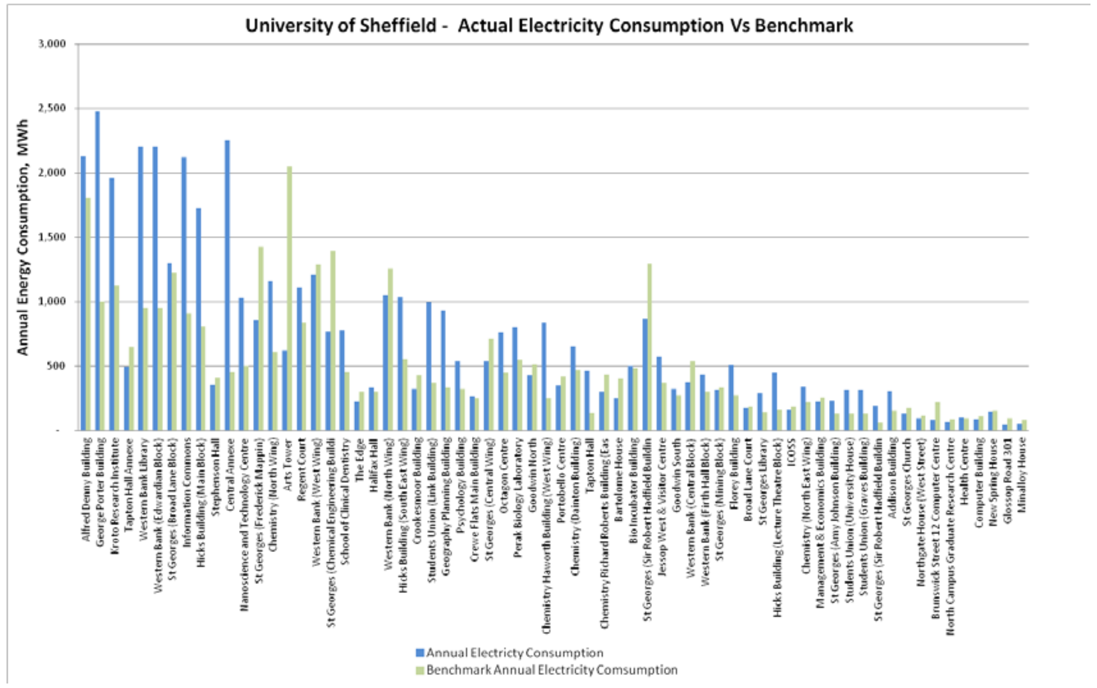


Figure 12: Comparison of annual electrical energy consumption of DEC rated buildings with electrical energy consumption benchmarks

As shown in Figure 11, the study demonstrates that the majority of the buildings with DECs fell below the heating energy benchmark. The exceptions are the Geography and planning building, the Western Bank Central Block, the Students' Union Link Building, and the George Porter Building.

On the contrary, assessment of the electrical energy consumption, as shown in Figure 12, concludes that the majority of the DEC rated buildings significantly exceed the electrical energy benchmarking figures.

A further plot of building energy use data follows, this time displaying the relative consumption per square metre of floor area, thus displaying their relative energy intensity.

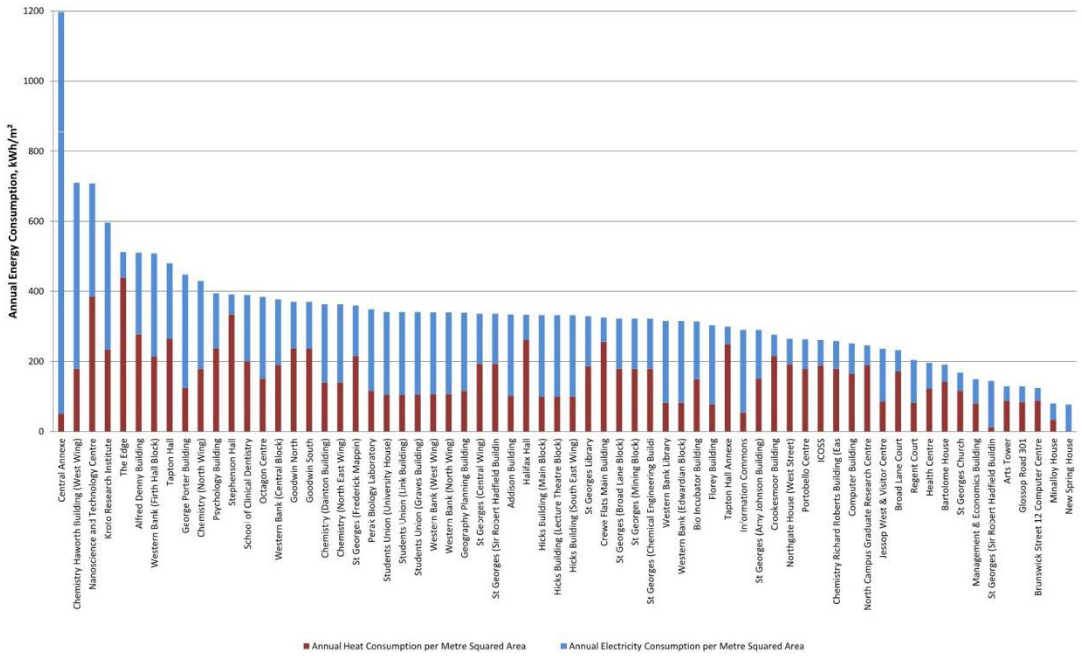


Figure 13: Plot of building energy consumption per square metre of floor area

The DEC rated buildings occupy 257,482m^2 (62%) of the Estate and estimated to amount to over 70% of the total University energy consumption. However the findings show that although reduction in thermal energy consumption and carbon emissions are required in order the meet the HEFCE targets, there is significant scope to reduce electrical energy consumption. This can be achieved through both building and behaviour change interventions as discussed in later section.

3.6 Refurbishment Work

The University Estate has undergone a refurbishment programme of mechanical services and lighting equipment carried out by the contractor Schneider and building fabric improvements with Bond Bryan Building Surveying. It is understood that this programme is to continue from early 2012 for a period of two years.

The aim of the refurbishment work is to reduce carbon emissions by 2,408 tonnes and provide a return on investment of 7.8 years. The planned refurbishment work will include the following elements of work.

3.6.1 Lighting

The installation of improved lighting controls and LED lighting is planned for a number of buildings surrounding Firth Court including the Alfred Denny Building, Edwardian Block, Central Block/Perak, and the West Wing.

3.6.2 Exhaust ventilation schemes from heat generating equipment in laboratories

The laboratory areas within the University use a high density of heat generating equipment such as fridges. The University plans to install exhaust ventilation schemes to remove this heat, reducing the risk of overheating and mechanical cooling loads within the buildings. The exhaust schemes are planned for the Alfred Denny Building, the Western Bank West Wing, and the Florey Building.

3.6.3 Free Cooling schemes

The planned free cooling schemes aim to save 995,000kWh of electrical energy. The schemes are planned for the Alfred Denny Building, Richard Roberts Building, Central Block/Perak, Students Union, Frederick Mappin Building, and the Nanoscience building.

3.6.4 Other Building services energy saving projects

Many other projects are planned across the Estate, aimed at reducing energy consumption. These include:

- Install electricity meters
- Improve BMS system
- Install variable speed drives on pump sets
- Optimise control on cooling systems
- Upgrade DHW plate heat exchanger controls with BMS link
- Chiller system upgrades
- Installation of PIR sensor control of fans and lights
- Push button control on ICT room cooling systems
- Installation of weather compensated heating circuits
- Improvement of AHU plant and controls
- BMS connections to district heat meters
- Repair faulty windows
- Installation of ventilation free cooling system

3.6.5 Building Fabric improvement projects

The University has also been working with the Bond Bryan Building Surveying team to upgrade building fabric elements with the aim of improving the energy efficiency of the Estate.

Building	Description
Hicks Building	Improved thermal insulation within the roof Re-cladding and insulation upgrade of plant rooms
Broad Lane Building	Re roofing including upgrade of thermal insulation Replacement of doors and windows with new thermally efficient units in place of steel casement single glazed units.
Octagon	Re roofing flat and pitched roof areas including increased thermal insulation Replacement of timber door sets with insulated steel doors.
North Campus	Flat roof re-roofing including thermal upgrade in deck
Vacant History Buildings	Sash window refurbishment (seals etc) 3A Potential uPVC windows 3A Potential wall lining 3A Potential ground floor insulation 387 Potential ground floor insulation Boiler replacement
Portobello Building	Re Roofing Works – Installation of new roof insulation under new single ply membrane and installation of triple glazed roof lights. Replace cladding to plant room roof with new insulated panels.
Robert Hadfield Building	Installation of new double glazed windows to lab / workshop area and offices
387 Glossop Road and 1 Clarkehouse Road	Re roofing including installation of new roof insulation laid between joists
CICS Hounsfield Road	Replacement of existing windows with new double glazed units

Table 3 – Building Fabric Improvement Projects

4 Infrastructure Strategy Approach

The existing infrastructure will play a key role in the future energy strategy for the University.

4.1 Supply

The current energy demands across the University estate are met through three main solutions;

- Heat supplied from the Sheffield city heat network, operated by Veolia;
- Natural gas supplied via the public infrastructure for heating; and
- Electricity supplied via the local distribution infrastructure.

The capacity and integrity of this infrastructure will have a direct influence upon the energy supply and generation options open to the University as it develops over the short, medium and long term. As such understanding the opportunities and limitations of the local infrastructure and therefore where investment may be required in the coming years will be key in developing a suitable energy strategy for the University.

4.1.1 Veolia Heat Network

The Sheffield city heat network, operated by Veolia, is supplied from the Veolia energy-from-waste (EfW) plant situated to the east of Sheffield city centre, the Bernard Road facility. The network supplies heat to over 140 buildings across the city and has been developed over a period of 50 years.

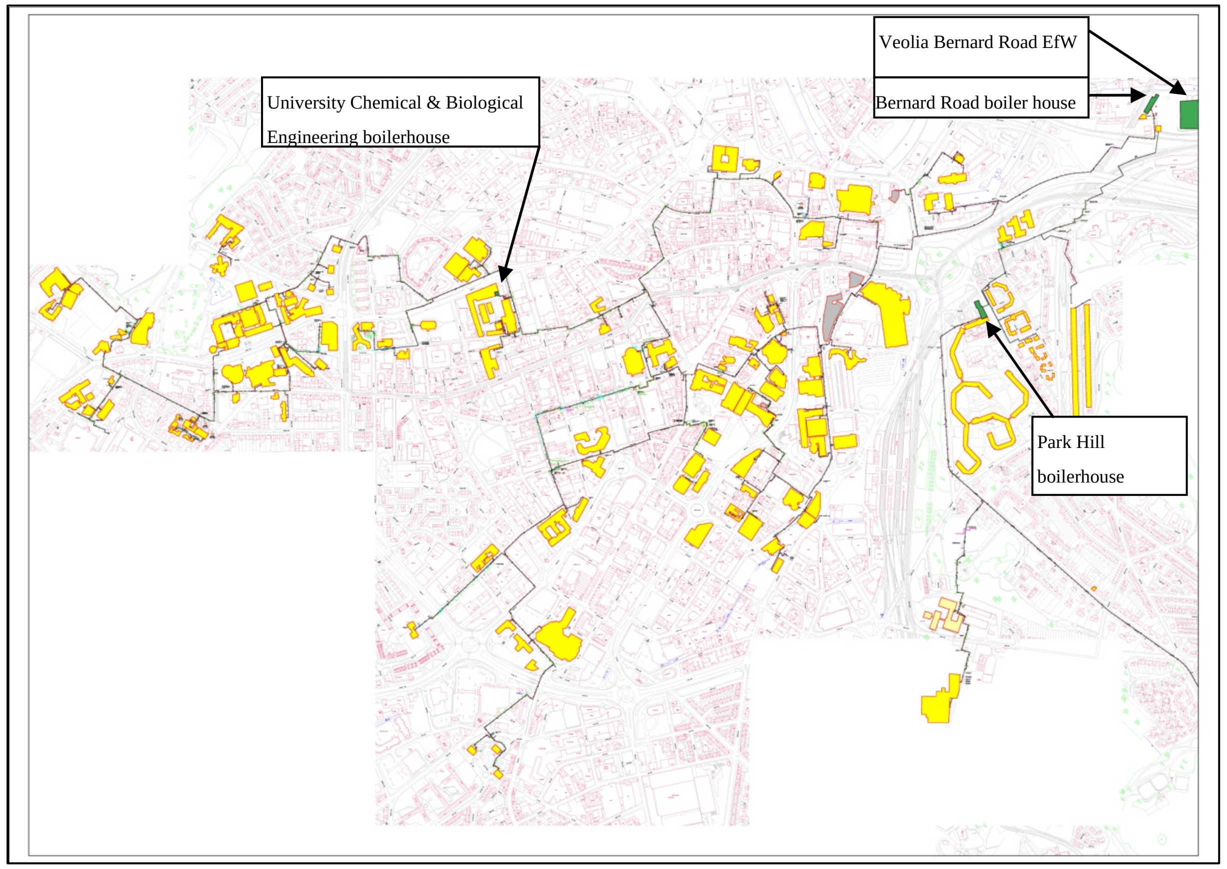


Figure 14 - Veolia Heat Network

The heat network serves a total of 50 buildings within the University's estate from the St George's campus to the Goodwin sports complex.

The Veolia heat network provides low carbon heat as a result of being primarily supplied by the EfW facility. Back-up supply systems are provided by natural-gas and oil-fired boiler plant located in three locations; at Bernard Road, Park Hill and the University's Chemical and Biological Engineering Building. See Figure 8 for the gas distribution.

The carbon emissions factor of each unit of heat delivered to the University buildings by the Veolia network is lower than that of natural gas as 50% of the waste fuel stream serving the Bernard Road EfW facility is deemed renewable biomass, see below:

Heat Type	Emission Factor (kgCO_2e/kWh)
Natural Gas	0.183
2012 Veolia Heat Network	0.137

Table 4 – Carbon Emission Factors for Heat

The variability of Veolia carbon emissions over time to the present factor presents element of reputational and financial sensitivity to the customers it serves. Since the auditable calculation methodology was approved by DEFRA, the perception is that the emissions factor of heat supplied by Veolia has increased by around 30% from around 0.10 to 0.137kgCO_2e/kWh. This matter is discussed in more detail in sections 5 and 7. Briefly, the reasons for the rise are; that the DEFRA approved calculation method has been adopted, and standby/supplementary boilers have been operated for longer periods due to high winter demand and unforeseen network and EfW plant outage.

The interfaces between University buildings and the heat network infrastructure vary across the estate. Some buildings are connected to the Veolia heat network, with hydraulic separation via dedicated heat exchangers. Other groups of buildings are connected to small secondary networks via a single heat exchanger. Due to this mix of connection practices applied across the University's estate the level of energy data available is poor. Of the 50 buildings supplied by Veolia, 48 have Automatic Meter Reading (AMR) capable meters, however most are inaccessible due to the presence of asbestos.

On-going discussions with Veolia have been conducted as a key part of this energy strategy study. These discussions have focussed upon options for the University to work more closely with Veolia in order to ensure future security of supply and therefore business continuity as well as maximising the opportunities available to the University in terms of carbon and cost reduction.

4.1.2 Electricity Infrastructure

The majority of the buildings within the main campus areas of the University's estate are supplied via two high-voltage (HV) distribution rings. These systems are supplied via the local distribution network. All buildings not connected to the University's distribution systems are supplied via separate connections.

Drawings of a section of the existing infrastructure and associated data have been made available by the University. Based on the information made available and assessment of the opportunities and risks associated with the existing infrastructure has been undertaken.

An HV/LV scheme for the Western Bank Electrical Infrastructure has been made available and is shown in the figure below.

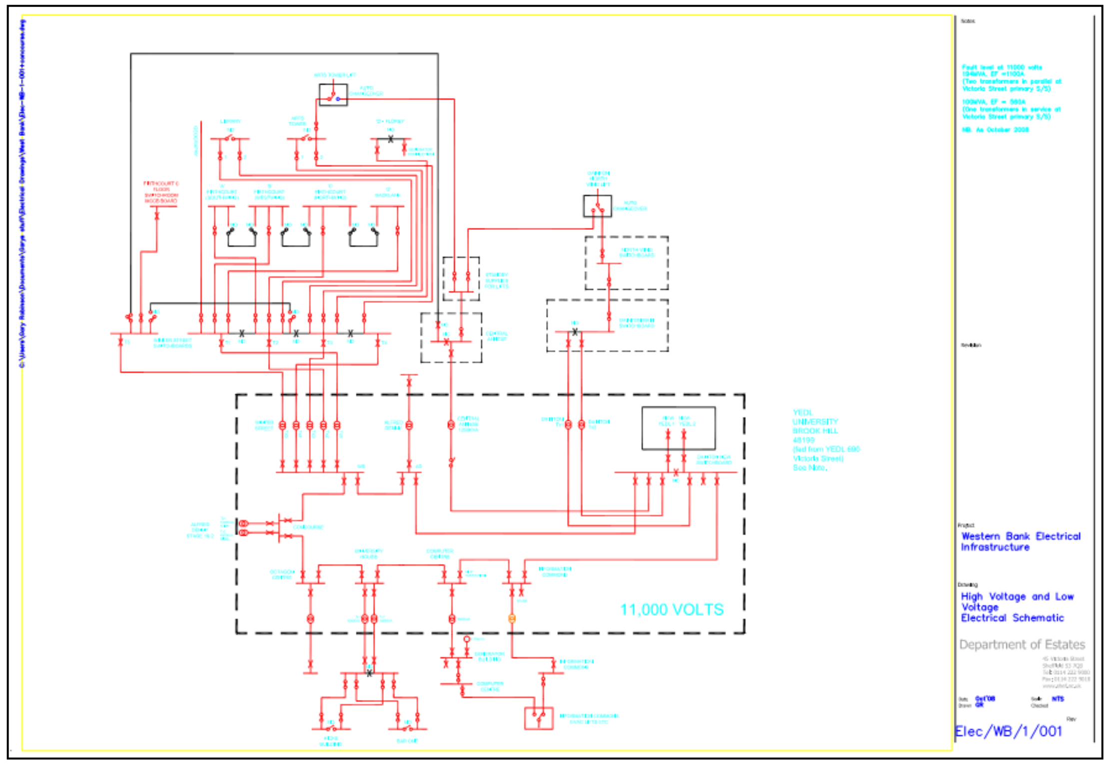


Figure 15 - Western Bank Electrical Infrastructure

The schematic made available indicates the University system is provided with duplicate 11kV feeds from the Northern Power Grids (NPG) network. These connect into the Dainton New Switchboard which in turn provides six feeds out to the University private system. Downstream feeds are a combination of closed ring and interconnected radial circuits.

The diagram also shows a 1250 kVA generator connected at LV via switchgear within the Generator Building. It isn't clear if this is simply a standby generator or if it is capable of parallel operation.

The existing electrical infrastructure will directly impact upon the potential to connect self generation opportunities across the estate. Insufficient information has been made available to allow for definitive connection locations within the infrastructure to be identified. Other considerations that might limit opportunities for connection, for which we do not have information at present are: agreed supply capacity of the site's connection to NPG; the network utilisation level; andother considerations such as fault levels.

Based on the Western Bank information made available it appears that connection options for physical connection of generation exist at both HV and LV levels. Existing options for the HV connection of larger sources of generation (~ 1.5 MVA and above) include spare circuit breakers shown on Dainton New Switchboard and the Information Commons switchboard. Beyond this options may exist for the extension of switchgear within other substations.

Existing options for connection of smaller sources of generation appear limited with the only spare circuit breaker shown being on switchgear within the Information Commons switchroom. Beyond this, options may exist for the extension of switchgear within other switchrooms.

It is understood that in addition to the Western Bank Campus the University has a number of other facilities dispersed around the City and that these each have discrete connections to the NPG network. The number, size and nature of these connections has to date not been identified.

Without further information it is not possible to identify specific opportunities for the connection of generation at these dispersed sites. Options almost certainly exist although these would need to be explored on an individual basis.

If any potential projects for deploying self generation across the estate are pursued then a more detailed investigation should be completed on an individual basis. This study should consider:

- Physical connection arrangements;
- Impact of generation on existing systems; and
- Dialogue and connection permission discussions with NPG.

It should be noted that in almost all cases it will be necessary to seek permission from NPG to operate generation in parallel with the public network even if the connection point lies deep within the University's own network. NPG may also charge for feasibility studies, network reinforcement and witnessing of testing.

4.1.3 Metering

Current metering arrangements within the University's distribution systems are limited with electrical supplies metered at the connection point to the local distribution infrastructure only. The University are currently attempting to improve on the current metering arrangements through the work being undertaken by Schneider and by deploying a wider metering strategy. As a result the majority of the buildings connected to the Western Bank distribution infrastructure are now sub-metered to some degree.

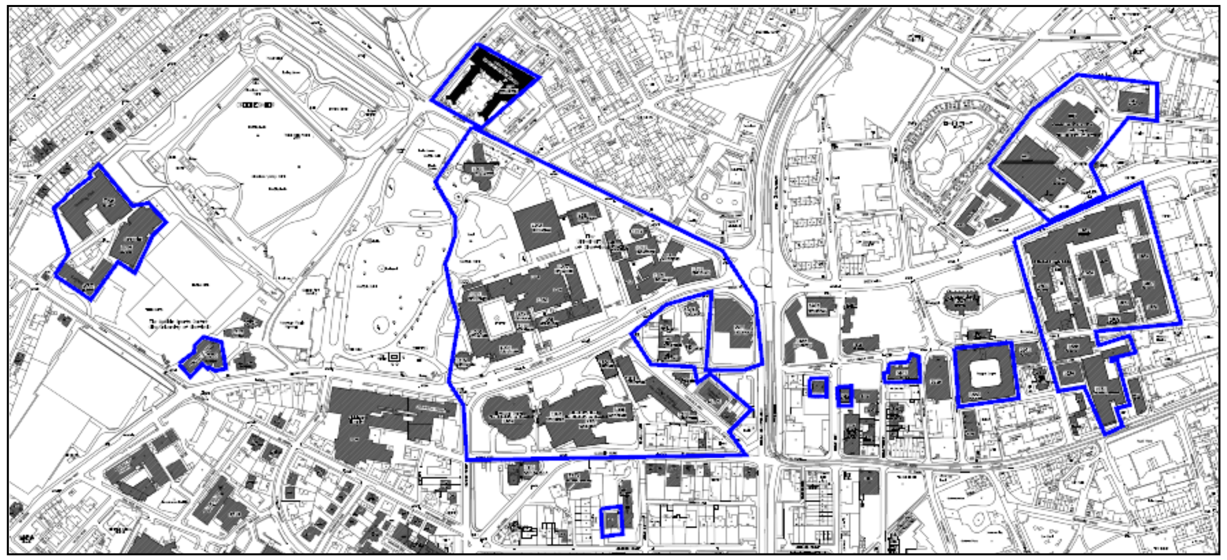


Figure 16 – Electricity Metering Zones for Western Bank & St George's campus areas

4.1.4 Energy Procurement

The University currently purchases all half-hourly metered electricity from Gasprom, while all non half-hourly metered electricity is supplied from Southern Electric.

The University currently purchases its electricity under a 'Green Electricity' tariff covering all supplies to the academic campus. The University pay a premium for this tariff, although this is negated by the offset in climate change levy. The University receives no carbon emission benefit from this electricity tariff under the Carbon Reduction Commitment (CRC) scheme.

4.1.5 Natural Gas Infrastructure

Where buildings are not connected to the Veolia heat network the thermal demands are met via the use of the natural gas network. Natural gas is supplied to a variety of buildings across the University's estate. These buildings include smaller loads within the main campus areas and the satellite buildings around the three main campus areas. There are no known constraints on the natural gas network in the University campus areas of Sheffield beyond usual anticipated civil engineering requirements.

However, greater reliance by the University on natural gas as a substitute or supplement to Veolia district heating will add a degree of risk in terms of business continuity.

Consumption data has not been forthcoming and gas network data is deemed inappropriate given the stage of this assessment.

4.2 Generation

The majority of the generation assets deployed across the University's estate take the form of natural gas fired boiler plant. These systems are utilised where buildings have not been, or cannot be, connected to the Veolia heat network.

4.2.1 Conventional Plant

No asset register has been made available as part of this study and as a result it has been difficult to take an overall view on the current boiler systems deployed across the University's estate. Where possible, plant has been inspected as part of building surveys. This has provided a general view on asset condition, age and capacity in a range of buildings across the campus.

Where possible, the hydraulic interfaces between the University's estate and the Veolia heat network have also been inspected.

4.2.2 Renewable Generation

Building Integrated

Following workshop events with all University faculties, it is understood that the only location for existing building-integrated renewable self-generation is atop the Hicks building, comprising 58 m^2 of photovoltaic panels.

The workshop with Accommodation Services reported that recent scoping work had been undertaken in relation to the possibility for further PV deployment on University residential buildings. However, following recent revisions to the Government's Feed-in Tariff structure, these plans are shelved on commercial grounds.

Offsite

A 900 kW-rated wind turbine currently operates at the University's Advanced Manufacturing Research Centre (AMRC), located on the Advanced Manufacturing Park to the East of Sheffield.

5 Behaviour Change Strategy Approach

The 2010 publication from HEFCE entitled ‘Carbon reduction target and strategy for higher education in England’ clearly stated the case for embedding behaviour change into institutions as an effective way of reducing carbon emissions.

Behaviour change is estimated to provide a significant potential for carbon abatement (0.2 $MtCO_2$ for the HE sector as a whole) which is comparable to the more ‘traditional’ interventions of building fabric upgrades (0.28 $MtCO_2$) and renewable energy (0.3 to 0.6 $MtCO_2$). However, whereas the investment required to realise the savings in building fabric and renewable energy for the sector is estimated as hundreds of millions, the investment required is described as ‘minimal’.

It is clear that a co-ordinated approach to behaviour change should form an essential cornerstone of any efficient carbon management plan.

5.1 Underlying principles

Addressing the buildings, infrastructure, technology and systems will not in itself be sufficient for the University to achieve its carbon reduction targets. There is also a need to address the people and behavioural issues, to support University staff, students and the wide range of stakeholders in adopting new behaviours and practices which help to promote energy saving and a more sustainable way of operating and living within the University. In effect, this is about creating a culture of energy saving and sustainability.

Arup’s past work and research within the area of ‘green’ behaviours has led to the development of a set of key factors which will influence the degree to which people will choose to adopt ‘green’ behaviours. These key influencing factors are shown in the model below:

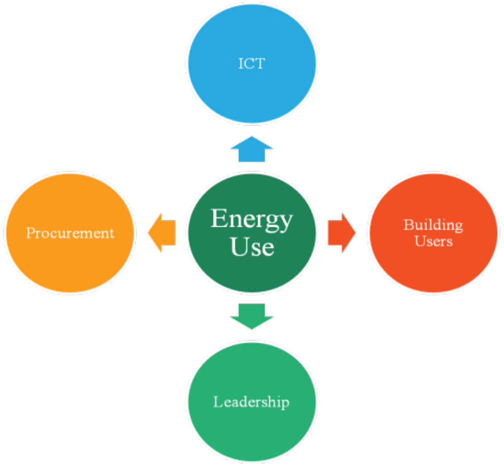
These influencers are briefly outlined in the table below:

Element	Description
Communication and information	Information and communications should be relevant, specific and tailored to the stakeholder groups, and should come from a credible source. Increase salience through novelty and relevance.
Social norms	Individuals are influenced by what they see and know others are doing, with an inclination to want to follow the majority
Leadership	Leaders need to visibly support and reflect sustainable behaviours in their own actions, promoting a positive attitude and reinforcing the sustainability agenda
Policy and procedures	Formalising sustainable behaviours through integrating them into policies and procedures and inclusion in staff appraisals
Addressing barriers to change	Understanding how past behaviours and routines may impede behaviour change, identifying barriers through consultation, helping to break existing habits, supporting gradual change
Attitudes	Supporting gradual shift in attitudes as a consequence of behaviour change
Effort and convenience	Minimising the effort required to behave in sustainable ways, making it easy and convenient
Information	Providing clear relevant and specific information that is tailored to the audience. Includes procedural information to inform individuals of what they can do
Control	Ensuring individuals are trained, informed and feel personally in control of being able to act in sustainable ways
Feedback	Providing feedback on performance to positively reinforce efforts and maintain motivation levels
Goal setting and competition	Providing comparative performance data for appropriate groups to encourage friendly competition and enhance motivation to achieve targets
Reward and recognition	Recognising and rewarding success through appropriate and suitable means

Interventions designed to promote behavioural change in relation to green behaviours should include consideration of these factors in order to ensure maximum impact and success.

5.2 Our approach

Arup's approach to the behaviour change aspect of this commission involved engaging with the range of stakeholders to explore the key influencers of 'green' behaviours, and to develop opportunities for Behavioural Change to be included in the Energy Strategy. The opportunities are to be developed in relation to the four key facets of the model below:



These four elements are outlined below:

5.2.1 ICT

This area relates to promoting energy efficient behaviour in both the individual and organisational through the use of Information, Communications and Technology (ICT) equipment. In addition to this, ICT can also be used as a method of communicating energy efficient behaviour strategies across the University.

5.2.2 Building Users

There is a need to support all individuals in changing everyday energy related behaviours, enabling gradual transformation of attitudes to energy saving practices and changing energy efficient behaviour from being optional and occasional to habitual, thus creating an energy efficient culture within the organisation.

5.2.3 Leadership

The approach includes consideration and engagement with University leadership to enable and motivate behaviour change. Leaders need to be supported in visibly demonstrating and reflecting their commitment to the energy efficiency agenda, and to begin to think differently about the ways in which University spaces are designed and used to maximise energy efficiency.

5.2.4 Procurement

Changing behaviour in terms of procurement, for this project, means developing an understanding of the decision making process, and putting greater emphasis on considering and incorporating energy efficient behaviour into the University's purchasing decisions and in the choice of products to be procured.

5.3 Application

It should also be noted that these four areas are not mutually exclusive; there will be some interdependence between these. For example, utilising ICT to effectively communicate messages relating to energy use will have an influence on building users; creating strong leadership with a visible commitment to saving energy will also impact upon other building users and may influence procurement decisions. Therefore, the approach does not seek to explore opportunities for each of these areas independently, but instead takes a holistic view, considering opportunities which together ensure an overall positive impacted through reduction in energy use.

The workshops and meetings held with key stakeholders enabled the behavioural change specialists within the Arup team to develop opportunities, through consideration and discussion of the key influencing factors. The opportunities which emerged are in the form of both enablers (those elements which are required to underpin and support actual behaviour change) and actions themselves.

In addition to the workshops held with stakeholders from the Faculties and Accommodation Services, members of the Arup team focusing on behavioural change also held meetings with representatives from the University's computer services (Corporate Information and Computing Services - CiCS), Procurement and The Energy and Environment Team services in order to ensure that all four elements of the model are addressed, in an holistic approach.

5.4 Existing University Activities

The University has already made significant steps forward in terms of promoting behavioural change in relation to sustainability, and has several behaviour change programmes that have either been delivered or are currently ongoing. These include:

- Green Impact environmental accreditation scheme: The scheme brings together staff, students and the wider community to encourage positive changes in environmental practices. It covers a wide range of environmental issues such as energy, recycling, water, transport, and biodiversity. There are currently 25 teams across the University taking part. Through participation in the scheme, teams can win a range of awards, from 'Working Towards Accreditation' to 'Gold' standard. This scheme is making appositive impact on promoting awareness and pro-environmental behaviour. However, Arup's research found that, specifically in relation to energy use, there is currently no direct link between energy use (i.e. amount saved) and behaviour. Providing information that enables people to understand the direct impact their behaviour has represents an opportunity to promote behaviour change.
- 'Student Switch off' campaign: This scheme targets appliance use in the student population. This programme has been underway since September 2009 and is supported by University Leadership. Accommodation Services have signed up to the scheme again in September 2011, reflecting a positive commitment, with an Energy and Environment Coordinator in post who is able to engage directly with students as a key element of this scheme. Almost 1500 student volunteers have also signed up to be "Power Rangers" as part of this scheme. The programme has seen significant success, with almost 10% of energy saved during the first four months, and 4% reduction in energy usage during 2010/11.
- Energy Fairy: a blog and twitter feed of energy saving tips, which includes 'walk-arounds', and the giving of prizes (biscuits) for where energy is being saved (e.g. by

switching things off). However, again the direct link between individual behaviours and amount of energy saved needs to be developed to ensure further success.

- Environmental Champions: Within the Faculty of Science several Environmental Champions have been recruited, through a top-down approach of calling for volunteers. These individuals are engaged in the Green Impact Scheme, but also provide a link between the Faculty and Estates and Communications on energy use monitoring.
- BeCause: a University-wide brand is currently being developed, to encompass all sustainability-related activity and demonstrate the University's commitment to sustainability, both internally and externally. This scheme is due to be rolled out in early 2012, with themes planned for the first 6 months which directly involve and engage the University Leadership, supporting the need for visible commitment from leadership to promote behaviour change.

Arup's approach therefore aims to build on the momentum and commitment that is already evident through the range of initiatives already happening across the staff and student population, creating opportunities which build on these initiatives and incorporate the psychological considerations needed to truly achieve behaviour change.

6 Drivers and External Influences

A number of internal and external influences directly impact upon current and future decisions taken by the University with respect to energy.

Internal drivers and influences primarily relate to the University's operation and in particular the need to provide business continuity. Business continuity is essential for smooth operation of the University's academic and estate facilities; adverse impact to business continuity ultimately has a cascading negative effect on commercial bottom line and reputational standing.

External influences impose on the commercial cases for self-generation and infrastructure and similarly interact with the long term business continuity of operations across the University's estate.

6.1 Business Continuity

In the context of this energy strategy, business continuity relates to security of supplies and the management of preventative maintenance in order to avoid outage and in particular extended mean times between failures which can exaggerate operational disruption risk.

6.1.1 Infrastructure impacts

The University is therefore exposed to business continuity risk from the following infrastructure level energy systems:

- Failure of electricity distribution network;
- Failure of University standby generators and UPS;
- Failure of University high and low voltage networks;
- Failure of natural gas supply network;
- Failure of University thermal generation and distribution systems (hot and cold);
- Failure of University natural gas distribution systems;
- Failure of Veolia heat network; and
- Failure of Veolia heat interface systems.

6.1.2 Operational and maintenance limitations

Operational and maintenance limitations influence the risks to business continuity due to Veolia and University shortcomings.

In this regard the main observations are that there appears to be no operating and maintenance planning undertaken jointly between the University EF&M and Veolia.

6.1.3 Asbestos impact

As stated in both building and energy infrastructure discussions the managed asbestos as registered by the University is present in most plant room areas and represents a significant barrier to improvements to maintenance, energy saving improvements and is therefore a business continuity risk.

6.2 Energy Costs

Future energy costs within the UK potentially represent both a risk and an opportunity to the University in the medium to long term. Many economists are currently predicting that energy prices will increase in the long-term as a result of spending on infrastructure within the UK, wider global energy market factors and government policy focussed on green investment.

Price projections made available by the Department of Energy and Climate Change (DECC) are shown in the two figures below. The data plotted show retail tariff projections for a 'commercial' consumer of electricity and natural gas supplied from the conventional means.

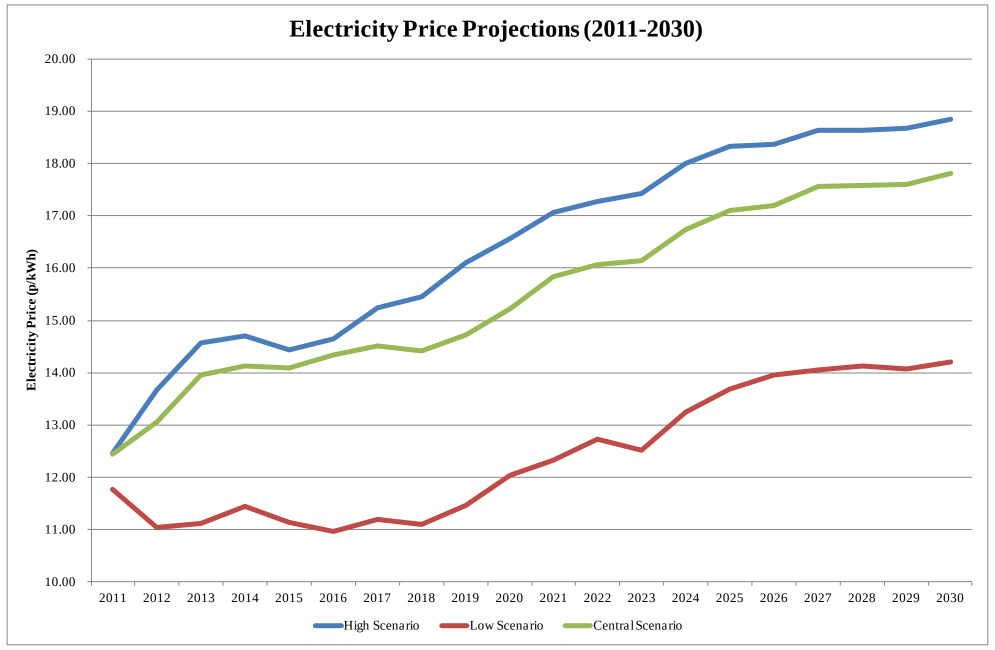


Figure 17 - Electricity Price Projections

The data made available by DECC predicts a clear increase in energy prices over the short to medium term. The low scenario predicts an increase in electricity prices of 2.3% per annum while the central and high scenarios estimate an annual increase of 4.1% and 4.4% respectively.

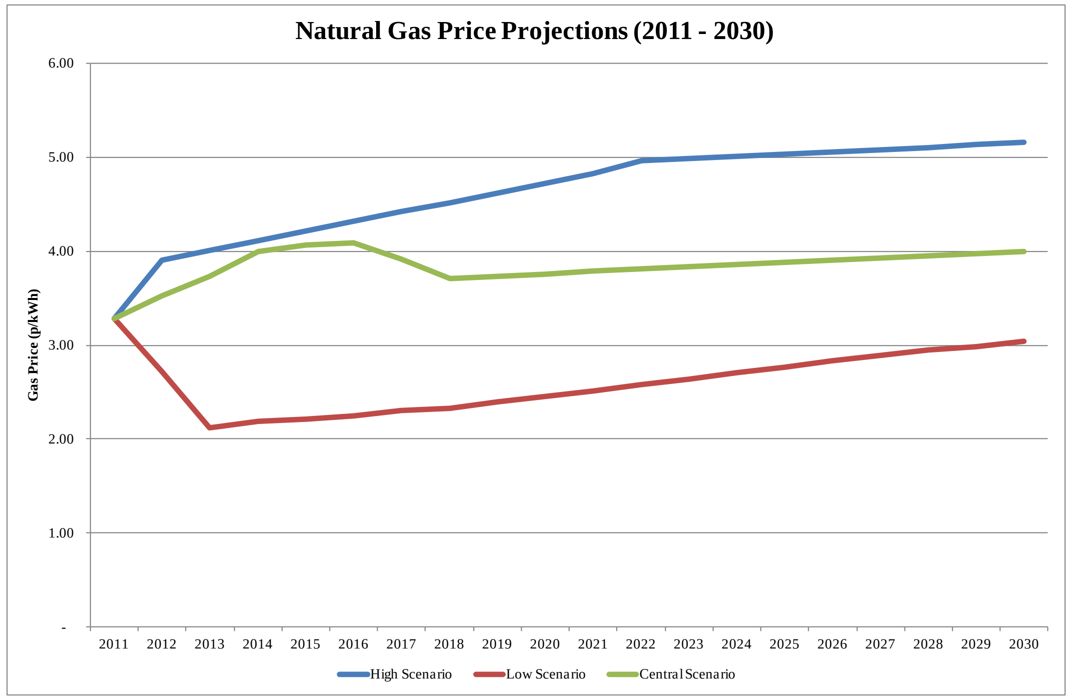


Figure 18 - Natural Gas Price Projections

Similarly, the projections of natural gas prices also show an increase for all three scenarios. The low scenario predicts a compound annual growth rate of 1.3% while the central and high scenarios predict rates of 2.7% and 4% accordingly. These projections show that natural gas prices are expected to increase at a lower rate than electricity prices. This can be assumed to be as a result of fewer policy changes affecting the natural gas market and a greater reliance on the wider global energy markets for supply.

The result of this is a potential risk to the business continuity of the University due to the current exposure to the energy markets. This risk could be mitigated by reducing total energy consumption and by considering the use of self generation systems across the estate.

As energy prices continue to rise, the commercial case for deploying self generation opportunities will improve. This is as a result of the savings associated with generating electricity, particularly from renewable sources, increasing.

6.3 Government Policy

Government policy has a major influence on the energy strategy of any large energy consumer. Current and future policy has the ability to open up and restrict a range of opportunities, particularly self generation options, and can also introduce a range of risks which need to be taken into account in short, medium and long term planning.

6.3.1 Carbon Reduction Commitment

The CRC is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large public and private sector organisations.

The Government has published a consultation on simplifying the CRC Energy Efficiency Scheme. The consultation document includes proposals which aim to streamline and simplify the scheme to create a new leaner, simplified and refocused CRC. The simplified CRC will deliver its energy efficiency and carbon reduction objectives whilst making compliance easier and less burdensome for participants.

As stated by Government in the October 2011 spending review, “The CRC Energy Efficiency Scheme will be simplified to reduce the burden on businesses, with the first allowance sales for 2011-12 emissions now taking place in 2012 rather than 2011. Revenues from allowance sales totalling £1 billion a year by 2014-15 will be used to support the public finances, including spending on the environment, rather than recycled to participants. Further decisions on allowance sales are a matter for the Budget process.”

Yet again the CRC is the subject of review and reform as suggested by Government in the 2012 Budget announcement that: “The Government will consult on simplifying the CRC Energy Efficiency Scheme to reduce administrative burdens on business. Should very significant administrative savings not be deliverable, the Government will bring forward proposals in autumn 2012 to replace CRC revenues with an alternative environmental tax, and will engage with business before then to identify potential options. Allowances sold with respect to 2012–13 emissions will be £12 per tonne of carbon dioxide.”

6.3.2 Electricity Market Reforms

The Electricity Market Reform (EMR) White Paper is not directly impacting on the University but will instead indirectly have a bearing. The EMR sets out the Government’s commitment to transform the UK’s electricity supply to ensure that our future electricity supply is secure, low carbon and affordable.

The package of reforms in the 2011 paper are geared to ensure that the UK has flexible, smart and responsive energy system, powered by a diverse and secure range of low-carbon sources of electricity.

The paper highlights that we face a number of unprecedented challenges in the coming decades. The main concerns for the UK over the coming years are:

- Security of supply;
- The need to decarbonise electricity generation;
- Likely rise in demand for electricity; and
- Expected rise of electricity prices.

6.4 Incentives

Incentives currently available for the generation of low and zero carbon energy have a significant impact upon the commercial viability of deploying a range of technologies. The requirement to rely on these incentives in order to meet investment criteria introduced a potential risk to the University when consider the deployment of self generation solutions.

Understanding the current opportunities and risks associated with the various incentive schemes will be key in managing the investment risk for the University.

6.4.1 Feed-in Tariffs

The Feed-in Tariff (FiT) scheme, introduced in 2010, provides incentives for the generation or low and zero carbon electricity from small installations. A range of technologies are supported and receive a payment for each unit of electricity generated from an eligible and accredited system. Systems up to a capacity of 5MWe are eligible for the scheme.

Tariff rates are defined based on technology type and capacity and are originally defined on the basis of providing a return on investment of 5%-8%. The scheme is funded through a levy on electricity suppliers.

The FiT scheme has resulted in a significant take up of renewable electricity generation across the UK. This take-up was significantly above the UK government's projections and resulted in a 'fast-track' review of tariff levels for PV systems.

The scheme is currently undergoing its first full review of tariff levels, the revised tariff levels are set to be introduced from April 2012.

6.4.2 Renewable Heat Incentive

The Renewable Heat Incentive (RHI), introduced in 2011, provides an incentive to generators of heat from renewable sources. The scheme has been set up to sit alongside the schemes for incentivising electricity generation from renewables, i.e. ROCs and FiTs.

Under the scheme, generators of renewable heat are paid a tariff per unit of heat generated. The tariff level varies across technology type, installed capacity and date of installation and are payable for 20 years. The tariff rates have been defined on the basis of bridging the gap between conventional heating technologies and renewable systems, and tariffs have been defined on the basis of providing a return on investment of up to 12%.

Tariff rates and eligibility criteria for the scheme have been programmed to be conducted on a regular basis. This will ensure that the tariff rates reflect the current market conditions and the likely reduction in costs associated with greater technology development and take-up.

The RHI scheme is currently funded by the UK government and a fixed amount of funding has been made available for the scheme. As a result it is unlikely that the scheme will remain open to new entrants beyond the short to medium term.

6.4.3 The Renewables Obligation

The Renewable Obligation Order came into force in 2002 and is designed to encourage the generation of electricity from renewable sources. Electricity suppliers meet the Renewables Obligation by presenting Renewable Obligations Certificates (ROCs) which are issued for each MWh of renewable electricity produced. Suppliers can meet the obligation by either presenting ROCs issued for their own generated renewable electricity or by purchasing ROCs from other generators on the open market.

ROCs are a tradable commodity and are generally sold through auction sites. The current market value for 1 ROC is approximately £50. As of 1st April 2009 a new ROC banding system has been in place with the aim of encouraging the take-up certain capital intensive renewable technologies, the banding levels are currently under review.

The RO scheme is currently planned to be phased out under proposals within the EMR. As of 2017 new generators will not be eligible to sign-up for the RO scheme and will instead have access to the FiT CfD scheme.

6.4.4 Feed-in Tariff Contract for Difference

The Feed-in Tariff Contract for Difference (FiT CfD) scheme is planned to be introduced under the EMR. The scheme is intended to replace the RO as the primary mechanism for incentivising the generation of low and zero carbon electricity.

Few details of the scheme are currently known but the principle behind the scheme is that the level of incentivisation will vary with electricity wholesale prices. While electricity prices are high, the level of incentivisation will be low and while electricity prices are low the level of incentivisation will increase. This will result in generators receiving a reasonably constant income stream made up of electricity sales and incentives.

6.5 Carbon

Based on the energy baseline developed and presented above, a carbon baseline and projection has also been developed and is shown in the figure below. In order to produce this baseline a number of carbon emission factors, required to convert volume of energy consumed into an equivalent volume of carbon emissions, are required. These have been defined in the table below.

Energy Type	Emission Factor (kgCO_2e/kWh)
Natural Gas	0.183
Electricity	0.521
Veolia Heat Network	0.137

Table 5 – Carbon Emission Factors

The carbon emission factors for natural gas and the Veolia heat network have been assumed to remain constant over the assessment period under consideration.

6.5.1 Emissions projections

Emissions projections of conventional fuels are not anticipated to change over time, however the natural gas network may be de-carbonised to some extent in the medium to long term by the introduction of bio-gases of one derivation or another.

The carbon emission factor for electricity has been assumed to reduce over time as the UK government progresses with its plans to decarbonise the national electricity infrastructure. The figure below shows the projection of carbon emission factors for electricity made available by DECC.

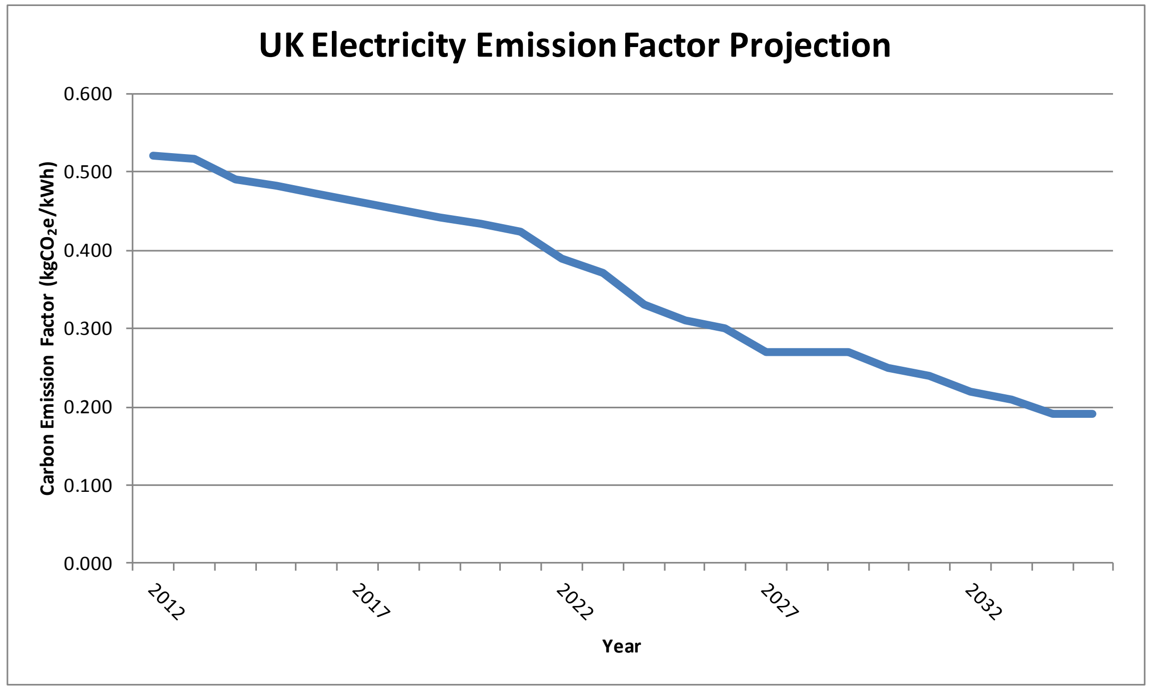


Figure 19 – UK Grid Supplied Electricity Emission Factor Projection

The projection of electricity emission factors clearly shows that over the next 20 years the emissions associated with the use of electricity supplied via the national infrastructure will drop substantially. The projection estimates a compound annual decline of 4.3% in the emission factor between 2012 and 2035.

As introduced in sections 3, the variability of Veolia carbon emissions over time to the present factor presents elements of reputational and financial sensitivity. Since the auditable calculation methodology was approved by DEFRA, the perception of consumers including the University is that carbon emissions of heat supplied by Veolia have increased by around 30%, i.e. from 0.10 to 0.137kgCO2e/kWh.

The constituents of the waste streams that feed the Bernard Road facility influence the calculated emissions factor, as does the operating reliability of the plant and the district heating network efficiencies insofar as supplementary/standby boiler fuel usage and network losses.

It should be noted that with regard to speculations around the impact of the constituent make-up of waste is concerned, the raising or lowering of EfW plant energy emissions factors has not been witnessed in practice in recent times by Veolia.

This matter is discussed in more detail below.

6.5.2 The future of waste

With reference to the constituents of waste streams in the UK, presently the Veolia Bernard Road plant receives waste from a confined South Yorkshire catchment area and results in an annually variable heat emissions factor as shown below.

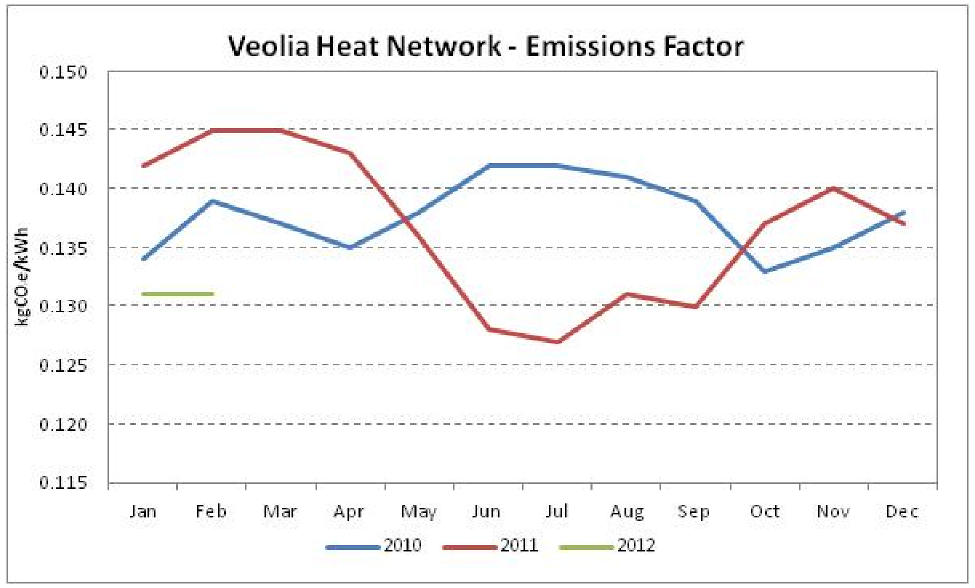


Figure 20 - Veolia Heat Network Emissions Factors 2010-2012, information courtesy of Veolia

When presented over a longer time frame it can be seen that since 2008 using an audited waste stream carbon content of 0.275kgCO_2 per kilogramme of waste and relative to the EfW Bernard Road facility operational hours the following graph shows the variability of the heat supply emissions factor. The influence of the EfW facility monthly operating hours is clearly visible, i.e. less operation means greater reliance on standby boilers and higher overall heat emissions factor.

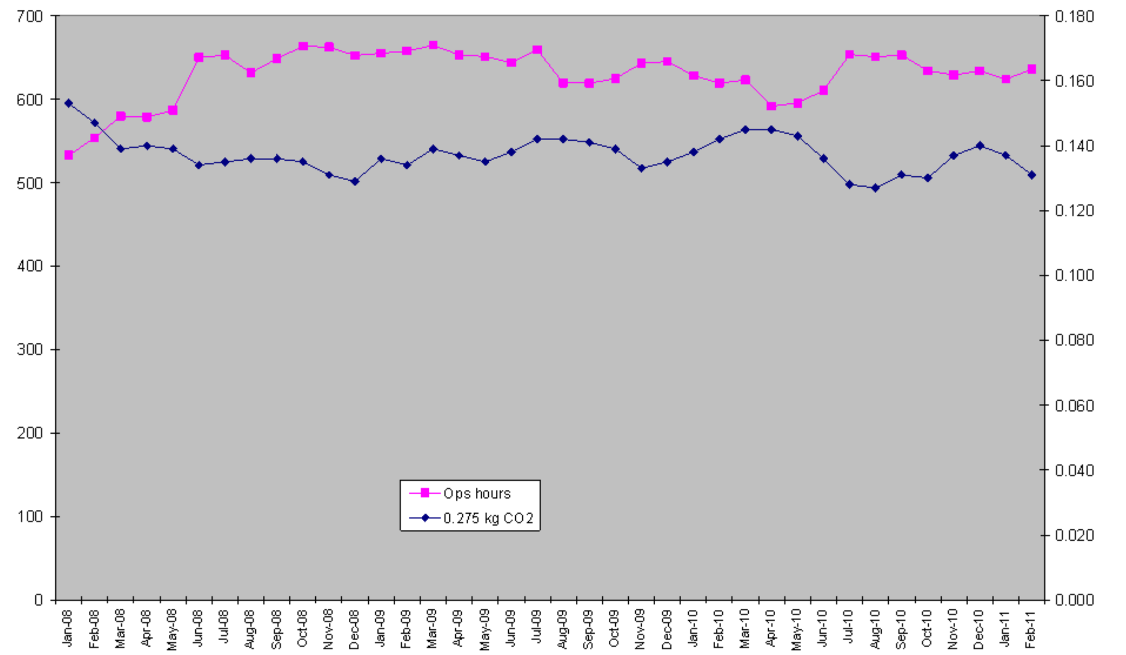


Figure 21 - Veolia heat supply emissions factor and EfW facility operating hours, information courtesy of Veolia

The question remains; how is the audited carbon content of waste likely to change in the future at the Bernard Road facility given the changing environment of refuse collection in England and what will the impact on heat supply emissions factor?

Traditionally the UK has relied on landfill as the main method of waste disposal but the introduction of waste reduction, recycling and energy recovery targets brought in through the European Waste Framework Directive and the Landfill Directive has increased the use of alternative disposal methods. The UK Government has also imposed a Landfill Tax, an escalating levy which must be paid on every tonne of waste sent to landfill. The tax currently stands at £64 a tonne for 'active' waste (increasing to £72 per tonne from 1 April 2013) and £2.50 a tonne for 'inactive' waste.

In a report commissioned by Shanks[2] the amount of Municipal Solid Waste (MSW) sent to landfill in the UK is forecast to decline to 6.5mt (million tonnes) in 2020, from 31.8mt in 2008/09. This would require 24.2mtpa of residual treatment capacity, or 2.4mtpa more than is already scheduled. Similarly, 5.5mtpa of food (organic) waste is forecasted to be separately diverted from the waste stream and treated by 2020. As of 2010, less than 2.0mtpa of capacity exists and therefore at least 3.5mtpa of additional organic treatment capacity may be required.

Forecasts of treatment demand are illustrated in the figure below, presented as a portion of waste that was landfilled in 2008/09, the baseline year. Existing volume that is being diverted has been omitted for simplicity.

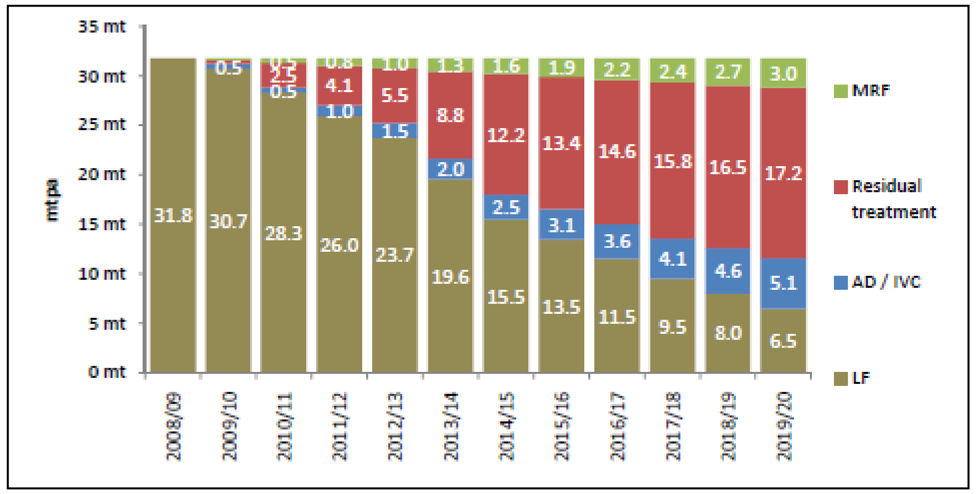


Figure 22 - Recycling, recovery and disposal demand forecast 2008 – 2020

This suggests that there are no concerns over supply of feedstock for Energy from Waste (EfW) plants either now or in the near future as demand outstrips capacity. As the volume of organic waste treated via Anaerobic Digestion (AD) and In-Vessel Composting (IVC) increases the composition of waste sent to thermal treatment plants will change. For all types of thermal treatment this will have a positive effect on the Calorific Value (CV) of the waste and will in turn have a positive effect on their efficiency. Separate collection also contributes to the homogenisation of that portion of the waste stream destined for thermal treatment.

6.5.3 HEFCE Targets and the Carbon Management Plan

Faced with the drivers of change presented above the Higher Education Funding Council for England (HEFCE) have set targets for carbon reduction of University and higher educational establishments which set out a trajectory for reduction over time. The HEFCE targets largely align with the UK Government 2050 targets for 80% reduction from 1990 levels albeit at a more accelerated rate of reduction. The graph below shows both the government and HEFCE targets presented in terms of the University.

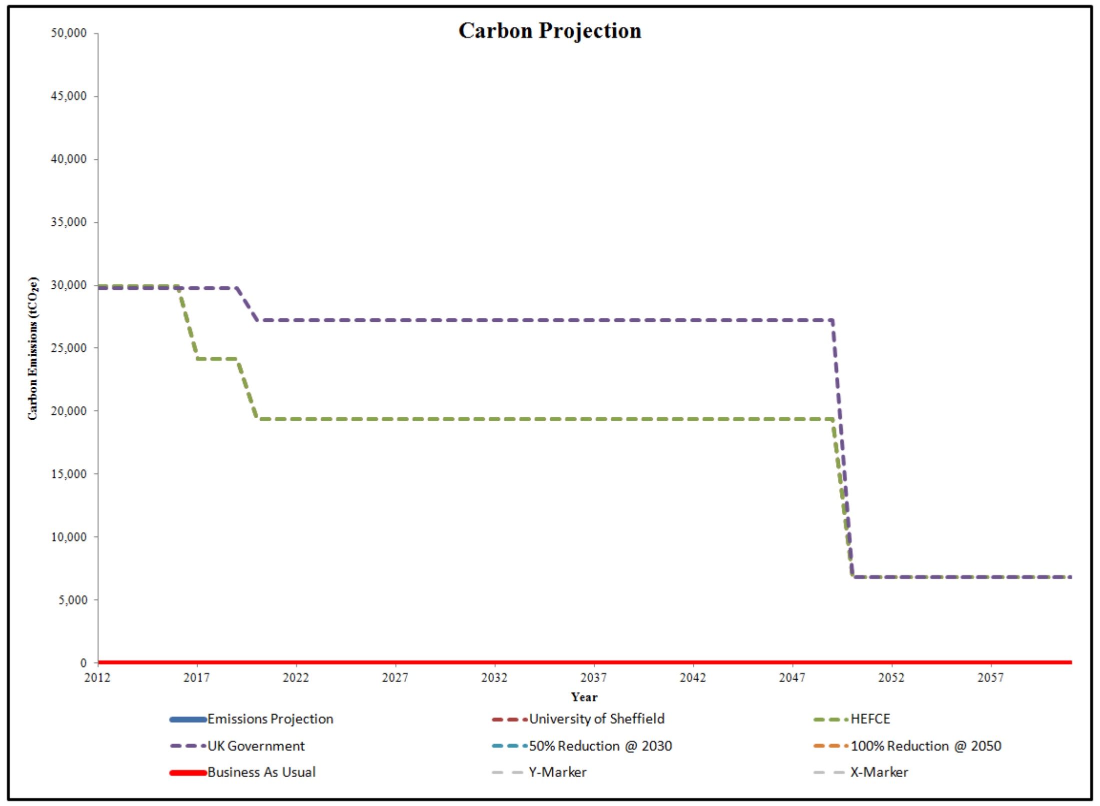


Figure 23 - HEFCE & UK Government Carbon Target Reduction Trajectory for the University of Sheffield

While HEFCE have set the national aspiration targets for the HE sector it is unlikely that the University will strictly adopt the target beyond 2020. In recognition of the aspiration to achieve the targets, the University Carbon Management Programme (CMP) sets out the reduction strategy.

6.5.3.1 The University Carbon Management Programme (CMP).

The University of Sheffield Carbon Management Programme (CMP) Strategy and Implementation Plan (SIP), was published February 2008. It sets a carbon emissions target of 20% below the 2005-6 baseline Academic year by 2016-17.

This equates to annual carbon emissions savings of about 20,000 teCO_2e and reduction in annual costs of £6m by 2016-17.

Completed actions

The 2008 CMP outlines actions already completed to reduce carbon emissions from energy use. These included: the development and extension of the local energy from waste district heating scheme; installation of M&T systems; procurement of low energy equipment; improved HVAC controls; installation of insulation; relighting; reduced PC power wastage; and improved BEMS controls.

---
[2] Patel V. Municipal Waste Treatment - Capacity Forecast v3.0. 2010

Planned actions

The CMP outlines emission reduction opportunities split into three areas: Long-term enablement actions; No- and low-cost actions; and Actions requiring investment.

Long-term enablement actions include: budget devolution, Sustainability Policy development, web site promotion, Green Purchasing Policy implantation; Carbon Offsetting; increased use of teleconferencing; the appointment of Energy Engineer and Environmental Controls Engineer; and replacing of sub-meters at the end of their useful life.

No- and low-cost actions include: awareness raising; energy efficient procurement; use of IT power efficiency features; priority to maintenance that reduces energy use; and the adjustment of BMS set points and time schedules.

Actions requiring investment include: improving building fabric; improving lighting controls; use of standalone controls such as TRVs, presence sensors and time switches; use of BMS outstations; motor controllers for refrigerators; water boilers in kitchenettes; time switches to control point of use electric domestic water heaters.

Actions identified but not considered in as much detail include: installing a chilled water distribution system; installing voltage controllers; further BEMS upgrades; boiler replacements; motor replacements and inverters; lighting upgrades; improving heating controls; and installing dedicated chillers.

Having reviewed the CMP during this strategic assessment an update is presented by virtue of the recommended interventions supported by the dashboard model.

7 Carbon Baselines

Based on the energy data made available by the University and the surveys completed of the estate, a baseline position based on the existing estate and operations has been developed. This baseline has been used to assess the relative merits of each of the opportunities under consideration against and in developing the overall energy strategy for the University.

The baselines developed are therefore key to informing the outputs and the extent to which the University will have to invest in order to meet its targets, aims and ambitions over the coming years.

7.1 Methodology

Due to the lack of energy data available at suitable resolutions the following methodology has been employed in order to calculate the baselines associated with the University's estate.

- Where metered energy data has been made available across the University's estate this has been used.
- Where this information has not been made available the data utilised within the Display Energy Certificates (DECs) for each individual building has been used.
- The carbon emission factors outlined above have been utilised in producing the energy baselines for the University's estate.
- The estate development plan to 2017 outlined above has been utilised in producing the energy baselines.
- Three scenarios have been included for post-2017 estate development as outlined above.

7.2 Carbon Emissions

Based on the methodology set out above, the data made available and the assumptions agreed with the University, the figures below set out the current baseline for carbon emissions across the University's estate.

Carbon emission projections under the three growth scenarios have been plotted alongside the HEFCE carbon emission targets as set out in the table below. These emission reduction targets are set against a 2005 baseline, assumed to be 35,000tCO_2e.

Year	Emission Reduction (%)	Target Type
2005	0%	Baseline
2012	12%	Milestone
2017	29%	Milestone
2020	43%	Target
2050	80%	Target

Figure 24 – HEFCE Carbon Reduction Targets

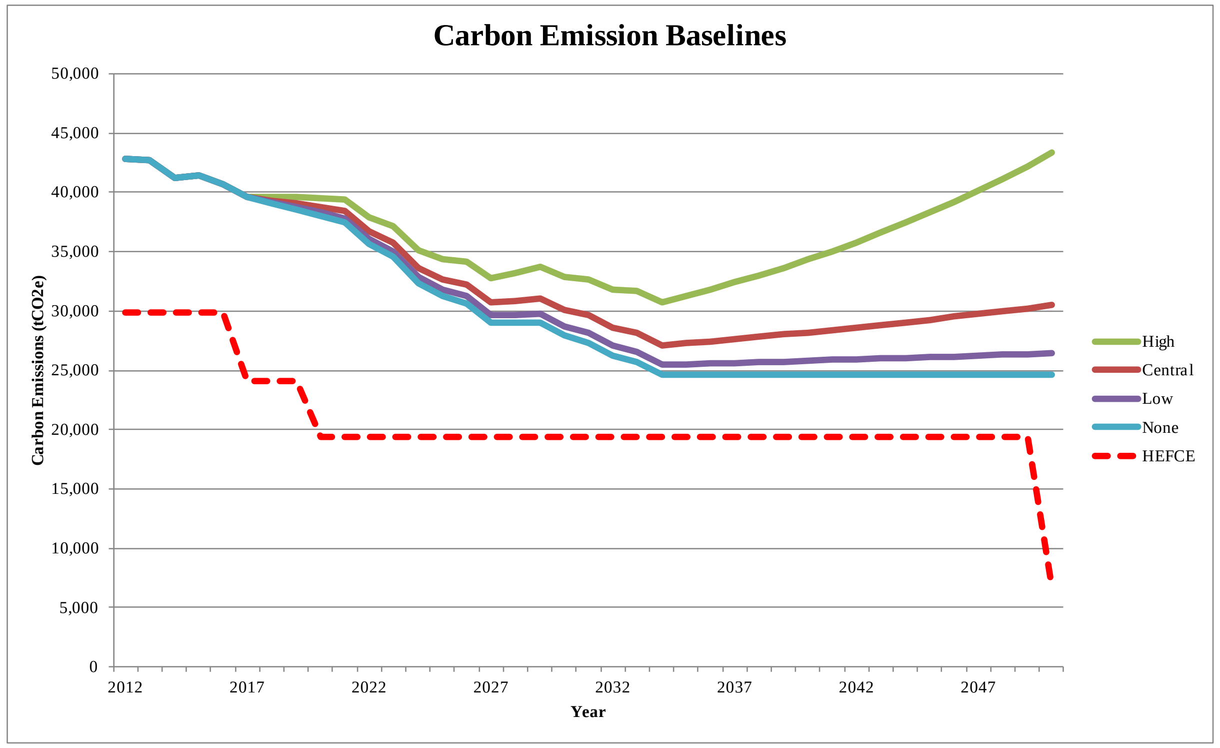


Figure 25 – University Carbon Baseline Projections

The projections produced for carbon emissions across the University's estate show a general decline in carbon emissions between 2012 and 2030 as the carbon intensity of grid supplied electricity reduces. After 2030 the emissions associated with the estate grow relative to the assumed growth rate of the University's estate.

Carbon emissions attributable to the consumption of electricity across the University's estate are currently responsible for around 66% of the total estates emissions. This is a result of the high consumption of electricity and the higher emission factor currently associated with grid supplied electricity.

The total contribution to carbon emissions from consumption of the electricity is projected to fall substantially as a result of the decarbonisation of the natural electricity supply infrastructure. It is estimated that the contribution from electricity consumption will fall to 25% by 2050.

All of the projections show the emissions for the University's estate remaining well above the HEFCE targets for emission reduction over the assessment period. As a result the University will require investment in energy and carbon reduction initiatives in order to meet the targets set.

8 Workshops

Workshops were held with a range of identified stakeholders including University Faculties, Accommodation, Sheffield City Council, local neighbourhood stakeholders and the local heat energy supplier. The workshops' aim was to engage local stakeholders in an inclusive process, enabling them to provide their own perspectives and ideas to feed into the Energy Strategy. This ensured that all potential interventions within the Strategy are realistic, achievable and would address the agendas of all stakeholders. In particular, the workshops aimed to build knowledge of initiatives developed by University Faculties independently of the E&FM team.

Initial workshops were held with all stakeholders to share the background and context for the project, and to begin the process of creating ideas and views about potential interventions which could be included within the Energy Strategy.

A second round of workshops with all stakeholders then provided the opportunity to further shape and refine these ideas and interventions. The following sections outline the key outputs from the workshop process, for Behavioural Change, Building Services and Self Generation.

Full transcripts of workshop notes are provided in appendix C

8.1 University Faculties

Workshops were held with both 'High Energy Users' Faculties (i.e. Engineering and Science) and 'General Energy Users' Faculties (i.e. Arts and Humanities, Medicine, Dentistry, Social Sciences).

From this the views and ideas of faculty leaders have been gained in relation to potential opportunities for energy reduction, thus ensuring that the Energy Strategy is a fully informed representation of ideas and concerns.

8.1.1 Outputs

The following topics were common discussion points within both the 'High' and 'General' energy consuming faculty workshops.

Growth

The general belief is that the University will grow significantly in the coming years, with a related requirement for 'scalable' infrastructure and self-generation strategy.

Research

The energy use inherent with research projects (in particular within the Faculty of Science) is similarly predicted to increase over time as technologies progress, with cutting-edge research requiring closer controls of environment and cleanliness.

Ventilation

A reoccurring concern between faculties was that of the lack of ventilation control within departments and spaces, leading to both overheating during summer months and the need for local electric heater use during wintertime.

Change of Use

Another common thread within discussions was the propensity for the usage of rooms and spaces to change over time, often leading to a demand for internal conditions quite different from those initially envisaged (and designed for).

Business Continuity

High energy user faculties are arguably the most mission critical in terms of need for business continuity specifically regarding energy security and resilience of supplies. Climate control of research laboratories and subject specimen life-support systems are of paramount importance to ensure the quality of ongoing research and attracting research funding and thus have a reputational impact.

8.2 Accommodation Services

Workshops are held with the University Accommodation Services and Accommodation Contract services representatives.

This provided the opportunity for Arup to gain in-depth understanding of the University's portfolio of accommodation and recent changes thereto.

Buildings

Over the past decade, the type of student accommodation within the University Campus has changed dramatically, from 70% catered units owned by the University to 70% self-catered en-suite facilities owned and operated by Catalyst, appointed under a PFI arrangement to perform a facilities management role.

However, some 1,000 beds have been retained by the University, predominantly in Victorian housing stock much of which has featured little in the way of investment and upkeep in the past 15 years.

In recognition of this, a 5-year programme of refurbishment and repair is underway, focussing on ageing boiler plant and building fabric improvements.

Behavioural Change

A 'Switch Off' campaign has been in place for 3 years, led by student volunteers in 'Power Rangers' roles.

A further programme is in place to incentivise 1st year students to achieve energy savings via competitions between shared accommodation blocks resulting in end-of-year prizes.

Additional plans exist to raise the profile of energy use via the annual student accommodation survey, conducted each November.

Self-Generation

At present, no self-generation is present within accommodation buildings.

Options around the installation of Photovoltaics have been investigated but recent revisions to the Government's Feed-in Tariff scheme has led to plans being shelved on commercial grounds.

8.3 Local Neighbourhood Stakeholders

Invitations to attend two workshops were extended to the following local neighbourhood stakeholders:

- Sheffield Teaching Hospital Trust (STHT)
- Sheffield Children's Hospital Charitable Trust
- Sheffield Homes (SH)
- Sheffield City Council (SCC)

Representation during the two workshops was given by STHT and SCC.

The STHT in the immediate neighbourhood to the University campus consists of the Royal Hallamshire Hospital, Weston Park Hospital and the Dental Hospital. Both Weston Park and the Dental Hospitals are presently connected to the Veolia heat network. The Royal Hallamshire is served by its own steam generation and distribution system, without its replacement with low /medium temperature hot water systems at significant cost, sharing University infrastructure would not be practical at this time. However, the advantages of sharing low carbon energy infrastructure with the University over the alternative; Veolia network connection, was appreciated.

SCC provided insight into SH interests and to the local opportunities to develop links with the neighbourhood. It was mooted that SH may be taken back into the direct management of SCC, while detail was not provided it was expressed that existing SH connections to the Veolia network and some refurbishment was anticipated.

With regard to the Children's Hospital, no representation was made although a development site at Durham Road was expressly noted being owned by the University and as being a possible location for an energy centre or heat store location.

The University initiative 'BeCause' aims to address a need to act on Corporate Social Responsibility (CSR). 'BeCause' ties together the University's corporate influence on community and environment.

Other areas of discussion during the workshop were:

- Clean air zones were tabled by SCC as being an ambition, in theory and backed by Council policy this would constrain the University's carbon reduction ambitions and obligations.
- Pooling of neighbourhood food waste for a single Sheffield located anaerobic digester (AD) plant could be explored for the City.
- Off site wind turbine opportunities exist both on and off University land.

8.4 Veolia - Heat Provider

The workshops held with the incumbent district heating network provider and operator of the Bernard Road Energy from Waste facility, Veolia Environmental Services (UK) Plc, focused on four key questions relating to both energy/carbon performance and to security of supply of the district heat system both of which have a significant bearing on business continuity. The first workshop set the scene whereby University concerns were raised, the second workshop presented the opportunity for Veolia to respond and a third meeting was held on the request of Veolia to allow them to present their path to an improved relationship and more detailed technical interventions.

Security of Supply

With regard to levels of security of supply offered to the University, known systemic disruptions have in part been caused by shortfalls in district heating system capacity. At times the University have been potentially starved of heat supply during very cold weather periods. Heat demand across this city coupled with the inherent inflexibility of the EfW plant steam turbine operation and standby boiler capacity reliability issues has led to this insecurity.

Physical breakdown problems are similarly known to have caused interruptions in supply of heat to parts of the university campus. Communication of planned maintenance and/or lack of reactive maintenance planning are understandably the main reasons for University dissatisfaction and are at odds with modern service level and performance contacts provided on similar district networks in the UK.

Carbon Emissions

The University are obliged to manage their Carbon Reduction Commitment (CRC), with penalties for carbon emissions directly impacting on University operating costs. The Veolia district heat supply emissions factor has increased dramatically since 2008 due to the introduction of a DECC approved methodology for ascribing carbon emission to EfW district heating. The resulting increase in emission attributable to district heat supplied across the City and in particular the University as the largest single consumer has therefore been badly received.

Similarly, operation of standby boiler plant both natural gas and oil fired during EfW plant planned and unplanned outage and during exceptional cold periods causes the emissions factors of the district hearting supply to fluctuate upwards with a detrimental effect on University CRC costs.

In addition, the University is concerned about the future waste characteristics utilised by the EfW plant in terms of its carbon content, and the impact of this on the emissions factor.

Intervention Opportunities

The following interventions and actions captured during workshops and meetings with Veolia in order to address the highlighted operation shortcomings and concerns of the University have been proposed by Arup and largely accepted by Veolia as forming an improvement in service/performance offering:

Intervention/Action	Description
Reduce demand of District Heating network 1	Rationalisation/demand reduction expected to occur in DH1 which presently serving South Park Street, Norfolk Road and Claywood Drive
Thermal sores/accumulators	Positioned strategically on the DH network in close proximity to the University and/or dedicated to critical University buildings/clusters
Combined Heat and Power (low and zero carbon)	Developed jointly with the University at critical buildings/clusters
CHP heat injection (low and zero carbon)	Acceptance of surplus heat into DH from electrically optimised

Intervention/Action	Description
	CHP at advantageous heat sale tariffs
Absorption chilling	Developed jointly with the University at critical buildings/clusters to utilise summer DH and/or CHP heat
DH connection dual heat exchangers	Added resilience of heat supply to critical buildings by installing 100% redundant heat exchangers
Improved AMR metering	Additional heat meters and improved reading accessibility
Planned Preventative Maintenance collaboration Memorandum of Understanding	Jointly collaborate in the development and active management of priority planned and reactive maintenance of valves, pipework pinch points/age, heat exchangers, standby boiler plant etc.
Future of waste	Regular carbon content reporting and forecasting information

8.5 Workshop Summary

The following table summarises the key points raised during the workshops.

Workshop	Key Point
University Faculties	• Faculties expect notable University growth in future • Energy use in relation to Research is expected to increase • Improved ventilation strategy and controls critical and directly linked to energy use for heating (including electricity) • University teaching spaces prone to frequent changes of use and associated servicing & energy requirements • Business continuity must remain a priority in all energy strategy considerations
Accommodation Services	• Recent shifts in accommodation provision have resulted in a broad mix of building types and age, owned and operated by the University and their FM partner, Catalyst • A number of behavioural change actions and campaigns exist and are planned within accommodation blocks • Though investigated, no current plans exist for the implementation of self-generation within accommodation blocks
Local Neighbourhood Stakeholders	• Proposed Sheffield City Council 'clean air zones' could provide a limitation to University self-generation options • The respective heat distribution infrastructures of the Royal Hallamshire Hospital and the University are deemed incompatible at present, due to differences between operating parameters • Future consideration to be given to the pooling of food waste in relation to a potential new anaerobic digestion (AD) plant
Veolia	• Locating of remote thermal stores/accumulators mutually beneficial • Secondary heat exchangers to increase heat supply resilience • Heat injection principal accepted and to be investigated • Additional metering and KPI's to be put in place and form part of an MoU

9 Building Interventions

The building survey work and stakeholder workshops have identified a number of building energy saving interventions. These are discussed in the following sections:

9.1.1 Lighting Interventions

- **PIR lighting control**: Occupancy sensors can be installed as part of a lighting control system. They control lighting based on occupant detection and should be installed in intermittently occupied areas such as meeting rooms, circulation spaces, toilets, shared study areas and print rooms. PIR lighting control is not suitable for spaces of the University where lighting is necessary for health and safety purposes, for example, laboratories and kitchens.

- **Daylight linking lighting control:** Daylight sensors can be used to dim or even switch off lights to respond to room daylight levels, reducing operating and energy costs.

- **Replace inefficient fittings with high efficacy fittings producing the same lighting levels:** Significant cost reductions can be achieved by using energy efficient lighting such as T5 fluorescents. These significantly reduce operating costs, while decreasing internal heat load from lights.

- **Easily understood light switching labelling:** Easily understood light switch labelling is an effective way to reduce energy consumption, by ensuring that employees know which switches control which lighting zones. This is especially relevant for out of hours and weekend office use, and will reduce operating costs.

- **Provide programmable lighting control system:** Lighting control systems can switch off lights automatically or step down lighting levels for night-time security or reduced occupancies. This lowers operating costs.

9.1.2 Building Fabric Interventions

- **Improve U-values of walls and roof:** Upgrading wall and roof insulation can significantly reduce conduction through walls and roofs, decreasing the amount of heating and cooling required.

- **Improve air tightness of building:** Unwanted infiltration can increase the amount of unconditioned air into a space, increasing the heating or cooling requirements. Infiltration can also decrease thermal comfort, raise humidity levels, and introduce unwanted particulates, such as dust, into the environment.

- **Installed double/secondary glazing**: Secondary glazing can be installed with an existing single glazed system to improve insulation, without the need to completely remove the framing. Double glazing can provide equivalent savings however a complete refit of glazing would be necessary.

9.1.3 Heating Interventions

- **Install local heating controls within local heat emitters:** Incorrectly set or functioning controls can significantly increase energy consumption, and reduce thermal comfort for occupants. Modify set points to the upper and lower limits of acceptable thermal comfort boundaries.

- **Re-commission heating control system:** Rebalancing and re-commissioning all equipment ensures that systems operate as efficiently as possible, reducing running costs. Efficient operation could be sustained through the implementation of a comprehensive preventative maintenance programme. A comprehensive maintenance programme ensures that equipment works as efficiently as possible, extends the life of equipment, and reduces operating costs and energy use.

- **Install weather compensation systems:** Reducing the flow and return temperatures of the heating system during warmer periods of the year will reduce heat losses within the distribution system. Reduced flow and return temperatures will also allow condensing boilers to operate in condensing mode, reducing the energy used by the boilers.

- **Upgrade/replace central heating plant**: Modern boilers have increased efficiency (more heating can be provided with less heating fuel consumed), which can reduce the energy demand on the building. The introduction of variable speed pumps will also reduce energy consumption. Variable speed works by decreasing power to pumps to decrease flow rates to match decreased loads.

- **Insulate heating pipework:** Insulation reduces the amount of energy lost in duct and piping systems. It can also improve comfort levels for occupants.

9.1.4 Cooling Interventions

- **Install local, automatic, cooling controls**: Occupancy or switch control ensures that air conditioning systems do not operate needlessly, which saves energy costs and reduces greenhouse emissions.

- **Re-commission cooling control system:** Rebalancing and re-commissioning all equipment ensures that systems are operate as efficiently as possible, reducing running costs. Efficient operation could be sustained through the implementation of a comprehensive preventative maintenance programme. A comprehensive maintenance programme ensures that equipment works as efficiently as possible, extends the life of equipment, and reduces operating costs and energy use.

- **Install weather compensation systems**: Increasing the flow and return temperatures of the chilled water system during cooler periods of the year will reduce pipework heat gains within the distribution system.

- **Upgrade/replace central cooling plant**. Modern chillers/refrigerant cooling systems have increased efficiency (more cooling can be provided with less electrical power consumed), which can reduce the energy demand on the building. This may be a tax deductible improvement.

  The introduction of variable speed pumps reduces energy consumption further. Variable speed works by decreasing power to pumps and fans to decrease flow rates to match decreased loads.

- **Implement free cooling systems:** Free cooling systems use cold ambient external temperatures to provide cooling rather than operating the refrigeration system within the chiller. Avoiding the need to use the refrigerant system saves electrical energy.

- **Install shading/improve G-value of glass**: Shading devices such as brise soleil, internal or mid-pane blinds and solar control film can reduce heat gains. This will reduce the energy consumption of any mechanical cooling system and improve the feasibility of natural ventilation.

9.1.5 Ventilation Interventions

- **Install local mechanical ventilation controls**: Demand control ventilation involves monitoring carbon dioxide levels in the air and automatically varying ventilation rates proportionally. In this way, outside air rates are matched to actual occupancy densities, rather than on assumed occupancy patterns.
- **Introduce free cooling capability**: Air handling unit economiser cycles replace treated air with untreated outdoor air when outdoor ambient conditions are similar to those the air handling system would typically produce. Up to 100% outside air can be supplied to the system in this way, resulting in significant energy savings.
- **Upgrade/replace central mechanical ventilation plant**: Modern ventilation systems have increased efficiency typically through the use of variable speed fans and components that achieve improve specific fan powers.
- **Employ heat recovery within ventilation plan**t: Heat recovery systems transfer heat between inbound and outgoing air flow streams, reducing the heating (or cooling) demands of the inbound air.
- **Change to natural ventilation strategy:** If feasible, changing to a passive ventilation strategy through the introduction of an operable façade reduces energy electrical consumption associated with a mechanical cooling system.

  The introduction of night cooling in conjunction with exposed thermal mass can be used to lower the temperature of the thermal mass of the building when the outside temperature is below the internal daytime design temperature.

  If natural ventilation is not feasible throughout the year, mixed mode ventilation could be employed. Natural ventilation is used when ambient conditions are suitable, with A/C operated only during peak conditions, thereby reducing energy consumption.
- **Check and repair any major ductwork leakage**: Ductwork leakage increases the amount of energy needed to meet indoor air conditions, and reduces indoor air quality.

9.1.6 Energy data acquisition and analysis

- **Install sub metering**: Energy use monitoring allows the performance of the building to be tracked and indexed with other assets. Sub-metering on individual end uses, such as electric lighting, individual laboratories, or space heating, highlights any building uses that are operating inefficiently.
- The acquisition and analysis of energy data can be a powerful tool to instigate behaviour change as discussed in the behaviour change section of this report.

9.1.7 Laboratory Interventions

Guidance regarding energy efficiency in laboratories is provided in Appendix C however a summary is provided below.

Approximately 15% of the Estate sample is laboratories. Laboratories are high energy and water users, often using three to four times the energy per square metre than an office block. The energy usage tends to be dominated by the ventilation load - both the fan energy and the associated heating and cooling loads for the fresh air. The energy associated with laboratory ventilation typically accounts for 40%+ of total laboratory energy.

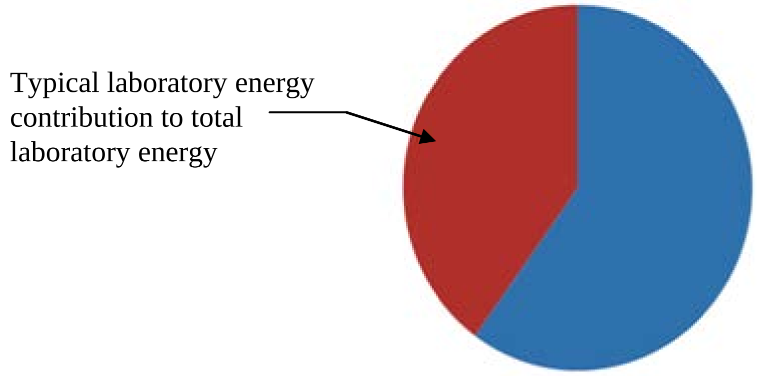


Figure 26: Laboratory energy breakdown

Therefore when looking at opportunities for reducing energy consumption in laboratories, ventilation is the key factor to consider.

9.1.7.1 Targeting Energy Reduction in Existing Laboratories – 5 Key Steps to Reducing Ventilation Energy

When looking at opportunities for reducing energy consumption in existing laboratories it is important not to compromise the functionality or safety of the facility. However, there are still a number of options for reducing energy that do not compromise these fundamental requirements.

There are five keys steps to consider, listed in order of impact:

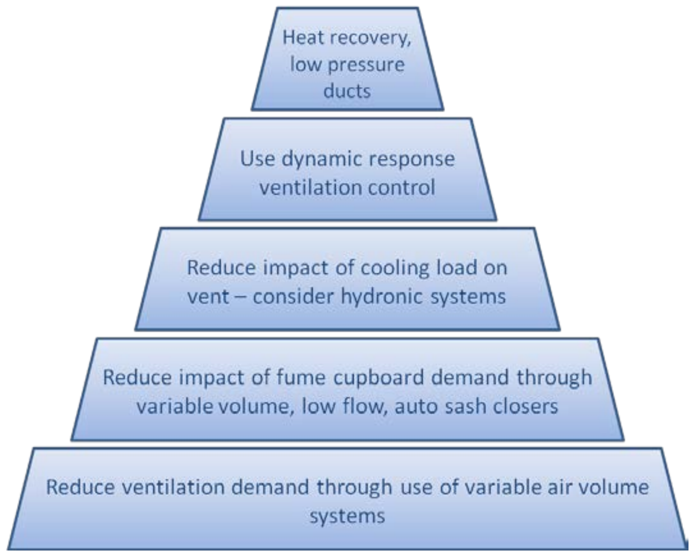


Figure 27: 5 steps for ventilation energy reduction

These five steps are discussed in greater detail in Appendix B**.**

9.1.7.2 Energy Associated with Laboratory Equipment

Energy usage associated with laboratory equipment is harder to address than ventilation energy as it is not controlled by the designer or laboratory user. There are however a few considerations that can help reduce energy consumption.

Diversity on Small Power Loads: Equipment diversity can have a significant effect on central plant sizing. This can have a beneficial impact on both electrical and mechanical plant sizes and efficiencies.

Equipment Cooling: Some items of equipment require direct liquid cooling and in the past this has often been done by running a hose from the cold water tap and letting the 'waste' water run to drain. This should be avoided due to the level of water wastage. It is preferable to install a closed loop process cooling system.

Room Hydronic Cooling: When equipment has high heat outputs to air (rather than to a water cooling system), it is worth looking at installing a local water-cooled system in the room, rather than relying on air cooling alone. Decoupling the heat load from the ventilation system, as described earlier, helps to reduce the ventilation energy and makes use of more efficient heat exchange by water. Often equipment-dominated laboratory spaces (such as microscopy suites) do not have the same contamination concerns as open laboratory spaces and therefore do not need high air change rates.

9.1.8 Building Intervention Energy Savings and Costs

Table 6 below summarises the indicative energy reductions and capital expenditure (CAPEX) associated with each building intervention. Appendix B summarises the assumptions used to calculate the percentage reductions. The CAPEX costs are based upon information within SPONS Mechanical and Electrical Services Price Guide 2012 and past project experience.

Energy reduction Intervention	% reduction in energy consumption	% reduction attributable to:	Intervention applicable to specific room (R) type or entire building (B)	CAPEX (£)	CAPEX Metric
Lighting Interventions					
PIR lighting control	10-15%	Lighting Electrical Load	R	14	£/m^2 (floor area)
Daylight Linking lighting control	5-25%	Lighting Electrical Load	R	14	£/m^2 (floor area)
Replace inefficient fittings with high efficacy fittings producing the same lighting levels	15-25%	Lighting Electrical Load	R	36	£/m^2 (floor area)
Building Fabric Interventions					
Improve U-values of walls*	3-10%	Space Heating Fossil Thermal Load	B	5.75	£/m^2 (wall area)
Improve U-values of roof*	5-30%	Space Heating Fossil Thermal Load	B	17.25	£/m^2 (roof area)
Improve air tightness of building*	10-30%	Space Heating Fossil Thermal Load	B	0.00	£/m^2 (floor area)
Installed double/secondary glazing*	10-30%	Space Heating Fossil Thermal Load	B	799.25	£/m^2 (glazed area)
Heating Interventions					
Install local heating controls within local heat emitters.	10-25%	Space Heating Fossil Thermal Load	R	1.25	£/m^2 (floor area)
Re-commission heating control system	10%	Space Heating Fossil Thermal Load	B	10,000.00	£ (one off cost)
Install weather compensation systems	3%	Space Heating Fossil Thermal Load	B	2,875.00	£ (one off cost)
Upgrade/replace central heating plant	15%	Total Heating Load	B	3.50	£/m^2 (floor area)
Cooling Interventions					
Install local, automatic, cooling controls	10%	Cooling Electrical Load	R	20.27	£/m^2 (floor area)
Re-commission cooling control system	10%	Cooling Electrical Load	B	10,000.00	£ (one off cost)
Install weather compensation systems	3%	Cooling Electrical Load	B	2,875.00	£ (one off cost)
Upgrade/replace central cooling plant	33%	Cooling Electrical Load	B	135.00	£/m^2 (floor area)
Install external shading/improve G-value of glass.	12%	Cooling Electrical Load	B	50.00	£/m^2 (glazed area)
Ventilation Interventions					
Install local mechanical ventilation controls	10%	Ventilation Electrical and Thermal Load	R	20.27	£/m^2 (floor area)
Upgrade/replace central mechanical ventilation plant	30%	Ventilation Electrical and Thermal Load	B	16.00	£/m^2 (floor area)
Employ heat recovery within ventilation plant	65%	Ventilation Thermal Load	B	16.00	£/m^2 (floor

					area)
Change to natural ventilation strategy.	100%	Ventilation/ Cooling Electrical Load	B	0.00	£/m^2 (floor area)

Table 6: Building Intervention energy reductions and costs

*The energy savings associated with building fabric interventions are a function of the building geometry and therefore will vary with building area and height.

9.2 Summary Buildings Recommendations

Surveys of the 38 sample buildings during the data gathering stage identified a number of opportunities for building energy saving interventions as outlined in the opportunities section of this report. Following a review of the remaining buildings within the Estate sample as outlined in section 3.3, the following section describes the scope and applicability of the interventions. A full breakdown of where each intervention is applicable is provided within Appendix A however the summary is provided below.

9.2.1 Lighting Interventions

In general, energy efficient light fittings such as compact fluorescents or T5 light fittings are installed across all areas of the sample buildings. There is, however, scope for the implementation of lighting control interventions.

The survey work showed that PIR lighting control may be appropriate within intermittently occupied areas such as seminar rooms, circulation spaces and sole occupant offices. The survey work also showed that the use of daylight linking within a number of well daylit spaces would also reduce electrical lighting energy consumption further.

The following table shows the proportion of the Estate sample, by room type, where lighting controls could be applied.

Space Type	% (m^2) of Sample Estate where intervention is applicable	
	PIR lighting control	Daylight Linking lighting control
Lecture theatres	0%	2%
General Offices	12%	8%
Classrooms/Seminar Rooms	6%	4%
ICT Suite	1%	1%
Retail and Leisure	0%	1%
Circulation/Lobby Spaces	14%	4%
Back of House	11%	3%
Library	4%	3%
Toilets and Changing Areas	2%	1%

Table 7: Applicability of lighting control interventions within the Estate sample

Many buildings included signage that promoted the switching off of lighting within corridor areas, demonstrating that behaviour change in the name of energy efficiency was being encouraged.

9.2.2 Building Fabric Interventions

Through visual inspection of the building fabric, the survey work showed that the majority (97%) of the wall constructions of sample buildings are performing well thermally speaking.

Through discussions with building occupants and visual inspection, the survey work showed that a quarter of the buildings may benefit from improvements to air tightness and roof insulation.

Many of the buildings are also single glazed (30%), suggesting that the reductions in heating energy consumption could be achieved through the installation of double glazing or secondary glazing.

9.2.3 Heating Interventions

Many of the radiators installed within the buildings are not controlled through thermostatic radiator valves or local thermostats. The survey showed that the heating system within approximately 16% of heated spaces across the Estate sample could be controlled in a more efficient manner. The survey work did not account for motorised two-port control valves locally serving rooms or groups of rooms.

The survey work identified areas with evidence of under or over-provision of heating. This included the use of portable electric heaters, and anecdotal evidence through conversations with occupants. Under or over-provision of heating was evident in 18% of the heated spaces and it is recommended that the heating control system is re-commissioned within these areas.

The majority (90%) of the accessible heating plant rooms contained weather-compensated, variable temperature heating plant. The central heating plant was also in good condition and as such, there is little need for upgrade/renewal work. However, as discussed earlier in this report, the heating systems that are likely in need of heating plant interventions are inaccessible due to the presence of asbestos and as such, further investigation would be required.

Un-insulated pipework was present in many of the older buildings, including the Frederick Mappin building, the Western Bank Edwardian Block and the Rotunda. Through conversations with building occupants, it is evident that in many cases, the losses through un-insulated pipework are causing discomfort and inefficient operation of the heating system. The large proportion of the swimming pool water treatment/heating system pipework within the central plant room was also un-insulated. Significant energy savings could be seen if this was rectified.

9.2.4 Cooling Interventions

The survey work showed that approximately 34% of the spaces assessed are cooled through mechanical means.

The mechanically cooled spaces are well controlled in the main however through conversations with building occupants, 2% of the mechanically cooled spaces are not. There was also evidence of over or under provision of cooling in a similar percentage of spaces. In these areas, it is recommended that the control system of cooling system is re-commisioned such that appropriate set-points can be achieved. Improved control of the cooling system will facilitate efficient operation.

Where accessible, central cooling plant, in general, was in good condition where only 4% of the mechanically cooled areas, through visual inspection, may need refurbishment or replacement. The majority of the surveyed central cooling plant did not include weather-compensated circuits and as such there is scope for energy savings through the increase in chilled water temperature during colder periods of the year.

Energy consumption associated with cooling systems can be greatly reduced through the reduction of the cooling load within each room. The reduction of heat gains can also improve the feasibility of the use of natural ventilation as a passive way of cooling. The survey work identified areas where solar shading, either in the form of blinds, external shading or through the use of solar film. These areas accounted for 7% of the Estate sample area.

9.2.5 Ventilation Interventions

The majority of the Estate sample was naturally ventilated (58%), 38% was mechanically ventilated and the remainder through a mixed mode solution (both natural and mechanical ventilation).

The survey work showed that 48% of the mechanically ventilated areas could benefit from improved controls. Many are operated from either a user operated on/off switch or time control. The use of CO_2 and temperature sensors to vary the ventilation rate may reduce the electrical energy required to operate the fan and the heating and cooling energy associated with treating the incoming air.

The ventilation plant assessed was in good condition and so the scope for plant upgrade interventions is limited. As noted previously, access to many plant areas was limited to due the presence of asbestos. There are, however, a number of opportunities (11% of mechanically ventilated areas) for the installation of heat recovery.

18% of the mechanically ventilated areas were deemed appropriate for natural ventilation. These spaces include rooms that are located on an external façade with relatively low internal gains, and those that did not rely on mechanical ventilation for heating. Detailed investigation of these spaces would determine the feasibility of a natural ventilation strategy.

9.2.6 Energy data acquisition and analysis

The University is currently undergoing a programme of installing energy meters with Schneider. Sub-metering of energy data is crucial in understanding, in greater detail, the opportunities the University has for achieving potential savings.

Sub-metering of key end uses of energy, such as lighting, space heating, small power within individual laboratories, and domestic hot water can identify where interventions are applicable.

The feedback of this data to those implementing energy saving measures can also help to drive and sustain behaviour change. It is recommended that the University's programme of installing energy meters is continued and that this data is shared out to those who are helping to drive energy efficiency across the Estate.

9.2.7 Carbon Projection

Based on the recommendations outlined in this section, the following carbon projection has been produced.

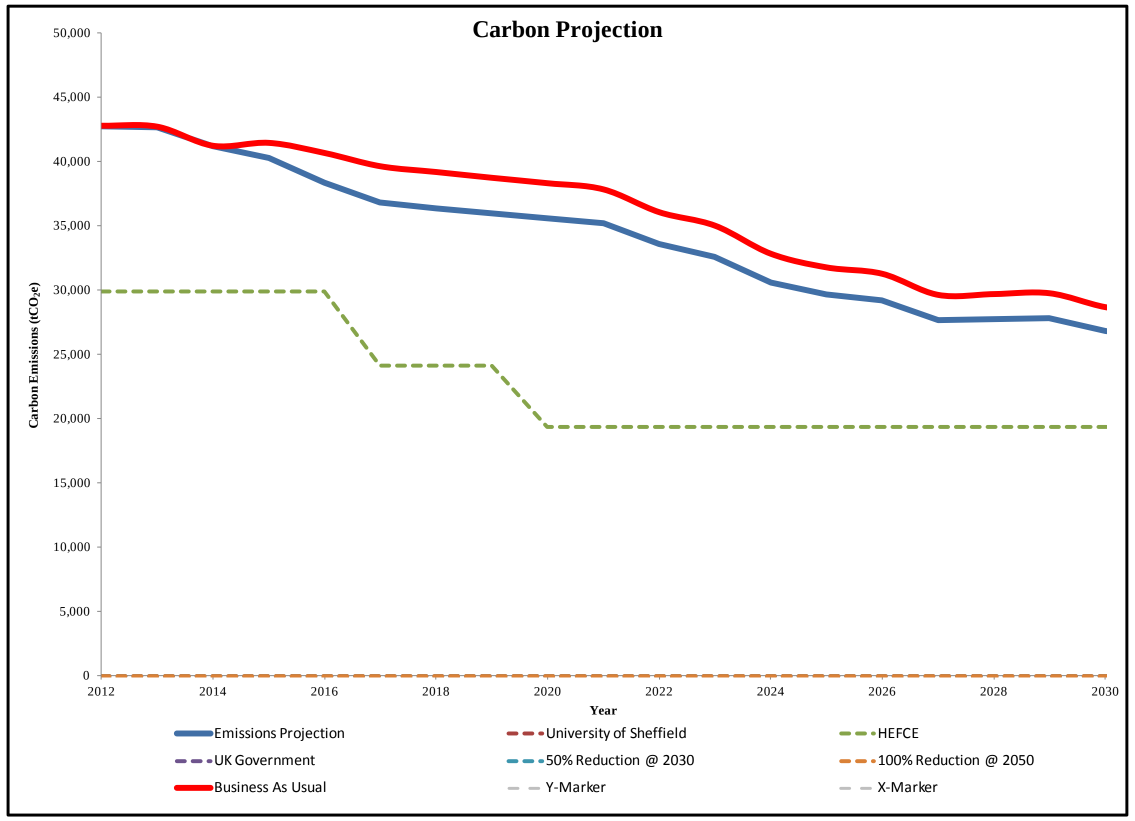


Figure 28: Carbon Projection resulting from Building Interventions

Whilst in isolation the resulting impact on carbon emissions is shown to be modest, the interventions will also produce important improvements in standards and conditions of building services within the University's existing stock, plus help to set standards for future buildings.

10 Behavioural Interventions

10.1 ICT

Effective use of ICT to communicate energy saving messages may reduce the need for and time required by Estates in achieving energy reduction, through promoting the message that energy saving is everyone's responsibility. Discussions relating to the use of ICT to promote communications in relation to energy saving behaviour led to the following potential opportunities:

- **Dashboards and screens:** aving a dashboard showing energy use data would be useful, but perhaps the focus needs to be more on personal devices (e.g. phones, computers). There is currently a system being developed and displayed in the Edge (student accommodation central hub) which displays energy use for accommodation blocks against the previous year, however this could be shown as weekly or termly so that students feel it is relevant to them and are prompted to act on this. A competition element (i.e. between blocks) could also be introduced.
- **University website:** Promoting energy saving behaviours through posting information and messages on the University website, especially in relation to individual buildings.
- **Email messages:** Emails could be used to promote energy saving behaviours, however, these would need to be specific with salient subject heading in order to avoid being seen as 'spam'.
- **Online learning:** There could be a 'Green Module' as part of the Library skills virtual learning environment.
- **Portal:** Key energy-saving (and sustainability) messages, 'nuggets' and links to feature on the University Portal (University's 'gateway' screen which users need to go through to access other systems). The new Portal is currently being developed and provides an ideal opportunity to add in this energy-saving communications element. Information relating to energy use within individual buildings (though metering) could be provided with half-hourly readings, with procedural information and ideas for what people can do to respond. Providing information directly relevant to the user by the system 'knowing' what building they usually work in or their department would also be a significant benefit of the system.
- **Access to Building Management Systems (BMS):** It would be useful to have an effective interface with the University's BMS, to increase understanding of energy use and provide key information to support communications (e.g. to feed information into Portal).
- **Social networking:** Use of Google Plus or similar Special Interest Forums focused on energy saving (but this needs to be well managed and more formalised to be effective).
- **Smart phone apps:** Communicating energy use for University buildings and accommodation blocks through a smart phone application can be powerful, and some blocks do have this in place. However, information needs to be timely and relevant, with additional information on what could be achieved (suitable targets set) so individuals can act on it. The existing Campus App could also be used to provide information relating to energy saving across the University.

10.2 Building Users

Discussions relating to how to engage and support all University users in changing everyday energy-related behaviours and establishing new practices and culture led to a range of opportunities being defined. It is strongly felt that across the University, individuals do *want* to save energy; there is a lot of enthusiasm at faculty level for something to be developed, an agenda that they can engage with. The opportunities are therefore centred around the need for energy saving to be viewed as everyone's responsibility and on how to harness the motivation and engage all in working towards shared energy saving objectives. The following potential opportunities are defined:

- **Dependency on infrastructure:** There is a need to get the 'foundations' right, so that people will buy in, in other words, the physical environment needs to be reflective of energy efficiency in order for building users to actively engage in energy saving. Sub-metering (e.g. within laboratory spaces) is required to provide accurate and relevant information on energy use, to promote users to respond.
- **Clear roles and responsibilities:** Saving energy needs to be viewed by all as everyone's responsibility (leadership, staff and students). Incorporating energy saving (and sustainable behaviours) into roles and responsibilities would help instil this degree of ownership and responsibility for all.
- **Communications strategy:** A clear and comprehensive communications strategy for all stakeholders needs to be designed and implemented, ensuring clear, specific and relevant messages are provided to all stakeholders, with information tailored to the target groups, and enabling two-way feedback of ideas and improvements. Messages also need to be continuously refreshed and updated to ensure the change momentum is maintained.
- **Communications activity:** External Relations Department are key for communicating and marketing messages in relation to energy saving and ensuring leadership are engaged. It should be noted, however, that communications activity in relation to energy saving needs to be integrated into existing schedule of work and not
- **Clear, specific and targeted information:** There is a need to create awareness through clear information, from student inductions and continuously through the year, to inform staff and students about energy use and costs and encourage them to change their behaviour. Faculty leads felt that the greatest impact will be achieved if information is provided at the level where individuals *can act*, and this applies to both the research and teaching environments. Information needs to be tailored to target groups (e.g. staff, students) and be specific and relevant. Within faculties, providing information on what energy savings *could be* spent on, and how these savings may be achieved, will encourage users to consider how they are using energy. Sub-metering within faculty areas will also enable direct information on energy use. Clear, relevant and timely information on how the heating systems in student accommodation work will promote understanding (e.g. reminding students of how the heating system works just prior to cold weather spells will reduce complaints and issues).
- **Empowerment and control:** It is felt that students may not feel they have the power or authority to act, to turn things off for example. Again this relates to clear communications and information being provided to ensure all building users understand what they can do and are enabled to do so, in both the teaching and research environments, and also within accommodation. Students need to feel a degree of control over their accommodation environment; installing 'boost' buttons on the heating in rooms for example would enable students to feel a sense of control (albeit limited) over their environment, which would potentially prevent them using electric heaters.
- **Accommodation survey:** The annual student accommodation survey provides an existing route for increasing the profile of energy saving behaviour and to understand current levels of comfort, behaviours, beliefs and attitudes relating to energy use. Understanding this data enables barriers to change to be identified and addressed.

- **Feedback:** People need to receive feedback on their performance for energy saving; they need to see what impact they are having, and understand what this means in the wider context (note the current Green Impact scheme does not include feedback, e.g. on amount of energy saved). Within faculties, communicating the *value* of what has been saved (e.g. in terms of investment in areas, or additional research will be more powerful than simply reporting figures).
- **Power Rangers support:** Student volunteer ‘Power Rangers’ have been leading the effort for the Student Switch Off campaign, and these volunteers need to be supported to maintain their motivation and focus towards promoting energy saving.
- **Reward and recognition:** People need tangible reward in order to maintain new ‘green’ behaviours (and thereby to establish habits). The current Green Impact Scheme has seen some success but rewards have not been sustained, since the tangible reward element is currently missing. Financial incentives have made significant impacts in other universities. Incentives should be offered for savings made against estimated energy use (e.g. for research groups), faculties/departments need to see a return which directly impacts *them* for their efforts in energy saving. If funds saved within faculties through energy saving could be ploughed directly back into teaching and research this would potentially have a significant impact in maintaining momentum for reduced energy use. Within accommodation, rewards need to have immediate impact (since the student population within accommodation changes each year).
- **Building user guides:** Guidance documents are perceived to be increasingly complex; faculty representatives commented that such guidance needs to provide simple, clear and easy steps for building users to follow, and to enable them to have control over their building environments.
- **Electric heaters:** There is currently no policy in place for use of electric heaters, for staff or students, in all University buildings. It is felt that providing information to users so they understand the amount of energy electric heaters use, and to provide prompts to consider alternatives (e.g. wearing additional layers) would have a significant impact on electric heater use. Also, if information on temperatures is provided locally, to show that the heating is working and at an appropriate temperature, would help discourage the use of personal heaters.

10.3 Leadership

Discussions relating to how to engage and support the University’s leadership to enable and motivate behaviour change through their own behaviour and commitment, led to the following potential opportunities:

- **Active leadership engagement:** Leaders need to actively engage in energy saving initiatives and visibly demonstrate their commitment, from Vice Chancellor through to all Faculty leads, department and laboratory managers. High level endorsement is felt to be key to success. The forthcoming BeCause campaign is viewed as being instrumental in achieving this.
- **Leadership roles and responsibilities:** The role of leaders in saving energy needs to be incorporated into roles and responsibilities, to be a formalised element of leadership responsibilities and practice. For example, where Heads of Department have embraced energy saving initiatives, and led by example, they have managed to bring all other building users along with them.
- **Effective links between leadership and Facilities Management:** Leadership reporting on energy use against targets and reporting on policy needs to be underpinned by regular, reliable and consistent energy use reporting from FM.
- **Formalised Energy/Environmental Champions:** The environmental champions that have already been recruited across the university need to be better supported in their efforts to promote energy saving. Their need to make an impact at ‘ground level’ through relatively simple approaches such as installing energy monitors on appliances, needs to be appreciated and acted upon by Estates (alignment of perspectives is required). This reflects a need for improved communications between Estates and volunteer ‘Champions’ within the Faculties. Formalising the Energy/Environmental Champion role across the university such that all faculties are required to ‘recruit’ at least one such volunteer would ensure cross-university drive and momentum in saving energy, with dedicated time to focus on meetings and actions. Formalising this role should include a clear role description, increased responsibilities, feed into personal career progression through training, and recognition and reward for effective performance.
- **University Sustainability Policy:** There is a need for policy to be developed to ensure that sustainable behaviour (including energy efficiency) is mandated and therefore adhered to by all University faculties and departments. The University Executive Board needs to develop and cascade this down. In alignment to this, regular reporting on energy use in Vice Chancellor meetings with Heads of Departments would ensure this remains high on the agenda.
- **Estates Green Agenda Policy and procedures:** Internal communications across Estates needs to be improved to ensure that all are working to the energy saving agenda, with policies and procedures to support this and ensure refurbishment and new build work reflects the green ethos (e.g. ensuring all new light fittings are energy-saving bulbs).
- **Accommodations Services Energy and Environment Coordinator role:** This role is established and provides a direct link for students. Other roles need to be created to increase this direct engagement with students (e.g. the existing ‘Residential Mentor role could include a formalised energy focus including activities such as projects focused on energy saving, visits to student accommodation to include coaching students on energy use).

10.4 Procurement

Discussions relating to how the decision making process for procurement could be improved to include greater consideration and emphasis on energy efficiency as a driver for purchasing decisions led to the conclusion that the responsibility for saving energy needs to be placed with the departments, through the policy and practices defined here. Procurement need to play a *supportive* role in helping ensure departments make fully informed and rational choices in relation to goods purchased and impact on energy use. The following potential opportunities emerged:

- **Sustainability Policy:** A Sustainability Policy needs to be created for Procurement (there is one in existence but this has reportedly been perceived as too ‘woolly’ and ‘unhelpful to end users’. A sustainability policy therefore needs to be developed which provides specific guidance to end users. The Sustainable Procurement Centre of Excellence provides guidance specifically for this.
- **Education/Information:** Departmental Budget Holders may delegate responsibility for purchasing to others; however, whoever is involved in making purchasing decisions nee*ds*

*to ensur*e full research (including energy data) which is effectively communicated to the Requisitioner to inform final purchasing choices.

- **Case studies/examples:** Procurement need to provide case studies or examples to departments to demonstrate the impact of making energy efficient choices and reinforce the importance of considering energy efficiency in purchasing decisions. It should be noted that case studies will probably be more effective if they can demonstrate the positive impact on the *departments'* research budgets, rather than demonstrating savings for the wider university.
- **Energy as a key evaluation criteria:** Energy efficiency should be a key element of the evaluation criteria for purchasing decisions, through use of a formal template.
- **Whole life costing:** Suppliers need to be strongly encouraged to provide whole life costing details for goods, with specific energy consumption data wherever possible.
- **Weighting for energy consumption:** Energy consumption criteria should be given sufficient (increased) weighting than is currently allocated, for purchasing evaluations.
- **Energy within purchasing rationale:** Rationale for purchasing decisions should always include sustainability and specifically energy efficiency considerations. Departments need to be provided with guidance to ensure this is included in their purchasing decision making and rationale, through a formal template.

10.5 Behavioural Summary Recommendations

In response to the opportunities developed through the workshops and interviews held during the data gathering stage, Arup's behavioural change team have developed a series of recommendations for interventions to support the University in reducing energy use and meeting its carbon reduction targets.

The interventions are listed below, together with a brief description, target group/area and linking to the behavioural influencing factors (see Methodology), which are addressed by the intervention.

Intervention	Description	Behavioural Influencing Factors
Enablers		
Removing Middle Management Barriers	Communicate the importance to Heads of Departments of the role they play in influencing behaviour change. Communicate cost effectiveness of behaviour change. Monthly meeting agenda items.	Leadership, Addressing Barriers, Communications
Formalise energy officer and Energy Champions role	Include in job descriptions, roles and responsibilities. Could be at Faculty and also department level.	Leadership, Policies and Procedures
Improve perceived support of FM team	Communicate the interventions that the estates team are already undertaking and invite extra proposal for FM actions needed.	Communications, Leadership, Attitudes
Improve perceived senior level support	Very visible high level support communicated down. Not just rhetoric or turning up at Green Impacts but leading by example. Possible monitoring of energy consumption of their offices.	Communications, Leadership, Attitudes
Communications strategy and implementation plan	Incorporate and develop/implement the opportunities relating to the setting up of communication routes such as forums, smart phone campus App adaptation, website add-ins etc. and ensure the circular feedback loops required, as well as linking in to the perceived leadership support.	Communications, Leadership, Attitudes
Actions		
Personal heating at work	Creating policy relating to the use of personal electric heaters and communicating this, providing advice on alternative approaches.	Policies and Procedures, Communications, Addressing Barriers, Control
Addressing Accommodation temperature levels	Providing policy, information and advice in induction packs and in-room information about heating system. Include procedural advice and information on what others do Providing timely top-up information (e.g. prior to impending cold spell). Installing personal 'boost' buttons for heating and temperature reader.	Policy and Procedures, Information, Communications, Control, Social Norms
Non-electronic Foyer display in accommodation buildings	Paper based poster, updated monthly with energy emissions data and a monthly focus on energy, including novelty element to capture attention. Door hangers to indicate support/commitment e.g. PC usage? Lights off?	Feedback, Social Norms, Attitudes

Intervention	Description	Behavioural Influencing Factors
Competitive elements for accommodation building based around frequently updated display	Rewards for energy performance against comparisons with previous month/term/week. Tangible, immediate rewards which appeal to students.	Reward and Recognition, Goal setting and Competition,
Increased use/support for Power Rangers	Increased / more prolonged / various communication to these. Provide support to allow them to alter the social norms within their group. E.g. Power rangers.	Competition, Social Norms, Attitudes
Rewards and Incentives: Department/Faculty level	Rewards and incentives for positive impact on energy use through group initiatives/programmes. Also reinforces leadership commitment.	Reward and Recognition, Leadership, Goal setting and Competition,
Rewards and Incentives: Individual Staff level	Rewards and incentives for positive impact on energy use through individual effort. Also reinforces leadership commitment.	Reward and Recognition, Leadership, Goal Setting and Competition,
"Turn things off" optimised operating regimes	Implementing policy and practice around switching things off, minimising usage.	Information, Policy and Procedures
ICT Communications	Include energy-related information, feedback and communications on the University's Portal Communications.	Feedback, Communications, Information,
ICT – only used when necessary	Implementing policy and practice around switching machines off, minimising usage.	Information, Policy and Procedures
Develop online learning module	Aimed at improving the general understanding of the importance of personal energy management.	Information, addressing barriers
Procurement Process	Implementing policy and practice in relation to the procurement decision making process, including revised template to augment sustainability considerations in purchasing and development of case studies and guidance.	Policy and Procedures, Addressing Barriers
Change Management Approach		
Overall change management support	All encompassing coherent and effective change management incorporating communications, rewards, incentives and accountability at a department level.	All

10.5.1 Defining the Enablers

The enablers listed in the table above are programmes that need to be taken to promote an increased awareness and understanding of the need for behaviour change throughout the university. These elements will not necessarily result in significant reductions in energy saving, but are required to create the culture to enable effective behaviour change in relation to energy saving. Each of the enablers is described in more detail below.

Removing Middle Management Barriers

Stakeholder feedback indicated that where Heads of Departments have actively embraced energy saving and demonstrated the behavioural change required, significant differences have resulted in engaging other building users in saving energy. Engagement of middle management is seen as a key enabler to demonstrate to the much wider building user population what can be achieved in terms of energy saving, and how this can be achieved. Heads of Departments need to have a clear understanding of the role they play in influencing behaviour change, understand the cost effectiveness of behaviour change, and visibly demonstrate their commitment through leading by example. Behaviour change for energy saving needs to be incorporated into regular review activities such as monthly team meetings.

Formalise Energy Officer and Energy Champions role

Stakeholder feedback indicated a need to formalise the Energy/Environmental Champion role across the university such that all Faculties are required to 'recruit' at least one such volunteer would ensure cross-university drive and momentum in saving energy, with structured communications between Estates and Champions, and dedicated time to focus on meetings and actions in order to actively promote behavioural change amongst building users. Formalising this role should include a clear role description, increased responsibilities, feed into personal career progression through training, and recognition and reward for effective performance.

Improve perceived support of FM team

An additional enabler which emerged was the need for the perceived, visible support from the FM team to be improved. Stakeholder workshops indicated that information (relating to energy consumption data, initiatives being undertaken) held by Facilities is not necessarily being communicated through to the Faculties. Regular, reliable and consistent reporting on energy use is required from FM to Faculty leadership, to enable Faculty leaders to communicate this information through the Faculties and define actions to address energy consumption. Links between Faculty leadership and FM need to be improved to ensure there are circular feedback loops in place to develop, implement and monitor behaviour change initiatives and ensure continuous learning and improvement.

Improve perceived senior level support

University leadership needs to show very visible support for energy saving and behaviour change, which needs to be effectively communicated down and actively demonstrated. In alignment with the University's vision and values, this is about taking action, not just rhetoric or simply turning up at Green Impact events. Rather, this is about actively leading by example, promoting behaviour change within own offices and departments and communicating the benefits of change to maintain the change momentum.

Communications strategy and implementation plan

Stakeholder engagement activities also indicates that effective communications need to be implemented in order to promote energy saving and behaviour change across the University. A Communications strategy and plan which meets the needs of all stakeholders needs to be implemented. The University's External Relations team also need to be actively involved in developing and implementing communications. Effective communications also needs to form a key element in the role leaders take in promoting energy saving, through the effective reporting and circular feedback on energy performance to the wider building user population and stakeholders.

Various opportunities arose through the workshops and interviews in relation to communications, particularly where ICT can be used to augment communications effectiveness, such as through the establishment of energy saving forums, the Smartphone Campus App including energy-related information, the Portal providing a communications platform for energy saving, and the inclusion of energy saving messages on screens (such as in The Edge).

10.5.2 Carbon Projection

Based on the recommendations outlined above the following carbon projection has been produced. This does not include the carbon savings outlined in Section 9.

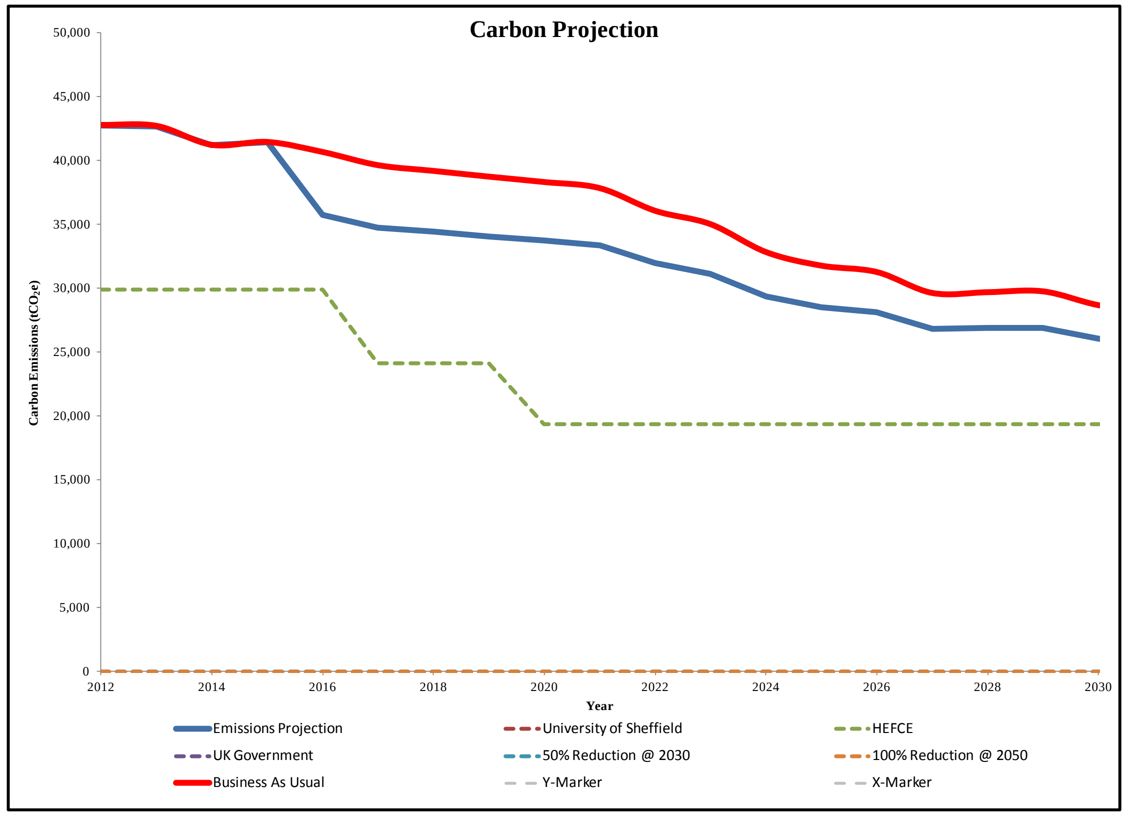


Figure 29: Carbon Projection resulting from Behaviour Change Interventions

This demonstrates the importance of successful behaviour change and how its effects on emission reductions can be at least comparable to those achieved via building interventions.

The trend shown for convergence of the BAU projection and the trajectory after interventions is due to the projected decarbonisation of grid electricity and resulting reduction in effect of related electricity savings achieved (in the absence of any accompanying low-carbon self-generation).

11 Self Generation Interventions

The University recognise the benefits offered by generating their own energy, alongside the importing of heat from the Veolia network and grid electricity, both in terms of energy resilience and the potential to displace existing carbon emissions.

This study has assessed the suitability and opportunities around self-generation in three broad categories:

- Building Integrated
- Stand Alone
- Offsite

11.1.1 Building Integrated

Building Integrated technologies are those which are installed and operated as linked to discrete buildings and systems. They are selected and sized based on energy demands of specific buildings with associated outputs accordingly limited, unless connections for export exist (such as a suitable electrical grid connection).

11.1.2 Stand Alone

This scale of technology refers to those types which would sit within the University's Campus but whose operation would not be linked to one building. Their operation is thus not limited by the energy requirements of specific building(s).

11.1.3 Offsite

The following table displays a complete list of all self generation technologies considered within this study.

Prior to undertaking a full assessment, the suitability of each technology at the three identified scales/categories was considered. This represents the first 'filtering' of technology options and is represented by the colour-coding applied within this table.

11.2 Self Generation Interventions

The following table identifies categorisation of self generation technology and their suitability to building integration, standalone and off-site development. This summarises those technologies considered at each scale within the initial self generation assessment.

Technology	Building Integrated	Stand Alone	Offsite
Gas Boilers			
Biomass Boilers			
Gas CHP			
Biomass CHP			
Biogas CHP			
Photovoltaics			
Ground Source Heat Pump			
Air Source Heat Pump			
Wind			
Nuclear			
Fuel Cells			
Anaerobic Digestion			
Gasification			

Table 8 - Self generation technology categories

11.3 Intervention Appraisal

In order to make a comprehensive assessment of the options available for the deployment of self generation, an Integrated Risk Management (IRM) approach has been adopted. This approach attempts to identify the most favourable option based upon a number of weighted criteria, while helping to identify the relative risks, benefits and constraints associated with the various options available.

The assessment prioritises the options under consideration by risk category or criteria and scores each option to identify the best solution. Criteria weightings help to differentiate between primary and secondary criteria.

11.3.1 Assessment Criteria

Before the options can be appraised, the criteria against which the options are to be considered and the relative weightings of each criterion must be defined.

The following criteria and weightings have been used to appraise the options for self generation to be installed across the University's estate. These are based on our understanding of the University's drivers.

Criteria	Weighting	Description
Capital Costs	100%	The capital investment required to develop the option will have a clear impact upon the commercially viability of developing a scheme. Options with lower relative capital investment requirements are preferred.
Operating Costs	80%	The annual costs associated with the operation of the self generation solution including resource costs, energy costs and personnel costs.
Spatial Requirements	80%	The required space to deploy a self generation solution may become a limiting factor in the denser areas of the site. Utilising larger amounts of space for the development of energy infrastructure also reduces the available land which may be used for primary business activities. The first weighting refers to the building scheme appraisal while the second weighting applies to the larger scheme scale.
Technology Integration	60%	The ease at which a particular option may be integrated into the existing site infrastructure and services will impact upon the likelihood of an option being developed or not. A scheme requiring significant modification to the existing infrastructure and services is less likely to be adopted and will incur significant increases in project costs therefore reducing the commercial viability.
Supply Chain & Market Availability	60%	Availability of each option and the associated consumables and expertise within the market is a key consideration when looking to

		adopt newer technologies. Less mature technologies may incur additional costs in terms of operation and maintenance.
Development Timescales	60%	The required timescales to deploy the self generation opportunity from investment decision to commissioning. Larger offsite and stand-alone solutions will required significantly longer development and consent time than options which can be integrated into existing plant rooms and energy centres.
Locational Suitability	60%	Not all potential self generation solutions will be applicable for deployment within the University's estate. Large renewable solutions which require a significant buffer zone will be an inefficient use of the University's estate compared to solutions which can use existing plant space and areas unsuitable for other activities.
Carbon Reduction Potential	100%	The ability of an option to reduce the carbon intensity of the energy utilised across the site is a key driver for the development of a CHP solution. Carbon reduction potential is mainly a function of the fuel/feedstock utilised.
Available Incentives	80%	The availability of incentive schemes for self generation options can significantly alter the commercial case for investment.
Research/Teaching Links	50%	Self generation solutions which have a clear link to other research and teaching based activities across the University will potentially bring added value. This could include the deployment of renewable technologies and links with the engineering and science faculties.
Future Proofing	60%	The majority of investments in self generation opportunities are long term investments over a period of 10 years or greater. As a result it is important to ensure that any generation or associated infrastructure developed across the University's estate is suitable for the existing demands of the University as well as the future demands.
Stakeholder Perception	40%	Due to the integration of the University within the local community the perceived view of any self generation options deployed may influence the final investment decision. Options which have minimal impact or provide opportunities for wider stakeholder groups should be seen as favourable.
Planning Considerations	50%	Restrictions associated with the planning system in place can directly influence the ability to deploy self generation opportunities within certain areas.

Table 9 - Intervention appraisal weightings

11.3.2 Appraisal Results

The results of the IRM assessment are shown in the following subsections.

11.3.2.1 Building Integrated

Type	Categories	Technology	1. Capital Costs	2. Operating Costs	3. Spatial Requirements	4. Technology Integration	5. Supply Chain & Market Availability	6. Development Timescale	7. Locational Suitability	8. Carbon Reduction Potential	9. Available Incentives	10. Research / Teaching Links	11. Future Proofing	12. Stakeholder Perception	13. Planning Considerations	Score	Priority
Building-integrated	Boiler	Gas Boilers	VG	G	G	VG	VG	VG	VG	VB	VB	VB	VB	A	VG	24.3	2
		Biomass Boiler	A	A	A	G	G	G	A	B	VG	B	B	G	A	25.6	3
		Biogas Boiler															
	CHP	Gas CHP	A	A	A	A	G	A	G	B	B	G	B	G	G	26.6	4
		Biomass CHP															
	PV	PV	B	VG	G	G	G	G	G	G	G	A	G	G	A	20.6	1
	Heat Pumps	Ground Source	B	A	B	A	A	B	B	VB	G	B	B	G	A	32.2	6
		Air Source	G	A	G	A	A	A	A	VB	G	B	B	G	A	27.4	5
	Wind	Wind															
	Nuclear	Nuclear															
	Fuel Cells	Fuel Cells	VB	A	VB	VB	VB	VB	B	G	VB	G	VG	VG	A	32.7	7
	Biogas	Anaerobic Digestion															
		Gasification															

Figure 30 –Building Integrated Technologies

The assessment completed for the Building Integrated self generation solutions has highlighted PV, biomass boilers and gas CHP as potential solutions for generation of heat and electricity, alongside the ongoing need for traditional gas boilers.

- **PV**: PV scored well across all the categories under consideration with the exception of capital costs and could potentially provide the University with a solution for producing zero carbon electricity across the estate. PV currently has a heavy reliance on incentive schemes to make investment commercial viable so a more detailed assessment will need to be conducted.

- **Biomass Boilers**: Biomass boilers have been identified as a potential method of supply low carbon heat to individual buildings across the estate. This technology has scored well across a number of criteria including integration with existing systems, availability, deployment timescales and availability of incentives. The carbon reduction potential of the technology will be limited if deployed in buildings currently connect to the Veolia heat network.

- **CHP**: The carbon and commercial benefits achievable via the operation of CHP plant have led to it scoring highly in the assessment. However, once again, its viability at a scale where such benefits can have a significant impact will be limited according to the demands of buildings currently featuring boiler plant and not a heat network connection. A further consideration for assessment is spatial requirements for the plant.

11.3.2.2 Stand Alone

Campus / Stand-alone Scale	Boiler	Gas Boilers	VG	G	G	VG	VG	VG	VG	VB	VB	VB	VB	A	VG	24.3	2
		Biomass Boiler	A	A	A	G	G	G	A	A	G	B	B	G	A	25.4	3
		Biogas Boiler															
	CHP	Gas CHP	A	A	A	A	G	G	G	G	B	G	B	G	G	24.0	1
		Biomass CHP	VB	B	VB	A	B	B	B	VG	VG	VG	A	VG	B	27.5	6
	PV	PV	B	VG	VB	G	G	G	VB	G	B	A	A	G	B	27.3	5
	Heat Pumps	Ground Source															
		Air Source															
	Wind	Wind	B	VG	VB	G	G	B	VB	G	G	A	G	G	B	26.4	4
	Nuclear	Nuclear															
	Fuel Cells	Fuel Cells															
	Biogas	Anaerobic Digestion															
		Gasification															

Figure 31 –Stand Alone Technologies

- **Biomass Boilers**: Biomass boilers have been identified as being a potentially suitable solution for self generation at a standalone scale, thought the associated spatial consideration for fuel storage and delivery.

- **CHP**: Gas CHP has been identified as the most favourable self generation solution at a stand-alone or campus scale. This technology has been identified as having positive attributes across the categories under consideration. Due to the location and density of the University's estate, the use of standalone renewable generation is limited. As a result the deployment of gas CHP is likely to present the only suitable options for the generation of low carbon electricity at this scale.

11.3.2.3 Offsite

Offsite	Boiler	Gas Boilers															
		Biomass Boiler															
		Biogas Boiler															
	CHP	Gas CHP	A	A	A	B	G	G	A	G	B	A	B	G	G	26.0	3
		Biomass CHP	VB	B	VB	B	B	B	A	VG	VG	VG	A	VG	B	27.5	6
	PV	PV	B	VG	VB	G	G	A	A	G	A	G	G	VG	A	23.6	2
	Heat Pumps	Ground Source															
		Air Source															
	Wind	Wind	B	VG	VB	G	G	B	VG	VG	G	G	G	VG	B	21.6	1
	Nuclear	Nuclear	VB	B	B	A	A	VB	VB	VG	B	VG	VG	VB	VB	31.5	7
	Fuel Cells	Fuel Cells															
	Biogas	Anaerobic Digestion	VB	A	VB	B	B	B	A	VG	VG	VG	VG	A	B	26.9	4
		Gasification	VB	B	VB	B	B	B	A	VG	VG	VG	VG	G	B	27.1	5

Figure 32 –Offsite Technologies

The assessment of larger offsite self generation options has identified wind and PV as potential options for electricity generation. The use of gasification or anaerobic digestion in conjunction with a CHP solution may also be a suitable solution.

- **Wind**: Given the University's proportionately large electricity consumption, the opportunity for large-scale self-generation offered by offsite Wind offers real benefits in terms of carbon emission reductions. The location of University off-Campus land holdings offer, coupled with its operation of existing turbine capacity, suggest suitability for this technology and will be assessed in further detail.
- **PV**: Whilst offering a similar potential in terms of electrical self-generation to offset grid imports, PV use on identified University offsite land would compete with that available for wind installations. In light of the comparative generation potential offered on a per m^2 basis, plus considerations of ongoing plant maintenance, wind has been selected as the favourable generation technology for offsite locations.

11.4 Detailed Assessment

Based on the short list derived via the IRM assessment, a more detailed assessment of the potential for deploying self generation has been undertaken at the three identified categories of scales.

11.4.1 Building-Integrated

The IRM analysis undertaken in relation to building-integrated self-generation concluded that PV presented the best opportunity for technology deployment.

Whilst biomass boiler and gas CHP capacity were also returned as suitable options, individual building-specific analyses would be required in order to conclude around the viable capacity and locations for such plant.

As has been stated earlier in this study, the University currently operate a limited PV array on the roof of the Hicks buildings. The potential for similar installations on select Accommodation buildings have been investigated but not taken forward at the time of writing due to the associated commercial case for implementation.

Though further work is required to determine the feasibility of installing PV at scale on University buildings, modules up to a total capacity of 100 kW has been determined as appropriate to contribute toward a total level of CO_2 emissions savings via self-generation technologies.

11.4.2 Stand-Alone

In consultation with the University's Estates team, a number of potential sites for self generation within the exiting City centre Campus are identified. These are displayed in the following figures.

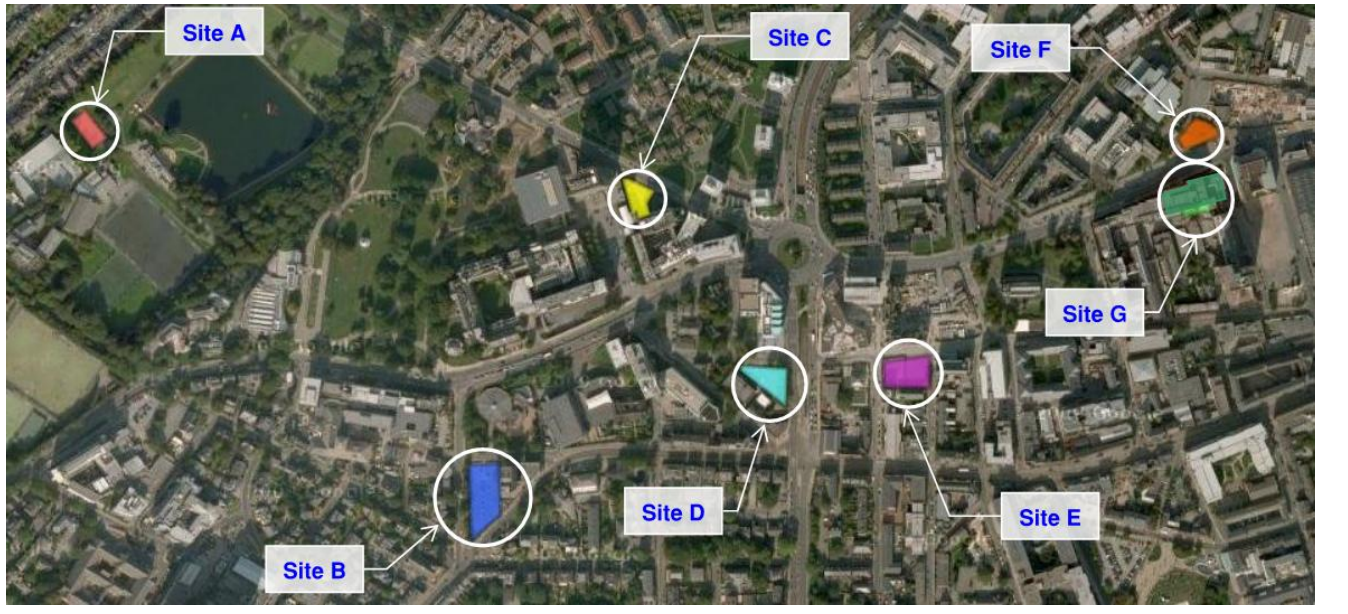


Figure 33 – Stand-Alone Self Generation Location Options

Brief descriptions of these locations are included in the following table, alongside key details of each site.

Site	Description	Approx Area (m^2)	Site Details
A	Car Park to NE of Goodwin Centre	800	• Veolia heat distribution pipework within close proximity
B	Car Park adjacent to Management School	2,300	• Area due to be redeveloped to contain multi-storey car parking • Veolia heat distribution pipework within close proximity
C	Car Park behind Chemistry Building (Bolsover Street)	700	• Immediately adjacent to large energy-consuming University buildings • Veolia heat distribution pipework within close proximity • Adjacent to area requiring maximum business continuity
D	Car Park adjacent to CICs Centre	840	• Veolia heat distribution pipework within close proximity
E	Site to West of ICoSS	1,300	• Current vacant site with potential to develop • Veolia heat distribution pipework within close proximity
F	Car Park adjacent to North Campus	1,550	• Immediately adjacent to large energy-consuming buildings • Veolia heat distribution pipework within close proximity
G	Broad Lane Boiler House	400	• Existing Broad Lane Boiler House • Large proportion of space leased to Veolia

Table 10 - Self generation energy centre / intervention locations

The IRM assessment performed in reference to technologies at the stand-alone scale reported that the implementation of heat (and power) generation is best suited via gas-fired CHP and biomass boilers, alongside the existing use of distributed gas-fired boilers.

The following table displays key opportunities and constraints for these technologies, in reference to the identified Campus sites.

Site	Key Opportunities	Key Constraints
A	• Veolia pipework present for possible heat injection • Anchor load present in form of Goodwin swimming pool	• Existing Veolia pipework diameter (150 mm) will limit heat injection potential • Site is adjacent to parkland and is overlooked by residential properties • Site has limited road access
B	• Area due to be redeveloped (potential to earmark space for new EC) • Veolia pipework present for possible heat injection • Good road access • Existing Veolia pipework diameter in vicinity is 200 mm	• Potential flue-routing challenge due to adjacent tall building
C	• Immediately adjacent to large energy-consuming University buildings • Veolia pipework present for possible heat injection • Good road access • Existing Veolia pipework diameter in vicinity is 250 mm • Adjacent to area requiring maximum business continuity	• Plot is irregular in shape • Potential flue-routing challenge due to nearby tall buildings • Site is highly visible
D	• Veolia pipework present for possible heat injection	• Existing Veolia pipework diameter in closest proximity (125 mm) will limit heat injection potential • Potential flue visibility challenge adjacent to major road
E	• Current vacant site with potential to develop • Veolia pipework present for possible heat injection • Adjacent to site of new Jessop East building which could be served	• Existing Veolia pipework diameter in closest proximity (100 mm) will limit heat injection potential • Potential flue-routing challenge due to nearby buildings
F	• Immediately adjacent to large energy-consuming buildings • Existing Veolia pipework diameter in vicinity is 350 mm • Educational potential for adjacent Engineering Dept	• Presence of adjacent new residential development
G	• Room is present within a large energy-consuming building • Existing Veolia pipework already accesses plant space and is set up for heat export (from oil-fired back-up boilers) • Existing flue arrangements in place	• With plant already present, only a limited proportion of existing space is available for new generation, in lieu of replacing elements of existing plant

Table 11 - Stand-alone self generation opportunities and constraints

For the purposes of this study, it has been assumed that there is an option to inject generated heat into in the Veolia distribution network, as was discussed within the related workshop events.

With adjacent building energy demands also a factor to be considered in location self-generation plant, though not fully limiting its scale, the following figure displays the identified Campus sites relative to existing University buildings.

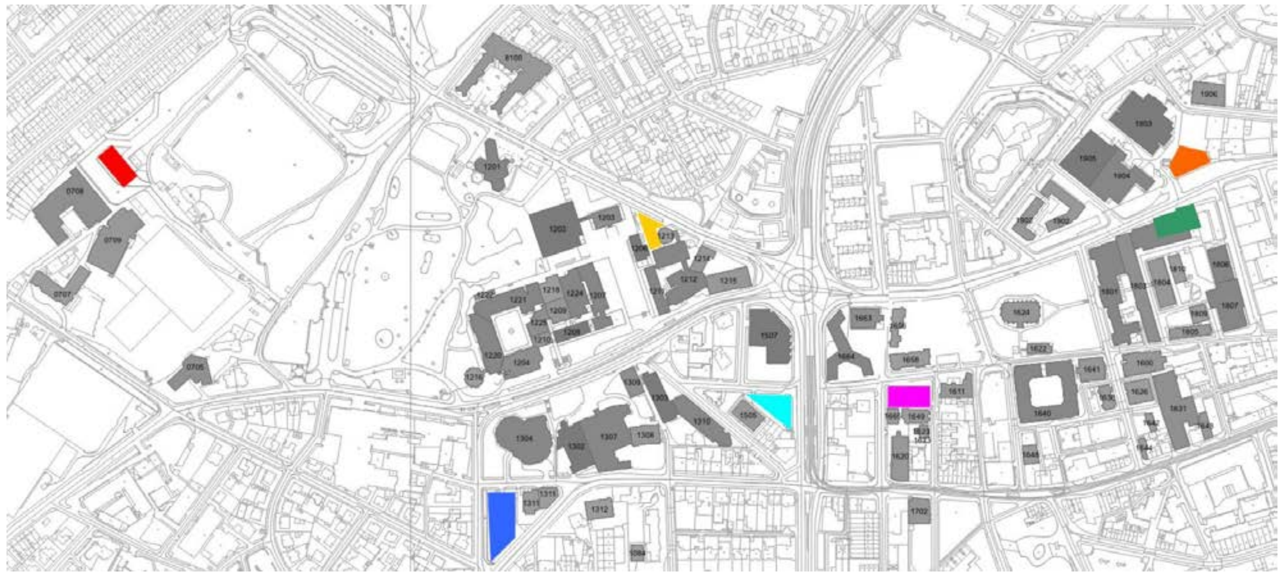


Figure 34 – Self Generation Location Relative to Campus Buildings

An appreciation of the available area within each identified site has been used, alongside any limitations for heat export represented by adjacent Veolia distribution pipework, in order to establish the approximate unconstrained capacity for the identified generation technologies within the identified sites.

These capacities are shown in the following table.

Site	Approx unconstrained Biomass boiler capacity (kWth)	Approx Unconstrained CHP capacity	
		Electrical (kWe)	Thermal (kWth)
A	1,500 – 2,000	1,300 – 1,700	1,500 – 2,000
B	2,500 – 3,000	2,100 – 2,600	2,500 – 3,000
C	3,500 – 4,000	3,000 – 3,400	3,500 – 4,000
D	1,000 – 1,500	850 – 1,300	1,000 – 1,500
E	750 – 1,000	650 - 850	750 – 1,000
F	3,000 – 4,000	2,600 - 3,400	3,000 – 4,000
G	500 – 750	3,000 – 3,400	3,500 – 4,000

Table 12 - Stand-alone self generation capacities

11.4.3 Offsite

In addition to those within the City centre, the University have control over a number of other off-Campus sites.

Advanced Manufacturing Research Centre

The Advanced Manufacturing Research Centre (AMRC) is a building and site owned and operated in tandem by the University and Boeing, situated within the Advanced Manufacturing Park to the East of Sheffield. This site is outlined in the following figure.

Figure 35 – Stand-Alone Self Generation Location Options

Bole Hill

Bole Hill is a very small site situated in Lodgemoor to the West of Sheffield, currently the site of an observatory. The site boundary is shown in the following figure.

Figure 36 – Bole Hill Site Boundary

Harpur Hill

The Harpur Hill site consists of two areas near Buxton in Derbyshire. Outlined in the following figure, the red area is leased from the HSE whilst the blue area is owned by the University.

The site currently features a series of bunkers which are used by a number of University departments for experimental work and storage.

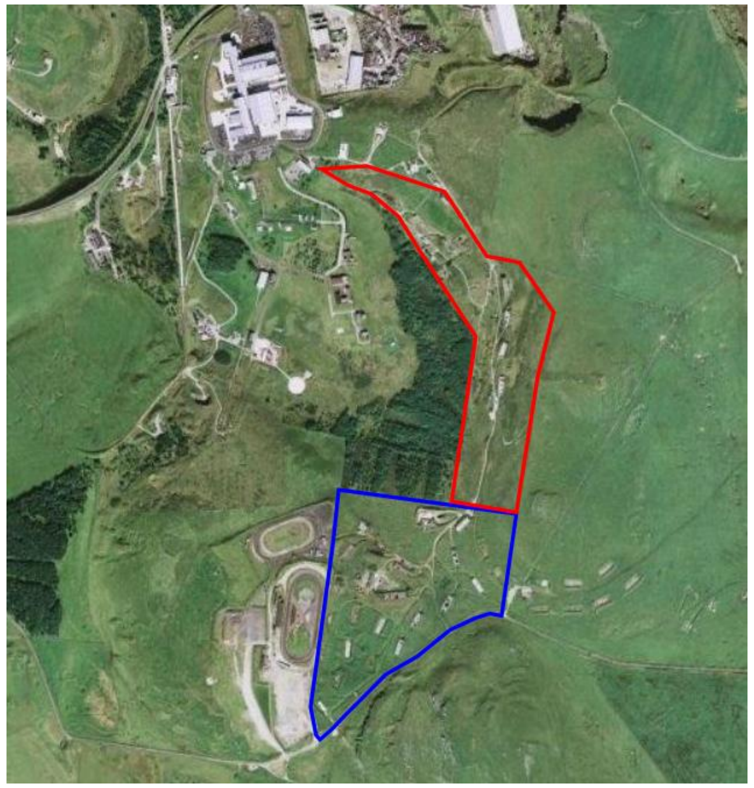


Figure 37 – Harpur Hill Site Outlines

The IRM assessment returned a clear indication that electrical generation via wind turbine(s) represented the best option for University carbon offsetting. As such, each of the three off-Campus sites are subsequently assessed in terms of their suitability for wind turbines, with results displayed in the following table.

Site Name	Key Opportunities	Key Constraints
AMRC	• Site is already proven suitable for wind turbines	• Presence of existing turbine • Proximity to the A630
Bole Hill	• Site soon to be vacated and available for redevelopment	• Constraints mapping shows close proximity to a public right of way
Harpur Hill	• Good identified wind speeds	• Constraints mapping shows limitations for leased area of site

Table 13 - Offsite self-generation opportunities and constraints

In recognition of the wind speed data and identified constraints for each of these sites, approximate viable wind turbine capacities have been derived and displayed in the following table.

Site Name	Approximate Wind Turbine Capacity (kW)	Notes
AMRC	900	It is understood that the University intend to introduce a second wind turbine at the AMRC site, comparable in capacity to that already present
Bole Hill	-	In light of both low wind resource and constraints to locating a turbine within the site boundary, this site is deemed unsuitable for self-generation
Harpur Hill	module(s) up to 2,500	This site features good wind speeds recorded at a range of heights, notably at 45m where measurements suggest an average speed of 7 m/s

Table 14 - Offsite wind turbine capacities referenced to wind regime

As with all sites identified as technically suited to wind turbine deployment, further feasibility work would be required., This should include consultation with the Ministry of Defence (MoD) and the Civil Aviation Authority (CAA), and an assessment to appreciate the impacts of noise on nearby dwellings.

11.5 Procurement, Funding and Structuring Options

A range of procurement options are currently utilised in the delivery of energy infrastructure projects and developments. The most suitable model or arrangement for the development of a self generation plant across the University's estate will depend upon factors including:

- The type and size of generation being deployed;
- desire to focus upon core activities and business;
- avoidance of capital investment;
- a desire to improve operational efficiency; and
- minimising cost and risk.

As a result an understanding of the characteristics of the different procurement opportunities is essential to ensure the correct decision is made.

11.5.1 Procurement Models

The following four options have been put forward as potential solutions for the development of self generation plant across the University's estate. The best option will depend upon University's position on investment and asset ownership and its appetite for operating and commercial risk.

The options are presented in order of increasing transfer of risk away from the University. These options provide examples of procurement opportunities and by no means set out all the potential arrangements which could be agreed between the University and external parties. Variants of each of the options can be envisaged.

11.5.1.1 University Investment & Operation

This is the base case or standard procurement method where the University designs, builds, finances, owns and operates the self generation plant. This procurement method limits contractual agreements with third parties to supplies of equipment and fuel.

Under this model the University retains ownership of all assets associated with the scheme and as a result must provide all the finance. Under this option, by default, the University will accept all operational and commercial risks associated with the scheme.

11.5.1.2 Sub-Contract Services

Under a sub-contract services model, the University procures the self generation assets, but each aspect of the operation and maintenance of the scheme is contracted to and managed by a sub-contractor. As a result the operational costs and risks may be partially or fully assigned to sub-contractors but the overall responsibility for performance is retained by the University. The University will also have to co-ordinate and supervise the contractors.

Contract lengths with sub-contractors are usually limited in length to 3-5 years, with the aim of incentivising good performance and ensuring continued value for money through the benefits of operational efficiencies. The downside of short term contractual arrangements is the difficulty in incentivising the contractors to obtain best use from assets, as the cost of repair and replacement is not their concern and the contractor may hope for additional monies from such activities. Ownership of the assets remains with the University under this model, including the responsibility of asset replacement.

11.5.1.3 Contract Energy Management

Under a contract energy management model a single contractor is employed to provide all operational aspects of the scheme. The single contractor therefore accepts all operational risk associated with the scheme unless otherwise set-out in the agreement. For example, the contractor may undertake to purchase fuel, manage the export of power, manage connections and capacity and undertake repair and replacement of equipment.

In a similar manner to the subcontracting model, the University would normally retain asset ownership and responsibilities for funding both the initial investment and asset replacement. However, CEM contracts can include the transfer of responsibility for repair and replacement.

Under this model the contract length is usually significantly longer than under the sub-contract model, with contracts up to 25 years, and sometime longer where asset replacement is included in the contract. Longer contracts make it easier to incentivise the contractor to look after the assets associated with the scheme, and avoid unnecessary replacement. Conversely, it is difficult for the University to benefit from the operational efficiency gains which are likely to occur over the life of the contract. To an extent, this problem can be mitigated through periodic performance reviews. But experience shows it is difficult to ensure ongoing value for money under a CEM model. Such arrangements are also less flexible when it comes to site changes such as expansion.

11.5.1.4 Energy Service Company

Under an energy service company (ESCo) model the selected third party takes on all aspects of the scheme including asset ownership and all commercial and operational risks. In return the University would purchase energy from the ESCo at a defined rate, typically linked to a number of indices.

As the third party provides the initial capital investment for the development of the scheme the value of this scheme to the University will be influenced by the relative cost of capital of the ESCo compared to the University. Larger energy companies have access to low cost capital as a result of the stability of the energy business and market in which they operate, and so may be able to fund the investment more cheaply than the University. To secure this value, it would be necessary to provide a demand guarantee and to organise a competitive procurement process that focusses on the rate for energy.

Contract terms under ESCo models are long due to the investment required with 25 to 40 year contracts not uncommon.

The ESCo model provides BAE with the opportunity (depending upon the perceived risk and performance levels) to pass on of almost all risks and responsibilities associated with the scheme. Given the long duration of contracts, inclusion of flexibility to respond to site and energy market changes can be included to some extent.

11.5.1.5 Summary

Table below provides a summary of the risks assigned to each party under the four models.

Model	Investment	Operational Risk	Commercial Risk	Asset Replacement
University Investment & Operation	University	University	University	University
Sub-Contract Services	University	University / 3rd Parties	University	University
Contract Energy Management	University	3rd Party	University /3rd Party	University
ESCo	3rd Party	3rd Party	3rd Party	University / 3rd Party

Table 15 – Procurement Module Risk Assignment

Option	Benefits/Opportunities	Costs/Constraints
University Investment & Operation	University retains the benefits of all efficiency improvements Limited 3rd party contractual arrangements required	Capital Investment Required Asset replacement risk remains with the University University responsible for design, procurement and implementation
Sub-Contract Services	Operational performance assured through short-term contracts University retains flexibility for its business	Capital Investment required Asset replacement risk remains with the University University responsible for design, procurement and implementation Construction and maintenance contract administration required
Contract Energy Management	Long-term contract potentially brings energy cost certainty to the University Reduced risk of wasteful asset replacement Contract administration simplified	Capital Investment required University responsible for design, procurement and implementation Difficult to ensure continuing value for money.
ESCo	No capital investment required Avoidance of investment decisions in unfamiliar areas University pays a predictable price for energy benchmarked to indices Asset replacement responsibility transferred ESCo responsible for design, procurement and implementation	Potential loss of flexibility for the business. Demand guarantee required

Table 16 – Procurement Model Opportunities and Constraints

11.6 Self-Generation Summary Recommendations

11.6.1 Stand-Alone PV

An accompanying assessment of existing University building roof area is recommended, to determine the amount of area offering suitable access, orientation and elevation for PV installation.

Capacity

This study has determined that an appropriate scale of PV capacity for building-mounting is in the order of 100 kW, translating to approximately 2,000 m^2 of suitable roof area.

11.6.2 Stand-Alone heat and CHP

The potential to generate and inject heat into the Veolia distribution network represents an opportunity for the University to maximise the self-generation of both heat and power.

Whilst renewable, biomass-fuelled CHP would maximise the CO_2 emissions savings achievable in this regard, the combination of current technology maturity and proven reliability (or lack thereof), plus the size and location of sites identified with the University for self-generation, mean that gas-fired CHP represents the better option for this generation at present.

The use of biomass in more proven boiler plant is a further option to increase the CO_2 savings attributable to generated heat. However, the logistics of fuel deliveries and storage, combined with flueing arrangements, would need to be considered as part of site-specific considerations for technology deployment.

Capacities

A total unconstrained capacity of gas-fired CHP plant has been identified as in the order of 10 – 13 MWe, with an equivalent for biomass boiler plant of 12 – 15.5 MW.

Whilst further site-specific feasibility studies will be required in order to optimise the rollout of CHP and biomass boiler modules across the identified opportunity sites, it is recommended that those sites which offer an opportunity to deliver electricity (and displace grid imports) to large energy-consuming University buildings be prioritised for CHP.

Similarly, the locating of biomass boiler capacity should consider the level of heat demand offered by adjacent buildings (or opportunities of new planned buildings) plus the potential to export heat to the Veolia network.

For this reason, initial CHP consideration in the following locations is recommended:

- Site C: Car park adjacent to Chemistry (Bolsover Street)
- Site G: Broad Lane Boiler house
- Site F: Car Park adjacent to North Campus

A total installed capacity of CHP across these sites of around 6 MWe is deemed to be achievable and capable of delivering CO_2 emissions savings toward the University's short-term HEFCE targets.

Further assessment around potential to implement biomass boiler plant with a combined capacity of 4 MW is also recommended.

Business Continuity

In addition to University self-generation, greater business continuity related to heat provision can be achieved via the locating of large thermal stores on the Campus. This option has actively been raised by Veolia, who recognise the increase in network resilience this would offer, and wish to site thermal stores in close proximity to key University load centres.

It is recommended that the following locations be proposed and discussed for the potential locating of Veolia thermal stores:

- Site A: Car park to NE of Goodwin sports centre
- Site B: Car park adjacent to Management School

11.6.3 Offsite Wind

Of the three identified University-owned sites off-Campus, those at Harpur Hill near Buxton and on the Advanced Manufacturing Park East of Sheffield have been identified as technically suitable for the deployment of wind generation.

Capacity

The identified (and proposed) potential to double wind turbine capacity at the University's AMRC facility would represent the additional of 900 kW generation.

In order to deliver significant progress toward the University's HEFCE targets of emissions reduction, it is recommended that deployment of additional wind turbine capacity in the order of 6.5 – 7 MW be considered on the Harpur Hill site, given both its size and wind resource suitability.

11.6.4 Commercial Analysis

The following table summarises the outline commercial analysis undertaken for the proposed capacities of self-generation technologies.

Technology Type	**Total Installed Capacity** (MW)	**Capital Cost** (£)	**Operating Cost** (£/year)	**Annual Displaced Operating Cost** (£)(£/year)	**Annual Operating Revenue** (£)(£/year)	**Net Operational Savings** (£/year)
Building-Integrated						
PV	0.1	270,000	4,300	-	9,000	14,500
Stand-Alone						
Gas CHP	6	3,225,000	1,200,000	1,450,000	-	250,000
Biomass Boilers	4	400575,000	1,150200,000	770,000	500,000	60,000
Offsite						
Wind	7.5	15,000,000	300,000	2,300,000	750,000	2,750,000

Table 17 – Self-Generation Commercial Analysis Summary

11.7 Carbon Projection

Based on the recommendations outlined above, the following carbon projection has been produced.

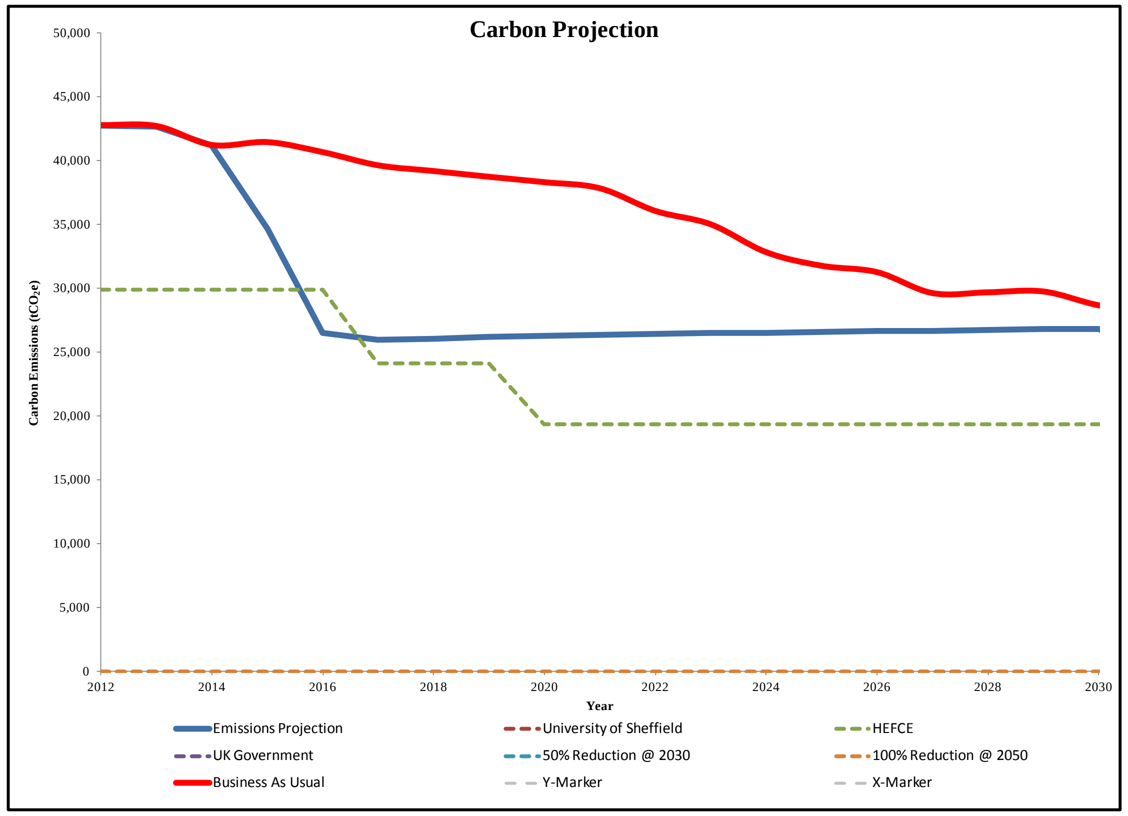


Figure 38: Carbon Projection resulting from Self-generation Interventions

The projection clearly shows the significant impact which self-generation is expected to have upon the overall carbon emissions associated with the University's estate.

Self-generation projects will be the single biggest factor in determining whether the University can meet the 2020 carbon reduction targets set by HEFCE.

It should be noted that within the projection each of the technologies recommended are installed and operated to the end of their operational life. These systems are not replaced after this point.

12 Modelling

In order to aid with understanding the overall impact of deploying a range of opportunities an energy strategy model has been developed alongside this technical report. The model has been developed with the intention of providing the University with a means of considering the impact of a range of opportunities and interventions against the baseline position for energy consumption and carbon emissions projected above.

The model has been designed and developed with flexibility in mind and allows the user to define up to 10 scenarios which can be easily compared and contrasted. The results of the model are presented in a dashboard layout.

12.1 User Guide

A user guide for the model has been developed and produced separately to this document and provides an outline and guide to utilising the model.

12.2 Dashboard

The model dashboard has been designed to provide a clear and concise presentation of key results produced by the model.

The Dashboard is divided into three main outputs and is presented alongside a selection of results data, a summary of the key assumptions and a number of options to provide the user with maximum flexibility and ease of operation.

The main outputs of the dashboard are described below;

- Carbon Projection

  The carbon projection presents a “business-as-usual” projection of carbon emissions for the University’s estate against a projection of carbon emissions after the deployment of the user selected options. These two projections are presented alongside a range of targets for carbon emissions.

- Cost/Revenue Projection

  The cost/revenue projection provides an indication of the levels of capital expenditure, annual operational costs and annual savings and revenues associated with the projects selected for deployment within the model.

- Marginal Abatement Cost Curve

  The Marginal Abatement Cost Curve (MACC) provides a method of comparing the relative cost of carbon abatement for a range of opportunities and interventions by considering the total volume of carbon saved and the cost per unit of carbon saved.

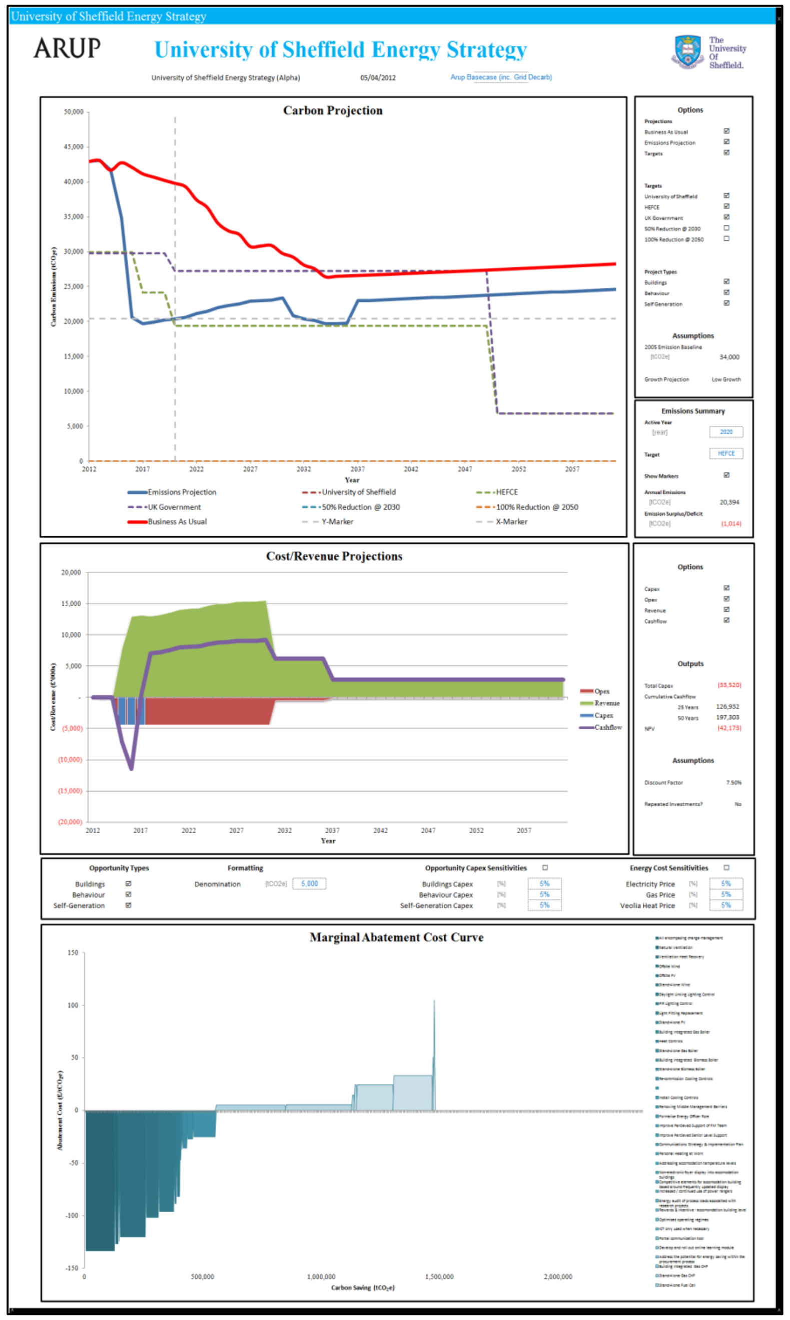


Figure 39 – Energy Strategy Model Dashboard

12.3 Project Selection

The model has been designed in order to allow the user to select from a range of pre-defined projects under the titles of buildings, behaviour and self generation.

The user may select which projects are active and therefore included within the carbon projection and cost/revenue projection outputs. The user may also define the scale of the project for each opportunity type.

- For building-based opportunities the user selects the total estate floor area to which the opportunity is to be applied.

- For behavioural opportunities the user selects the faculties to which the opportunity is to be applied.
- For self generation opportunities the user defines the capacity of the technology.

In addition the user may also define the date at which the opportunity is deployed.

12.4 Inputs, Variables & Assumptions

The model has been designed with maximum flexibility in mind and as a result the user has access to edit all of the inputs, variables and assumptions within the model. The main inputs have been split into three main categories:

- Static Inputs – Inputs which do not vary over time including discount rates;
- Variable Inputs – Inputs which vary on an annual basis including energy costs and growth rates; and
- Estate Development Plans – Plans for new build, refurbishment and demolition of the University estate.

12.5 Estate Development

The model projects the carbon emission associated with the estate based on a user-defined schedule of floor areas within the model. The user may define up to 92 individual buildings with the remainder of the estate summarised into 10 different building types.

The user may then define the total floor area for each building or building type on an annual basis as well as indicating the total area of each building or building type that is refurbished. These development plans are combined with industry standard energy consumption benchmarks to calculate the projected energy consumption and associated carbon emissions.

12.6 Buildings

A range of building based initiatives has been included within the model. These initiatives have been defined based on a range of benchmark data which has been normalised by floor area. Building initiatives have been identified during the site and building surveys completed across the estate. All opportunities have been identified as stand-alone projects.

The data included within the model for building based initiatives has been based upon a typical result from deploying that initiative type. This is due to the fact that each initiative will likely result in a slightly different outcome within each applicable building and each applicable space type within the building.

12.7 Behavioural

The opportunities identified throughout the course of this work have been used to develop a set of interventions for reducing energy use across the university which are included within the model. These interventions are separated into *enablers* and *actions*.

The enablers are programmes that need to be taken to promote an increased awareness and understanding of the need for behaviour change throughout the university. They will not necessarily result in significant reductions in energy saving, they are pre-requisites that will allow more specific actions to be successful.

The actions are specific activities targeted at a certain type of energy use or building user. It is these actions that will result in reduced energy consumption if carried out correctly.

Best Practice Guidance for the development of carbon reduction strategies proposes savings of between 10 and 20% energy use through behavioural interventions. The percentage changes that may be achieved through effective implementation of the actions included in the model are therefore created using this guidance.

It is estimated that implementing all of the enablers and actions within the model will result in a saving of around 11-12%. To realise further reductions, the actions listed, and more, will need to be drawn together into an all-encompassing, coherent and effective change management programme that pervades through all university activities. If this is truly embraced at all levels, it is feasible that the 20% reduction at the upper end of the prediction range could be realised.

The behaviour change facets of the model are therefore underpinned by the following assumptions:

- The percentage savings realisable from the actions are dependent on the enablers having been implemented. Savings from the actions are possible without the enablers but the magnitude is much reduced. Where multiple enablers are relevant, their effect on the savings possible from the actions is greater the more of them are implemented, reflecting a ‘positive feedback’ situation where people who are already aware of the issues are more receptive to further information.
- The actions are not mutually exclusive – combining actions will not equate to a cumulative percentage saving on energy as it is harder to save energy when action has already been taken.
- External support is required for ensuring a range of interventions are undertaken in a structured change management approach. External support provides overall programme management and ensures allocation of adequate resource for programme activity.

12.8 Self Generation

All self-generation opportunities considered as part of the IRM analysis have been included within the model. Benchmark data for each of the technology types and scales has been normalised based on peak installed capacity.

Self-generation opportunities have been split into three scales:

- Building Integrated
- Stand-Alone
- Offsite

This is as a result of economies of scale affecting each scale of technology and therefore the commercial viability.

No limits on the scale of each technology have been defined within the model as such the energy strategy report should be consulted in conjunction with the self generation options to understand spatial and technical constraints across the University’s estate.

12.9 Scenario Modelling

In order to establish the level of self-generation required in order to meet the University's 2020 carbon emission targets, three scenarios were tested using the accompanying energy strategy model.

These scenarios were considered on the basis of both retaining connection to the Veolia heat network and the removal of these connections and featured the following combinations of new self-generation technology:

1. Gas CHP within Western Bank + offsite Wind
2. Gas CHP within Western Bank + Biomass boilers on St Georges + offsite Wind
3. Offsite Wind only

12.9.1 Modelling Assumptions

The following assumptions were applied within each modelled scenario, to ensure an accurate comparison:

- 2005 University emissions baseline = 34,000 T/CO_2
- Estate development to be in line with University plans to 2017
- Total floor area growth rate beyond 2017 = 1% per annum
- No Grid decarbonisation (as envisaged within the 2011 DECC toolkit)
- All identified Buildings and Behaviour Change initiatives are successfully deployed
- Proposed 'sleeving' contracts for Veolia electricity provision are acceptable to HEFCE
- Where connections to Veolia are maintained, heat export or 'dumping' to the network from self-generation technologies is possible

The deployment timescales for the identified scenario technologies are assumed as follows:

- Biomass boilers - 2015
- Gas CHP - 2016
- Offsite Wind - 2018

12.9.2 Scenario 1: Gas CHP on Western Bank + Offsite Wind

12.9.2.1 Retaining Veolia Connection

The first carbon projection results plot for this scenario relates to the condition of retaining connections to the Veolia heat network, plus the installation of self-generation plant with the following capacities:

- Gas CHP = 6 MWe
- Offsite Wind = 11.5 MWe

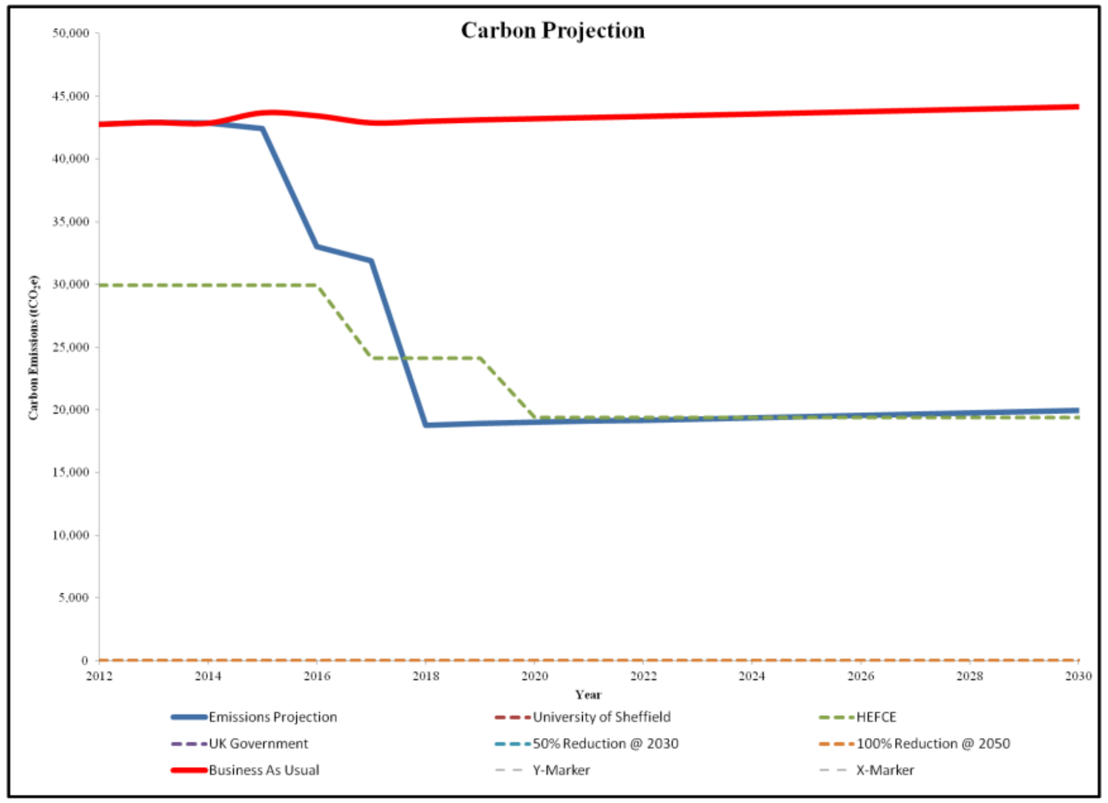


Figure 40 – Results of Scenario 1 (retaining Veolia connection)

The operation of this combination of self-generation plant is shown to facilitate a meeting of the University's 2020 HEFE target.

The predicted capital expenditure for this scenario is £43 million.

12.9.2.2 Removing Veolia Connection

The second projection is based on the removing of existing connections to the Veolia heat network and the installation of the following self-generation technologies:

- Gas CHP = 2 MWe
- Offsite Wind = 14.5 MWe

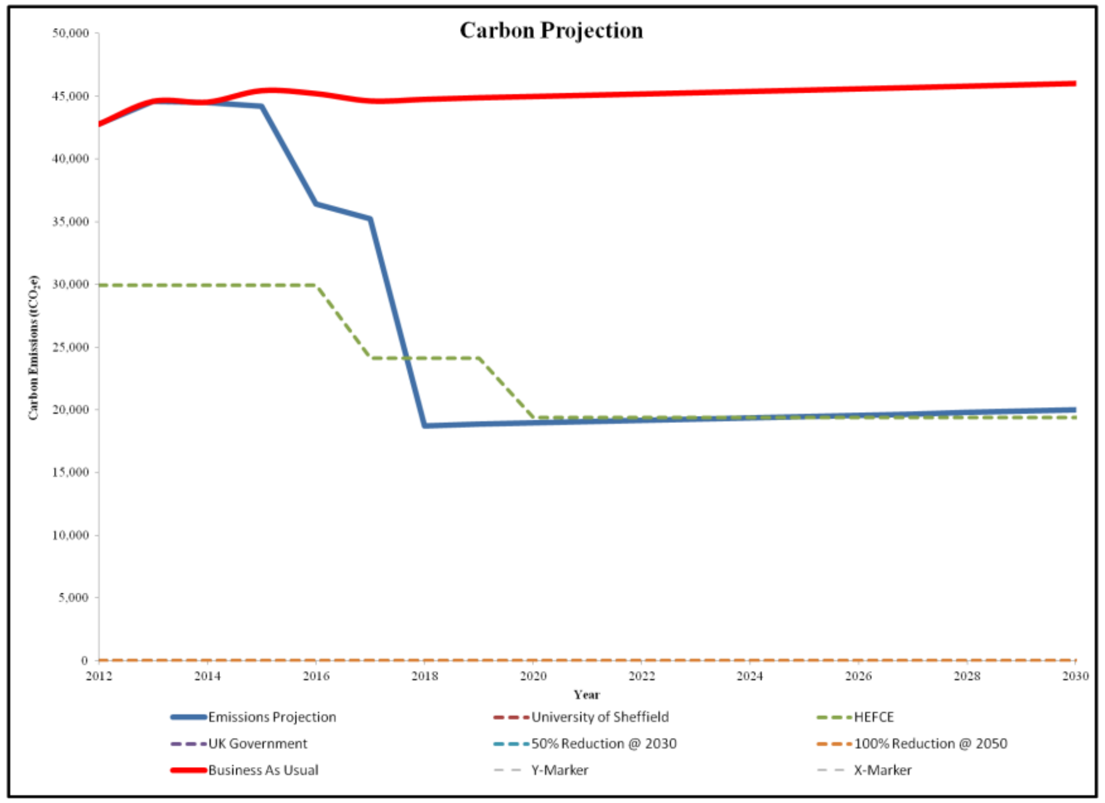


Figure 41 – Results of Scenario 1 (removing Veolia connection)

This combination of technologies similarly meets the 2020 carbon target and with a similar predicted capital expenditure of around £43 million.

However, an additional cost of £25 million is estimated to facilitate the disconnection of existing Veolia network connections and the associated additional heat generation plant required in order to still meet University demands.

12.9.3 Scenario 2: Gas CHP on Western Bank + Biomass Boilers on St Georges + Offsite Wind

12.9.3.1 Retaining Veolia Connection

For the second scenario, implementation of the following technologies was modelled whilst connections to Veolia were maintained:

- Gas CHP = 6 MWe
- Biomass boilers = 4 MWth
- Offsite Wind = 6.5 MWe

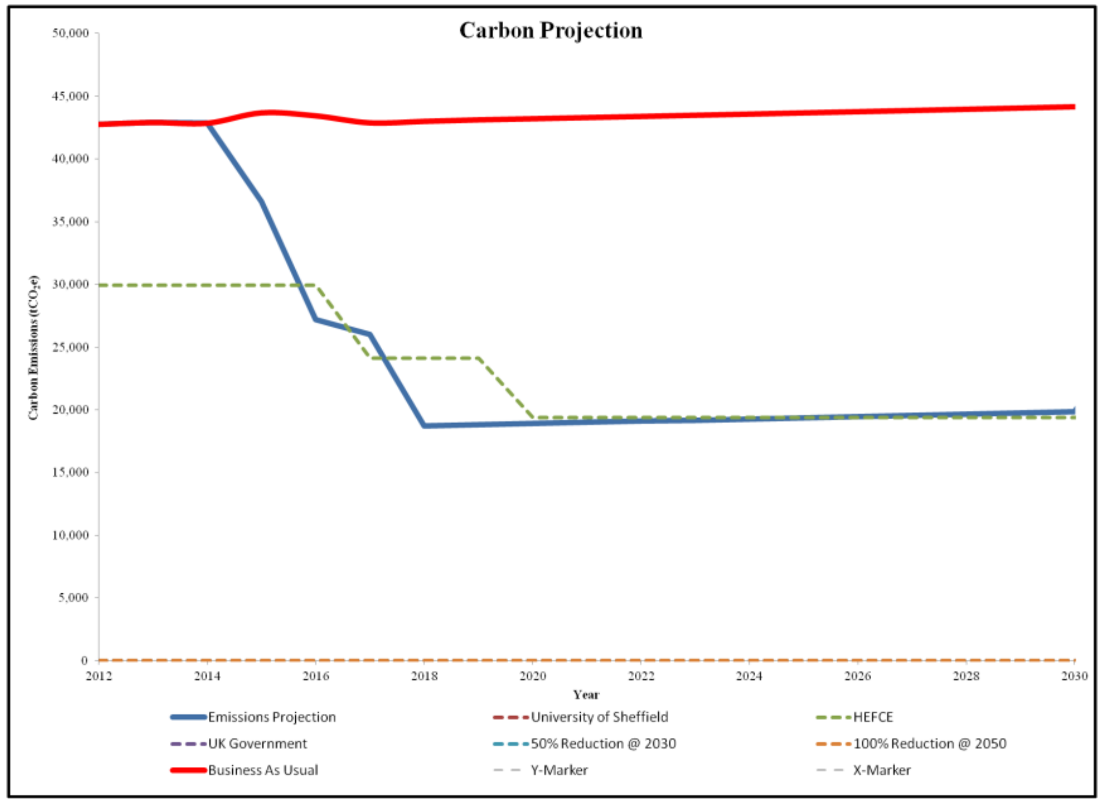


Figure 42 – Results of Scenario 2 (retaining Veolia connection)

The capital cost for this arrangement is predicted to be around £40 million.

12.9.3.2 Removing Veolia Connection

In addition to removing connections for Veolia, the following plot shows the effect of introducing the following technologies:

- Gas CHP = 2 MWe
- Biomass Boilers = 1 MWth
- Offsite Wind = 13 MWe

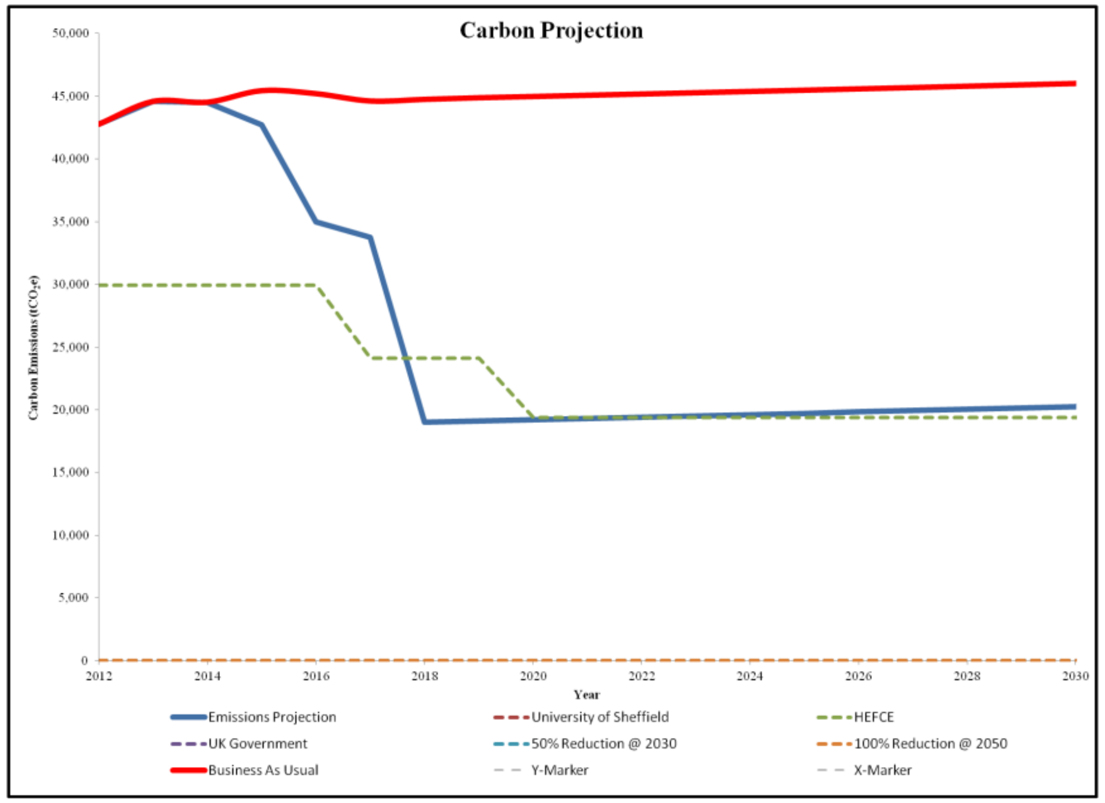


Figure 43 – Results of Scenario 2 (removing Veolia connection)

Whilst carbon targets are similarly met, and with a capital cost of around £40 million, the additional cost of replacing the heat demand gap left by disconnecting from the Veolia network remains as an additional £25 million.

12.9.4 Scenario 3: Offsite Wind Only

12.9.4.1 Retaining Veolia Connection

With Veolia connections remaining, this first scenario plot represents an installing of the following Wind turbine capacity:

- Offsite Wind = 13.5 MWe

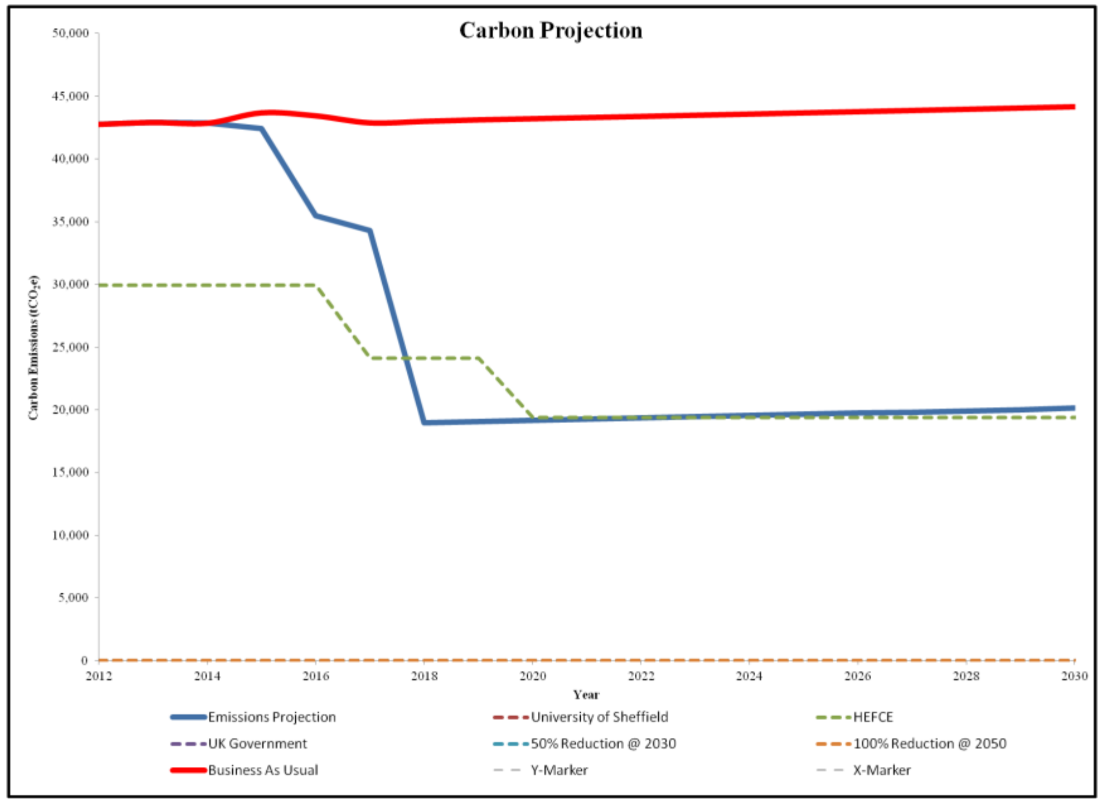


Figure 44 – Results of Scenario 3 (retaining Veolia connection)

The predicted capital cost for this option, under which the 2020 carbon targets are met, is around £39 million.

12.9.4.2 Removing Veolia Connection

In order to offset the carbon benefit of heat from the Veolia network, the installed technology capacity for this option is as follows:

- Offsite Wind = 15 MWe

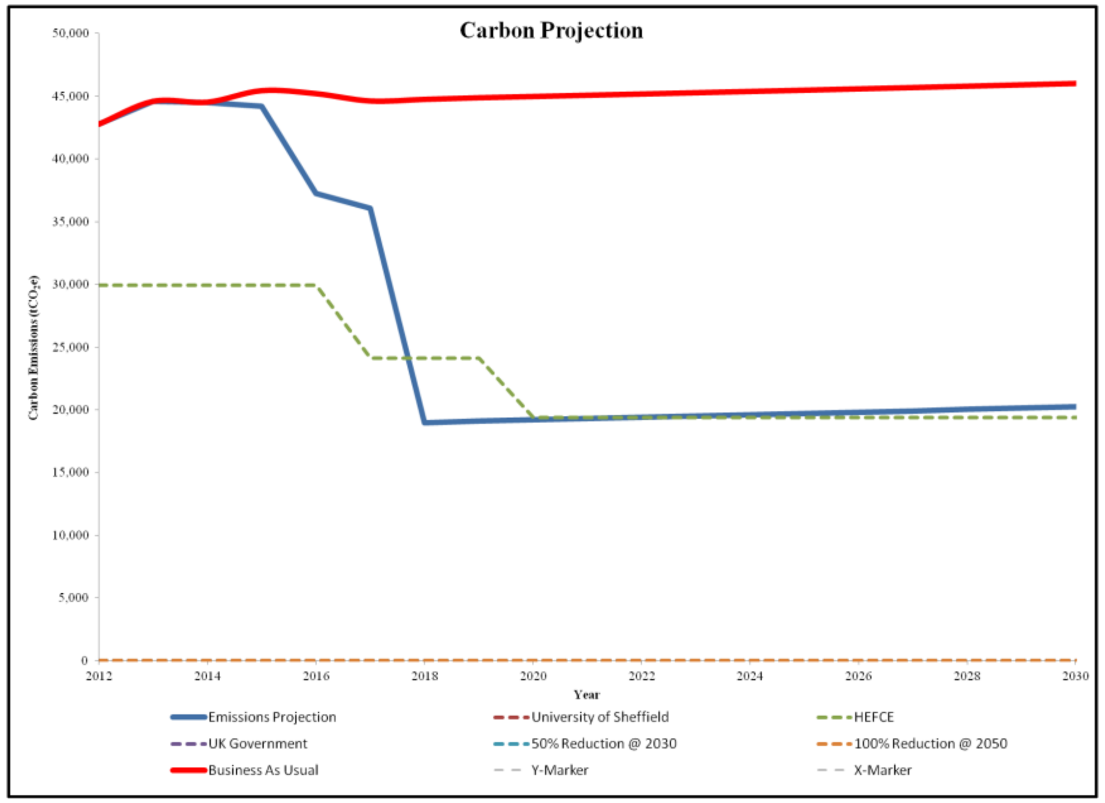


Figure 45 – Results of Scenario 3 (removing Veolia connection)

Alongside the cost of £25 million for removing Veolia network connections, the capital spend for new wind turbine capacity is estimated around £42 million.

13 Conclusions and Recommendations

13.1 Summary

The University have clear commercially viable strategic opportunities to reduce carbon and improve business continuity through behaviour change, building services upgrades and self generation low and zero carbon interventions. It is recommended that to deliver the interventions identified by this study the University address a number of constraining factors. The constraints are not unusual and given the right commitment can easily be addressed as enabling activities.

For the University to achieve the HEFCE 2020 carbon reduction target requirements, by far the greatest carbon reduction will be achieved by the introduction of self generation infrastructure. It is recommended that the University embark on the development of integrating CHP energy centres with elements of renewable boiler fuel at strategically appropriate locations, along with the application of off-site wind turbines and building integrated solar photovoltaics in a pragmatic and appropriate manner. CHP and renewable intervention capacities have been modelled against demand data and selected accordingly. The maximum benefit gained from CHP can be achieved by interconnecting these energy centres with the Veolia district heat network.

The Veolia network offers the University a greater advantage in terms of carbon reduction opportunities than are available to other less fortunate Universities without city district networks. To enable heat interconnection between developed University energy centres and the Veolia network a greater level of collaboration and understanding between the parties will be required. However, there is been a reticence to either party driving this, primarily due to a lack of Veolia customer service and relationship management over a number of years. Fortunately, new management and impetus in both parties has created more willingness to improve the relationship. Veolia are now responding to University customer requirements and have thoroughly engaged in working sessions over the course of this strategy development, exploring possible carbon and continuity interventions. It is recommended that to enable the development of University CHP energy centres a memorandum of understanding (MoU) be drawn-up and agreed upon by the University and Veolia. Such an MoU would be designed to address other intervention recommendations requiring enabling works and to foster an improvement in the long term relationship.

A long term relationship with Veolia is essential for improved University business continuity planning and energy system resilience. Planned preventative maintenance (PPM) regimes of both parties need to be developed in collaboration, along with agreed method statements of work and reporting when dealing with system failures and emergency repair. It is further recommended that the University explore the purchase of renewable electricity from Veolia's Bernard Road EfW facility which will become available towards the end of 2013 when their existing Non-Fossil Fuel Obligation agreement with the Non-Fossil Fuel Purchasing Agency ceases.

The dashboard model produced for the strategy combines gathered estate data with energy and carbon inventories to manipulate selected behavioural, buildings and self-generation interventions to produce carbon, financial and marginal abatement cost curves in a dashboard format. The model permits the creation and selection of intervention scenarios and adjustment of key variables. Recommendations have been produced using the model outputs combined with an understanding of interventions bearing on risk to the University Estate.

It is recommended that along with the self generation interventions, a roll-out of behavioural change management be undertaken consisting of faculty and departmental end user engagement and assignment of 'champions'. Behavioural champions within faculties and departments should be made responsible for communicating the need for change to the building users through stakeholder meetings and activity assignment to users. Communicating the energy and carbon performance of University buildings by effective use of the University's metered data in reports, building foyer read-out displays and smart phone applications are recommended as important behaviour changing interventions to be undertaken by the Estates team.

Building services refurbishment has been targeted by building use and service type, utilising available data and survey findings. The overall University stock was found to be performing to a good standard of energy and carbon. Where resolution of available data did not permit a fine granularity of examination, aggregated performance was proportionally derived and compared with best practice benchmarks. A series of commercially viable building interventions are recommended including heating, cooling, ventilation, lighting and building fabric improvements. However, constraints to plant room accessibility are extensive due to the managed asbestos presence across the University. Greater levels of energy and carbon saving than current ease of access permits are anticipated from plant room interventions. The presence of asbestos across the University is a significant obstacle to energy and carbon reduction, metering and effective maintenance. It is therefore recommended that building services plant room interventions are enabled by a commitment to remove all asbestos.

Modelled carbon reduction trajectories illustrate an achievable plan of action to meet the 2020 HEFCE target. Reductions over the business as usual trajectory will be around 19,000 Tonnes of CO_2 equivalent by 2020 made by the recommended behavioural, buildings and self-generation interventions delivery programme.

The self generation capacity, largely responsible for the carbon reduction as modelled will amount to around:

Intervention	MW capacity
PV	0.1
Gas CHP	6
Biomass Boilers	4
Wind	7.5

Counteracting University growth projections, decarbonisation of grid supplied electricity results in a gradual reduction in carbon even for the business as usual case.

The intervention delivery investment plan will amount to around £40M over a development programme running from 2012 to 2017.

The University has a clear route map to cost effective carbon reduction aligned where possible with City and neighbourhood initiatives. The recommendations presented position the University at the forefront of carbon reduction initiative within the City and will elevate the University's position in the higher education sector carbon reduction challenge, reportable through an updated Carbon Management Plan.

13.2 Recommended Interventions & Opportunities

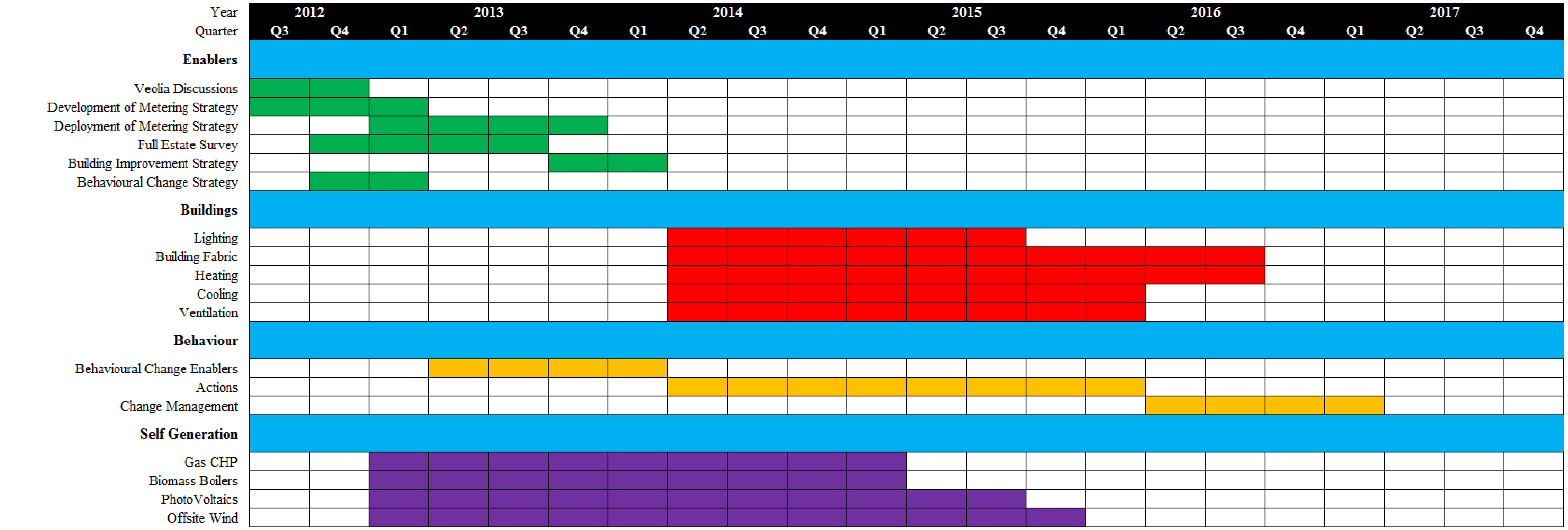
The recommendations are described here as a 2012 to 2017 strategic delivery of activities, costs, delivery programme and carbon reduction designed to serve the University in meeting 2020 carbon reduction targets while helping to safeguard the estate from energy cost and business continuity impacts.

Recommendations	Description	Estimated Cost	Duration	Estimated Annual Carbon Saving (T/CO_2/year)
Enablers				
Veolia MoU	Develop a working relationship with Veolia to improve business continuity, cost and carbon performance by: a) Developing the planned preventative maintenance (PPM) requirements applicable to both parties; and b) Identifying improvement opportunities with regard to the heat network operation, CHP self generation and other technology across the estate.	N/A	4-6 Months	N/A
Metering Strategy	Development of estate wide metering strategy to enable the University to gather detailed information of energy use across the estate. Aim to understand in significantly more detail the current consumption across the estate and therefore allow for more targeted actions to be considered.	£50,000	3-6 Months	N/A
Metering Strategy Deployment	Deployment of developed metering strategy across the University's estate.	£1,000,000	1 Year	N/A
Full Estate Survey	Completion of a full estate survey covering all large energy-consuming buildings and focusing upon building condition, operations, services and infrastructure.	£150,000	1 Year	N/A
Building Improvement Strategy	Development of an all-encompassing building improvement strategy for the University's estate including a deployment programme and business case for all opportunities and interventions.	£50,000	3-6 Months	N/A
Behaviour Change Strategy Development	Development of an all encompassing behavioural change strategy covering all facilities, buildings and operations across the University's estate.	£50,000	3-6 Months	N/A
Buildings				
Lighting	Implementation of best practice lighting control initiatives across the University's estate including PIR control in intermittently occupied areas and daylight linking systems in other spaces.	£2,320,000	6-18 Months	1,150
Building Fabric	Completion of survey work to fully understand the current performance of high energy consuming facilities not due for refurbishment or remodelling in the near future. Buildings expected to benefit from air tightness and roof insulation improvements. Deployment of a glazing strategy across the estate is likely to be beneficial.	£6,592,000	24-30 Months	608
Heating	Deployment of heating control systems to move away from central control to local thermostatic controls and valves. Survey of building spaces to identify under and over provision of space heating followed by re-commissioning of control systems and upgrading of heating systems where appropriate. Full survey of heating plant across the estate and development of asset register.	£376,000	24-30 Months	83
Cooling	Consideration of mechanical cooling control systems and re-commissioning of systems where appropriate. Deployment of weather compensated circuits resulting in increased water temperature during colder periods of the year. Survey of buildings to identify options for natural ventilation strategy across estate and deployment of solar shading where appropriate.	£984,000	18-24 Months	124
Ventilation	Deployment of improved ventilation control systems in mechanically ventilated areas including CO_2 and temperature sensor based systems. Survey to identify areas suitable for switching to natural ventilation.	£1,470,000	18-24 Months	947
Behaviour				
Behavioural Change Enablers	Deployment of all behavioural change enablers to facilitate the efficient and effective deployment of behavioural change actions. This should include removing middle management barriers, formalisation of an energy officer role, improving support of the E&FM team and senior management team and development of a communications and implementation plan.	N/A	12 Months	N/A
Actions	Deployment of all behavioural change actions across the University's estate focusing on the most applicable space types and high energy consuming faculties.	£98,000	12-24 Months	5,122
Change Management	All encompassing coherent and effective change management incorporating communications, rewards, incentives and accountability at a department level.		12 Months	
Self Generation				
PV	Installation of PV panels to appropriate identified University building roof area, with a total capacity of 100 kW	£270,000	12-24 Months	40

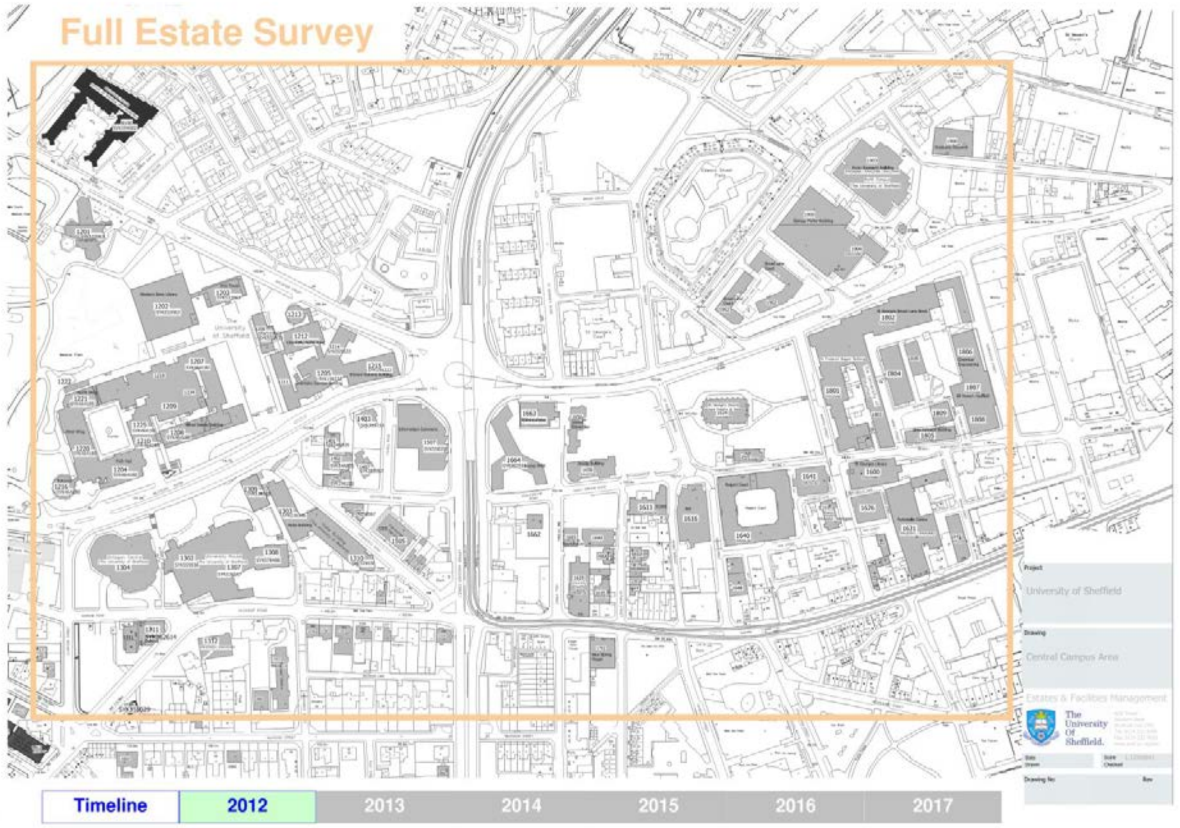
Recommendations	Description	Estimated Cost	Duration	Estimated Annual Carbon Saving (T/CO_2/year)
Gas CHP	Deployment of 6MWe of gas CHP, prioritising the synergies of sites where large University building electrical loads exist in combination with the presence of a mini-heat network serving St Georges to Jessop campus area and Veolia connection pipework to facilitate heat injection.	£11,000,000	12-24 Months	5,500
Biomass Boilers	Incorporation of around 4MW of biomass boilers at locations suitable for heat provision to existing or future buildings and supplementary injection into Veolia distribution pipework.	£575,000	12-24 Months	6,400
Offsite Wind	Increase in 6.5MWe of offsite Wind generation via an additional turbine at the AMRC site and potential multiple turbines at the Harpur Hill site.	£15,000,000	24-48 Months	9,250
	Total Capital Programme Estimate	£39,985,000		

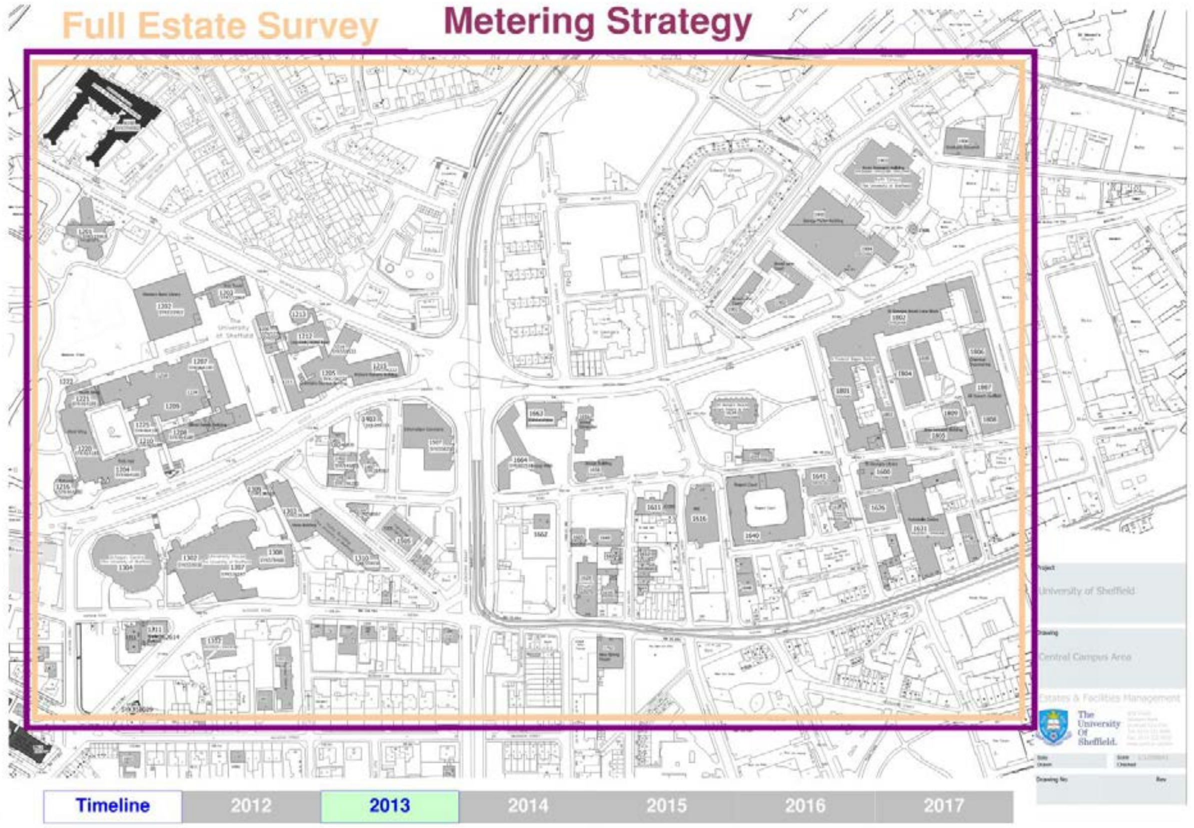
13.3 Intervention Delivery Programme

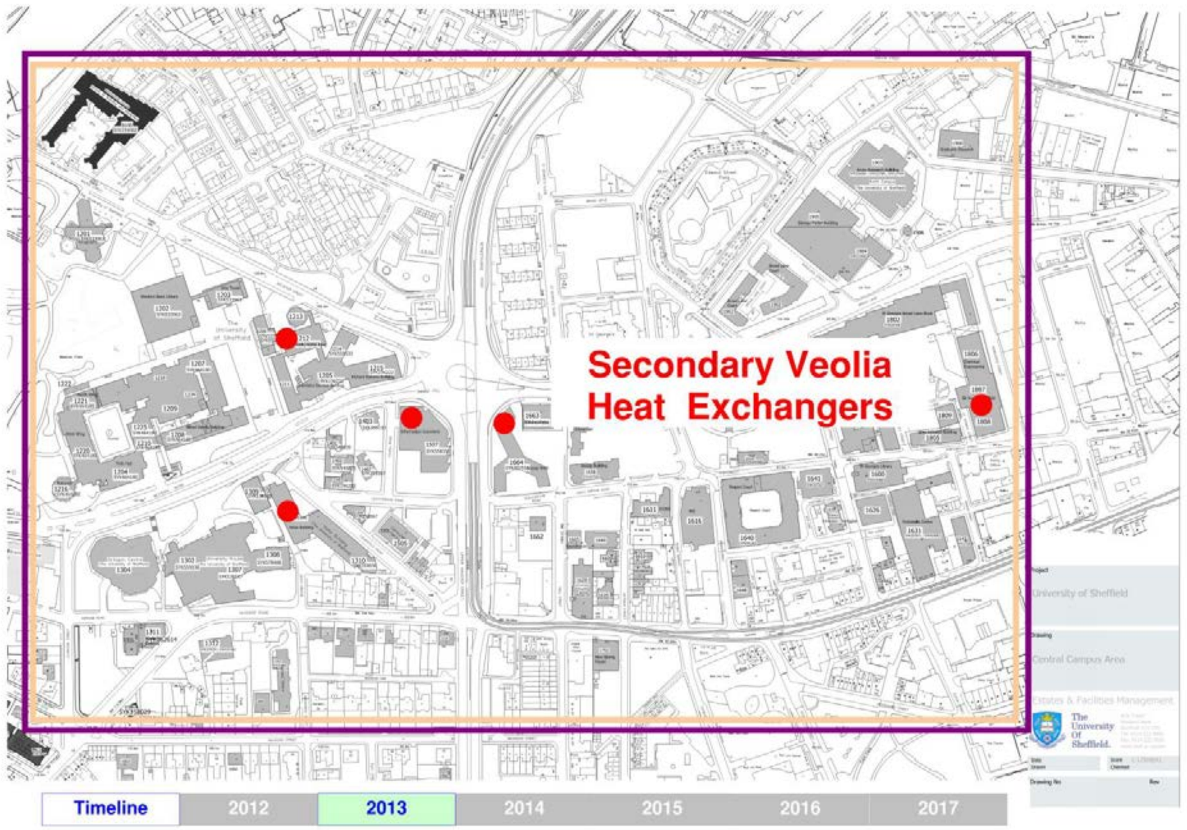
The following programme provides a graphical interpretation of the recommended interventions delivery programme.

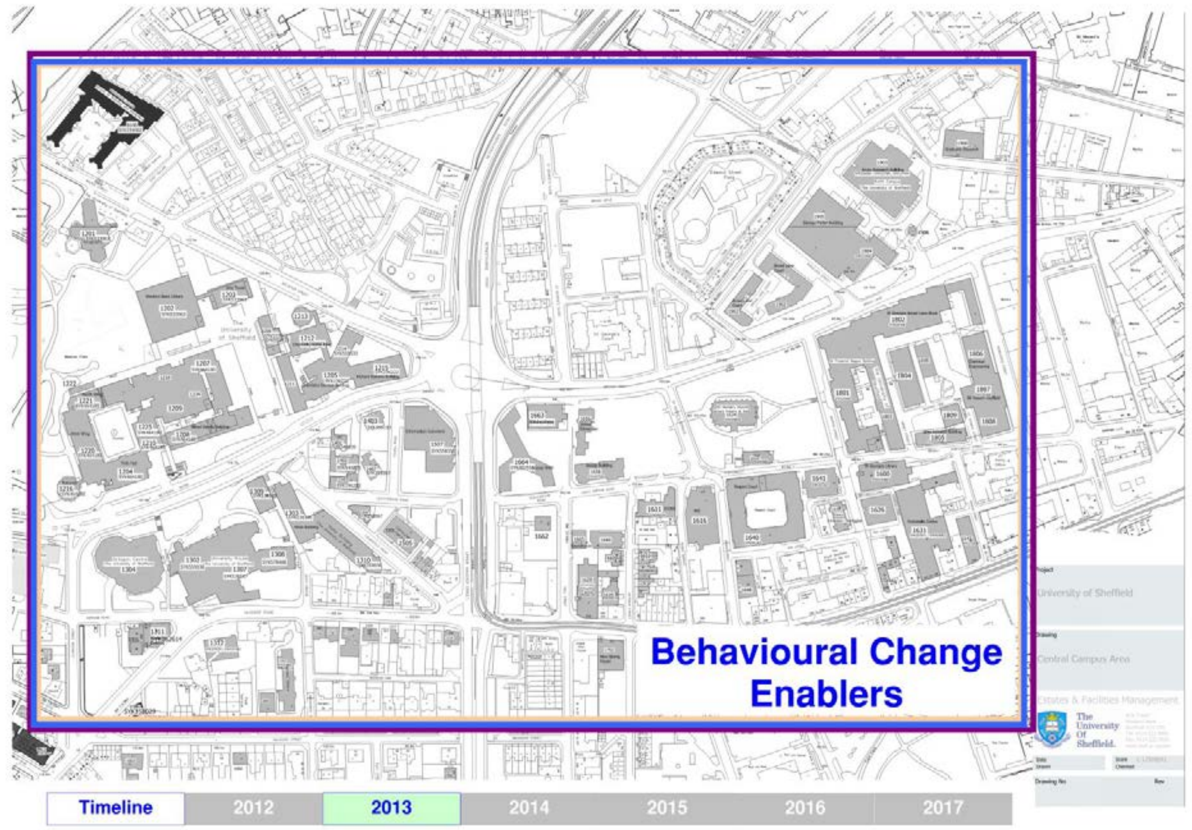


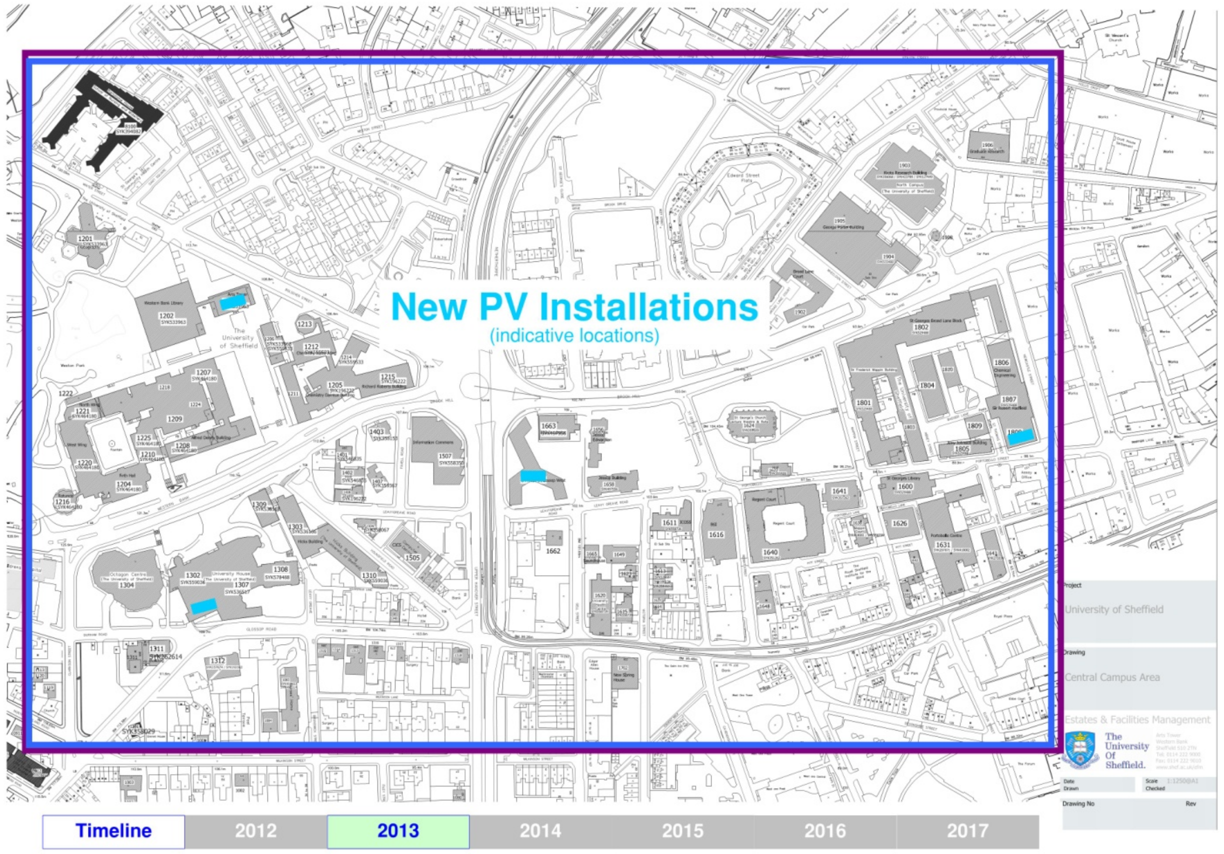
13.4 Intervention Timeline

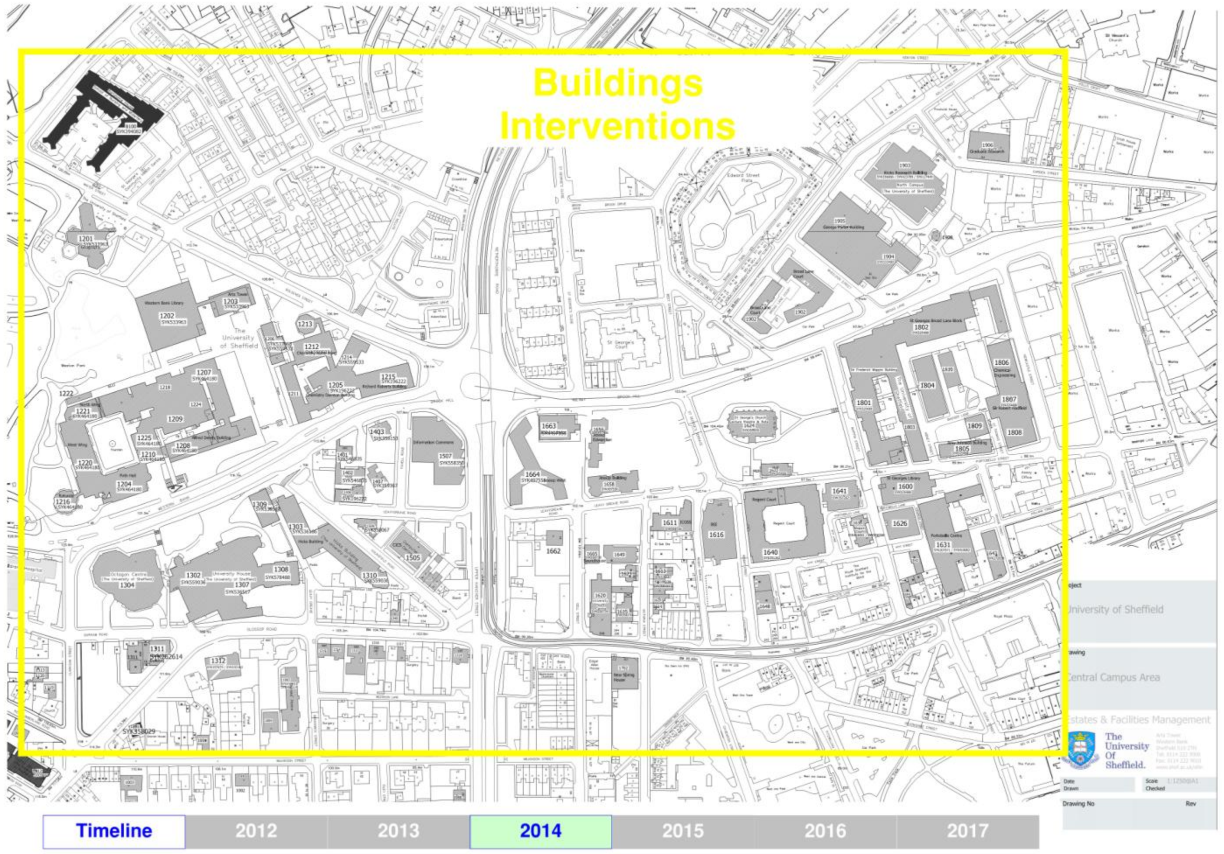


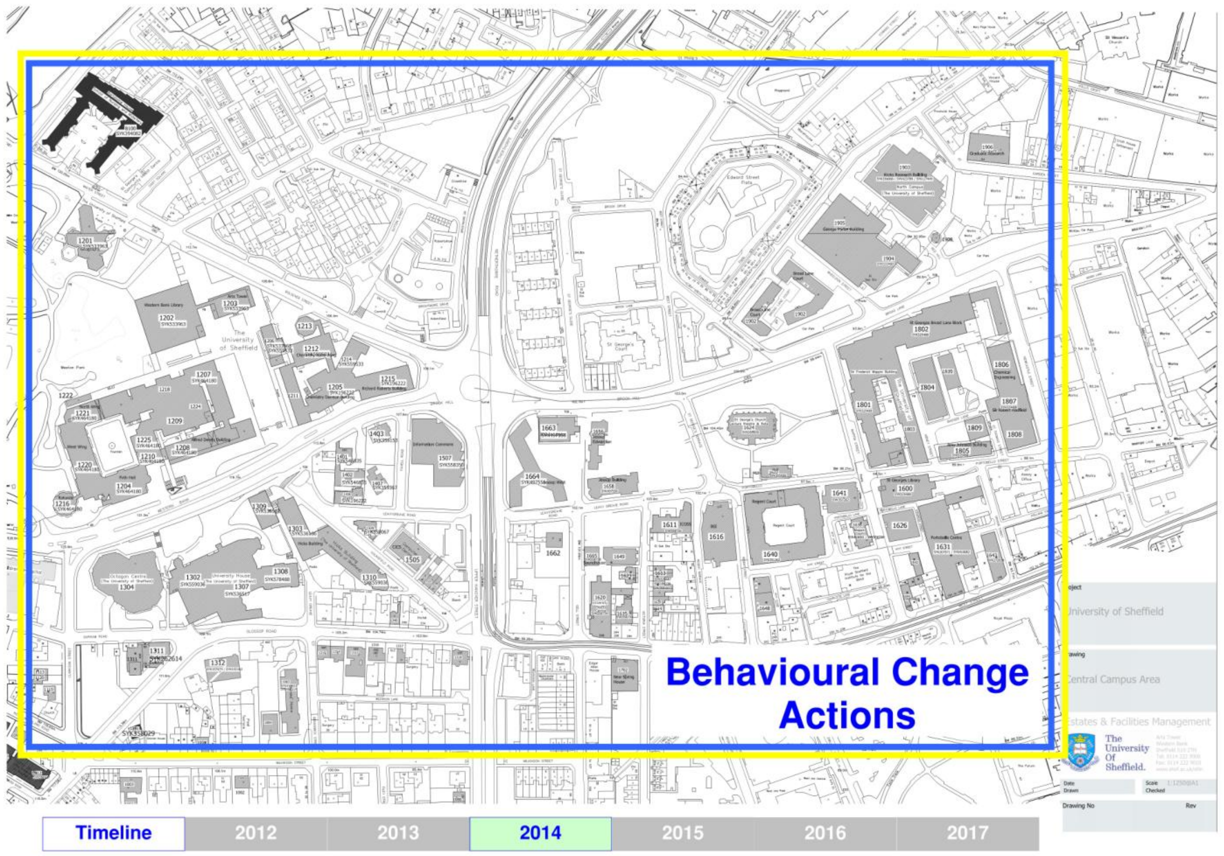


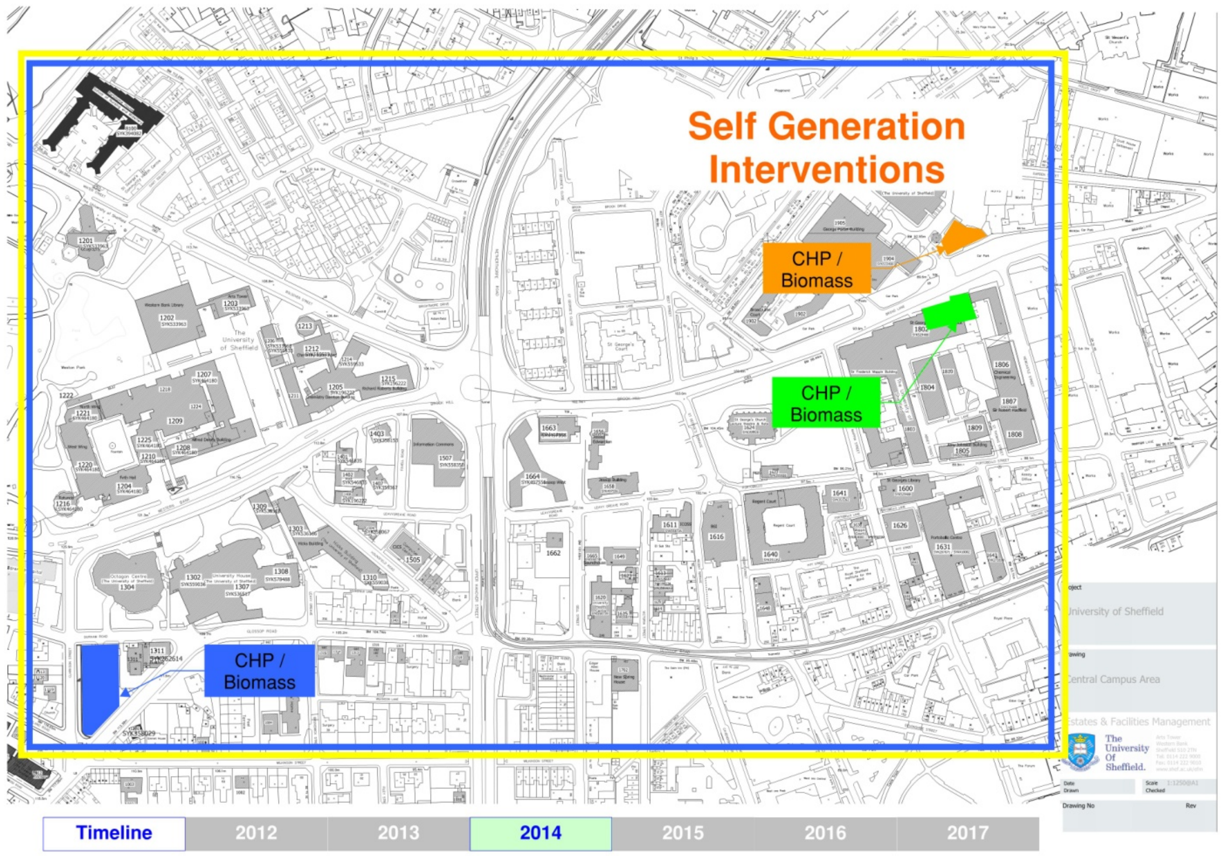


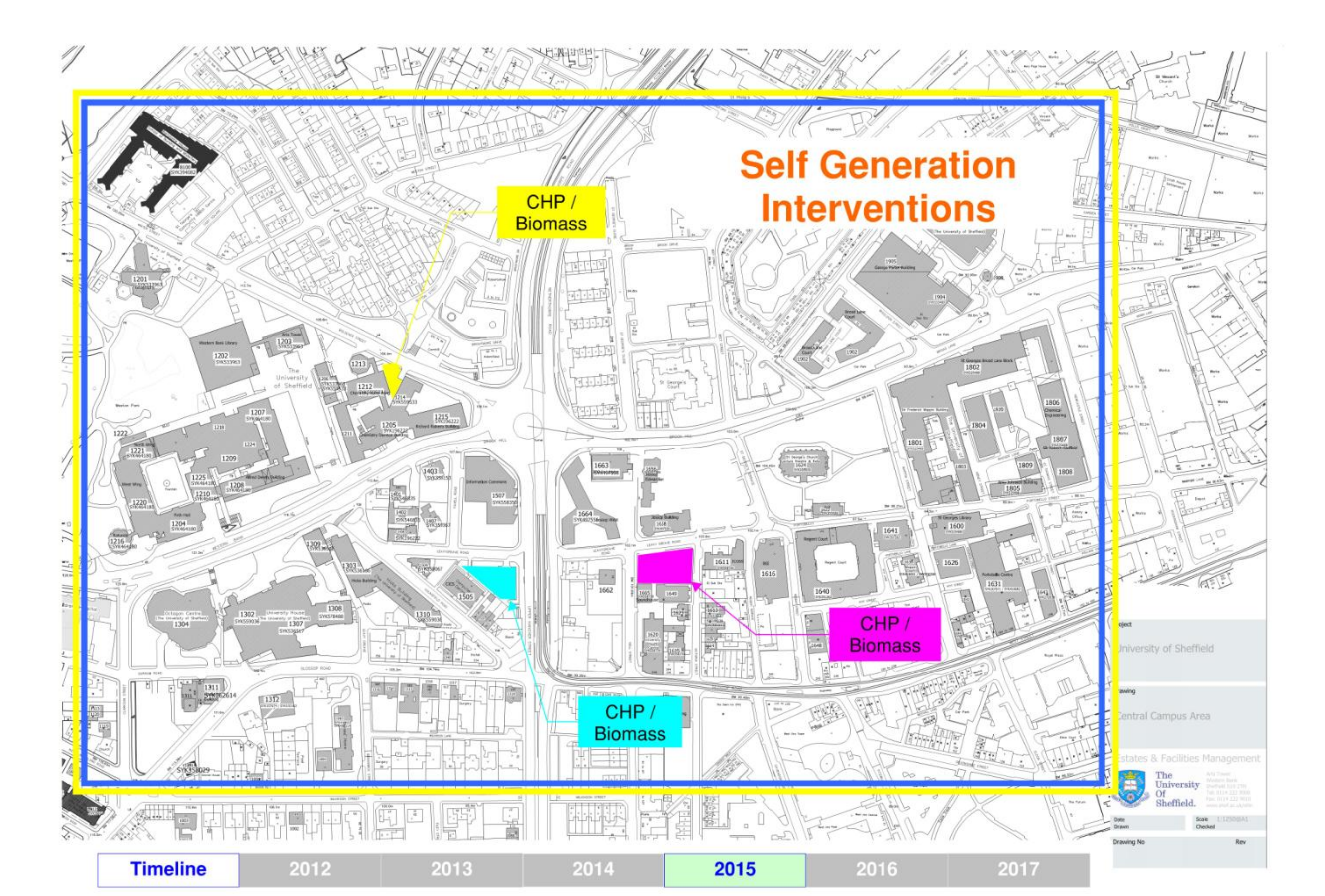


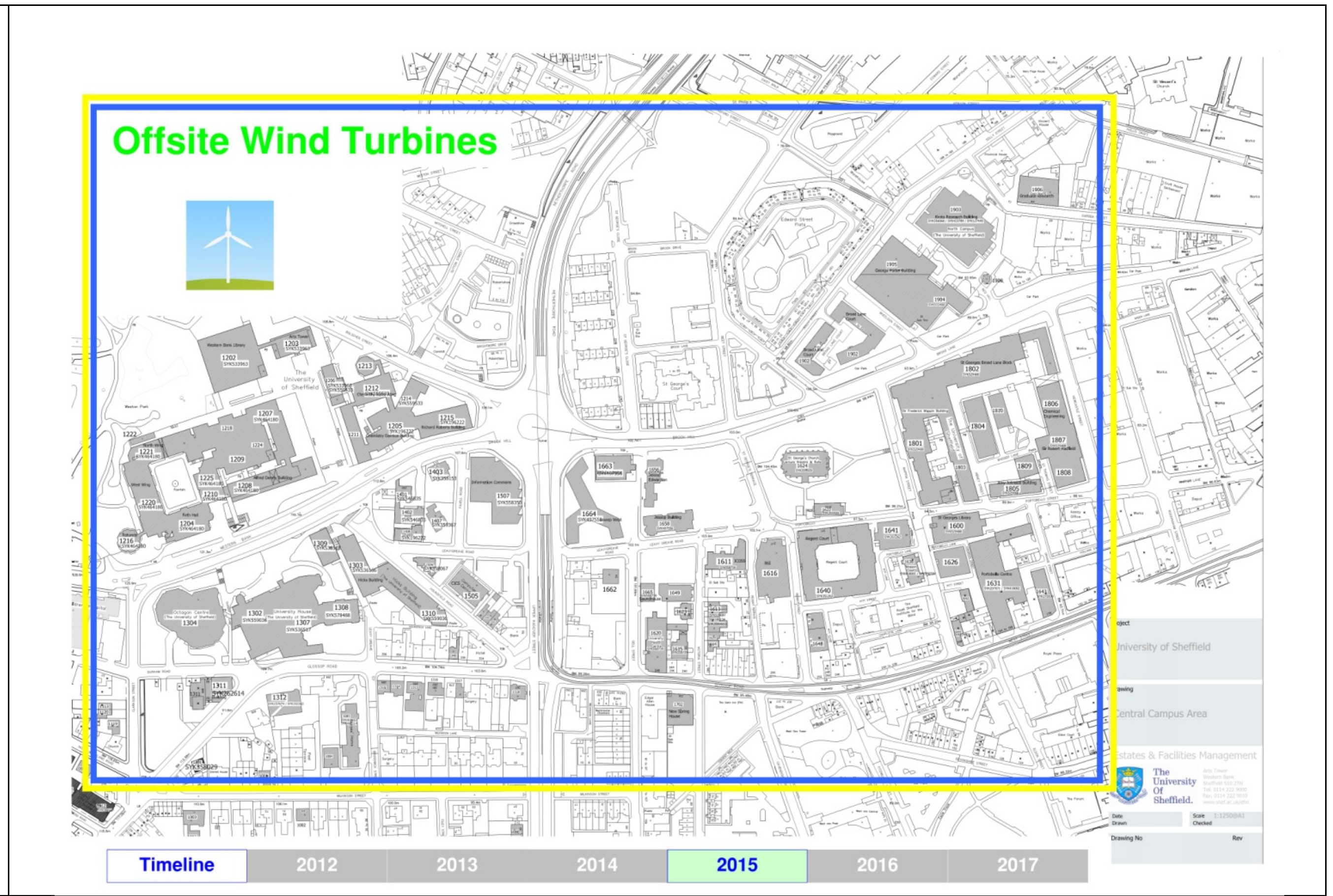

New PV Installations
(indicative locations)
Timeline
2012
2013
2014
2015
2016
2017

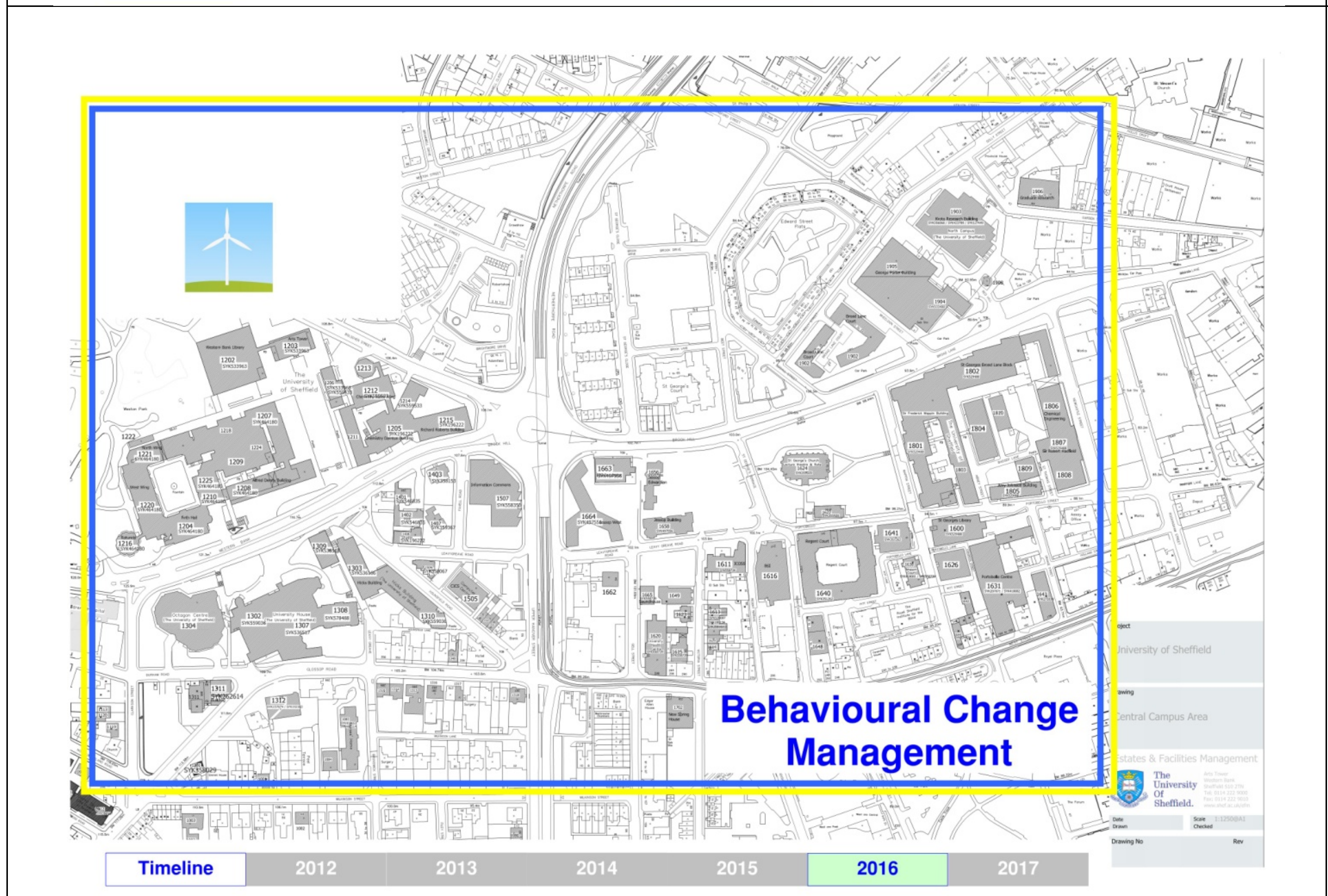

Buildings
Interventions
Timeline
2012
2013
2014
2015
2016
2017

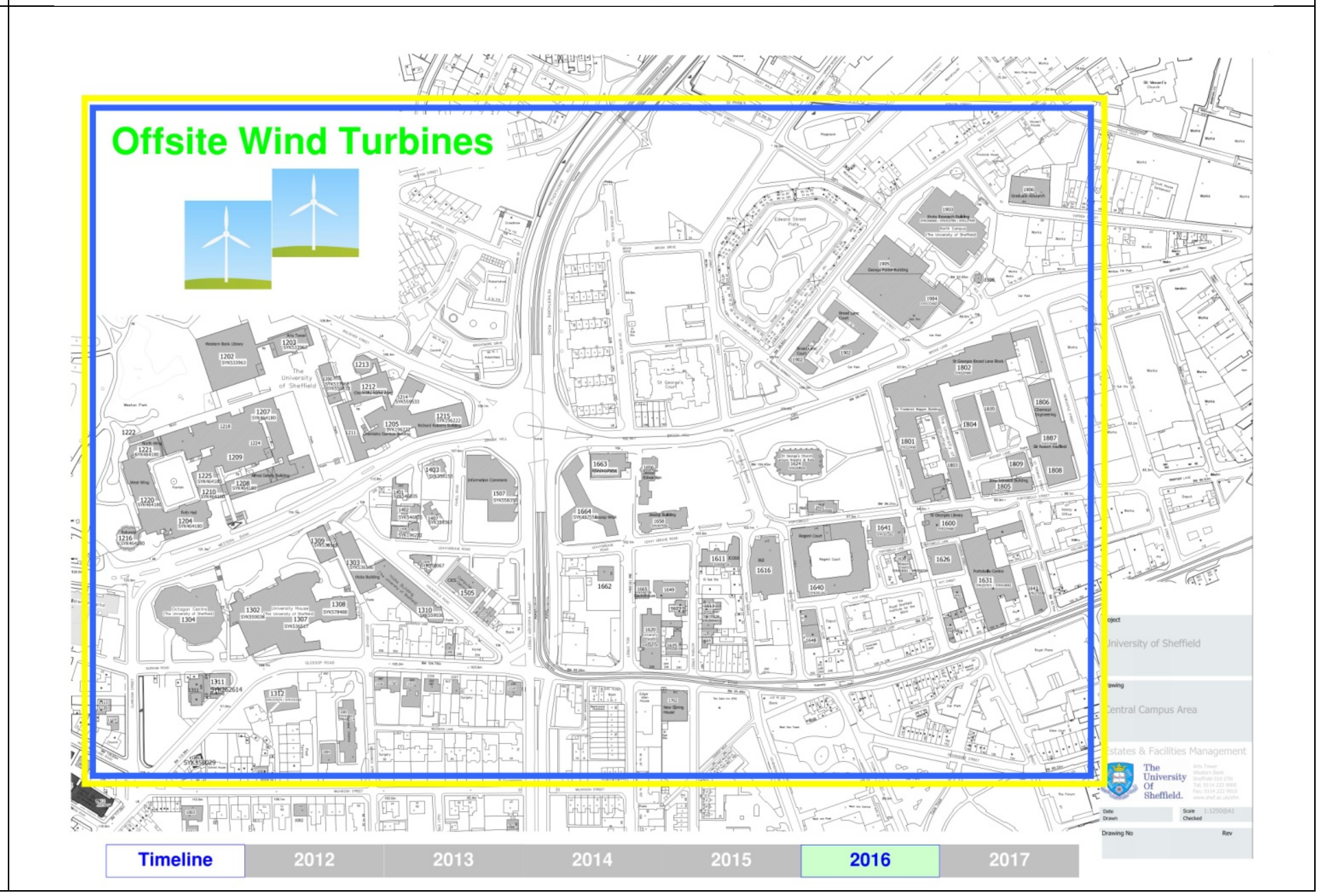

Behavioural Change
Actions
Timeline
2012
2013
2014
2015
2016
2017

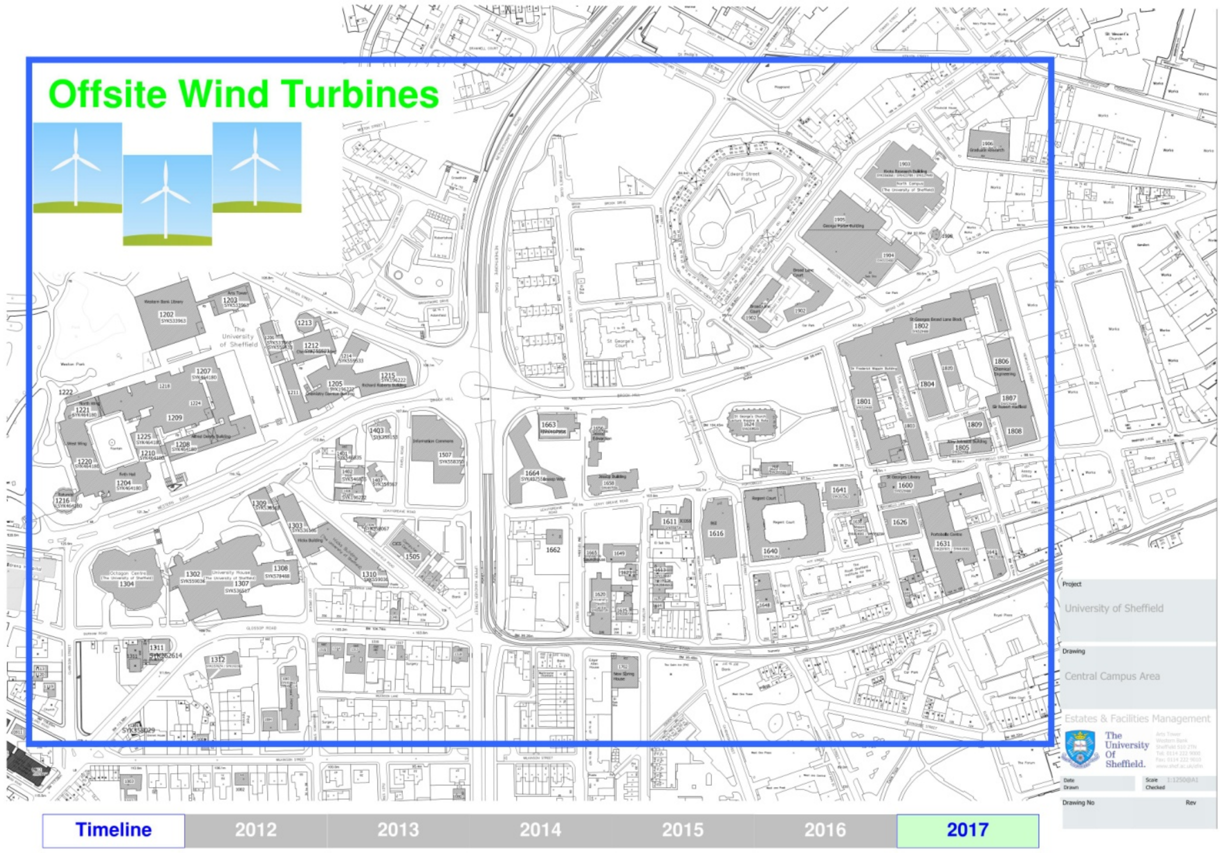

Self Generation
Interventions
CHP /
Biomass
CHP /
Biomass
CHP /
Biomass
Timeline
2012
2013
2014
2015
2016
2017


Self Generation Interventions
CHP / Biomass
CHP / Biomass
CHP / Biomass
Timeline
2012
2013
2014
2015
2016
2017


Offsite Wind Turbines
Timeline
2012
2013
2014
2015
2016
2017


Behavioural Change Management
Timeline
2012
2013
2014
2015
2016
2017


Offsite Wind Turbines
Timeline
2012
2013
2014
2015
2016
2017


Offsite Wind Turbines
Timeline
2012
2013
2014
2015
2016
2017
University of Sheffield
Central Campus Area
Estates & Facilities Management
The University Of Sheffield.

13.5 Carbon Management Programme & Strategy Implementation Plan Updates

The University first produced their Carbon Management Plan (CMP) document in 2008, as part of their participation in the Carbon Trust's Higher Education Carbon Management (HECM) programme.

The Plan comprises the following key actions and deliverables:

- Quantification of emissions reduction opportunities and projects (in terms of cost, revenue and carbon)
- Balancing of projects providing emissions reductions with complementary actions to embed effective carbon management
- Scheduling of chosen projects and interventions into a plan of action to fit with other University priorities and resources
- Coordination of the plan with existing plans, policies and strategies
- Defining of ownership and governance within the plan, including the definition and communication of roles and responsibilities of individuals at all levels to ensure the plan is delivered and reviewed and benefits measured

13.5.1 Alignment with Energy Strategy

The University's goals for the CMP closely align with the remit and deliverables of this wider energy strategy piece of work. As such, an accompanying exercise has been undertaken to assist the University in their updating of the document for 2012.

This support is being offered for specific areas of the CMP, as described hereafter.

13.5.1.1 Carbon Management Strategy

The conclusions and recommendations section of this strategy commission will be used to update this section, covering the general priorities and principles to be adopted to help delivery of the CMP vision and to achieve the targets it sets out.

13.5.1.2 Emissions Baseline and Projections

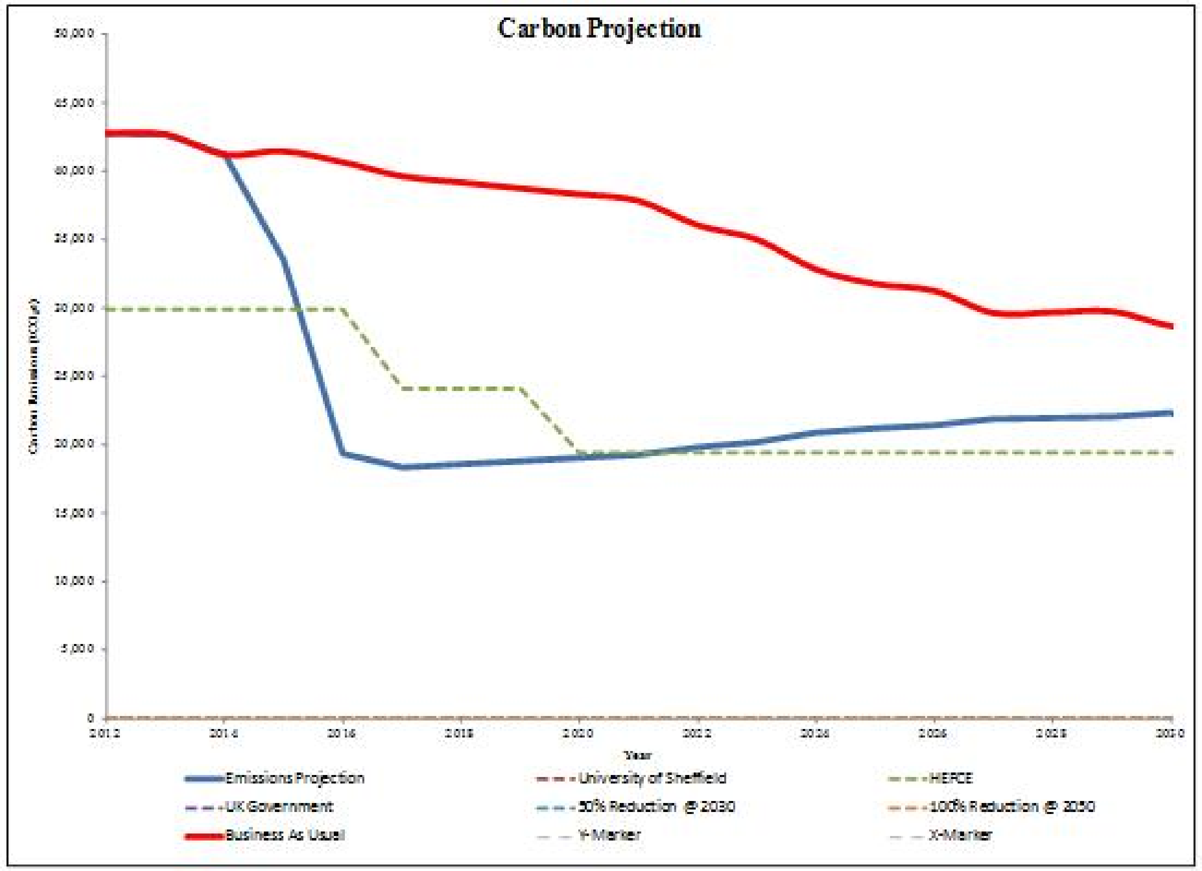
The energy strategy work will serve in particular to update the previous CMP's campus (Scope 1 and 2) emission projections, along with the projection of the business as usual scenario.

13.5.1.3 Carbon Management Implementation Plan

The clearest section of overlap with the energy strategy, inputs will be provided around not only identified projects and interventions but also the various accompanying enablers and actions.

13.5.1.4 Stakeholder Management & Communications

The accumulated knowledge and feedback gained via the various stakeholder engagement workshops will be used to assist in an updating of this element of the CMP.



Appendix A

Received Information Register

A1 Received Information Register

ARUP

Incoming Document Register

Job No. 218999-00

Discipline Energy +

Document Type Assorted

Sheet No. 1

Received From (Company Name)

University of Sheffield

Project Title	**Date Received**													
Energy Strategy	Day	7	9	14	20	6	13							
	Month	12	12	12	12	1	1							
	Year	11	11	11	11	12	12							
Document/Drawing Title & Filename	**Doc No's.**	**Doc Rev.**												
Main site Half hour electrical data	PR 2.1 Electricity data 01.xlsx	X												
HV & LV Electrical SchematicFile Name: Elec-WB-1-001+concourse A1 Layout	Elec/WB/1/001		X											
Non residential heating data	PR 2.2 Heating data 01.xlsx			X										
Basic Schneider phase 2 project details	Energy Strategy - Basic Schneider phase 2 project details.msg			X										
Behaviour change programmes	Energy Strategy Info- Behaviour change programmes.doc			X										
Question 4.4 Who to speak to on behaviour change	Energy Strategy Info- Question 4.4 Who to speak to on behaviour change.doc			X										
University Of Sheffield Staff Contact Details (Energy Strategy)	University Of Sheffield Staff Contact Details (Energy Strategy).msg			X										
Non-residential sites' LV electricity data from 1 August 2009 to date	PR 2.1 Electricity data 02.xlsx				X									
Electrical Schematics	Electrical Schematics					X								
Campus Maps	Campus Maps					X								
HV Network Drawing	HV Network Drawing					X								
Veolia Network Map	Veolia Network Map					X								
University Property Register	University Property Register					X								
Campus Images	Campus Images					X								
Utility Map	Utility Map					X								
DECs	DECs						X							
OS Maps	OS Maps						X							
HX Asset Register	HX Asset Register						X							
Schneider Metering Examples	Schneider Metering Examples						X							

Purpose of issue													
Preliminary													
Billing													
Tender													
Contract													
Construction													
Requested													
For Approval													
For Comments													
For Information	X	X	X	X	X	X							
Record/As Installed/As Built													
Returned with comments													
Planning													
Media Type - P = Paper, E = Email/Electronic, CD = CD/Disk, A = Arup link/Intranet Site													
Logged In By													

Appendix B

Interventions Options

B1 Building Survey Data

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
0402	Stephenson Hall	Residential Accommodation	4651.7	D	C	No	1960-1979	Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Halifax Hall
								General Offices	100.34	✓	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Stephenson Hall
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Crewe Flats Main Building
								ICT Suite	10.88	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Mappin Court Flats
								Retail and Leisure	931.77	☐	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Broad Lane Court
								Kitchen	462.08	☐	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	821.57	✓	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	857.27	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	2812.27	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	122.69	✓	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	95.57	✓	☐	☐	☐	✓	✓	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
0705	Psychology Building	Faculty of Science	2414.1	F	C	No	1960-1979	Lecture theatres	93.61	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	Crookesmoor Building
								General Offices	556.52	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Psychology Building
								Classrooms/Seminar Rooms	529.07	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Geography Planning Building
								ICT Suite	217.09	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	Chemistry Haworth Building (West Wing)
								Retail and Leisure	51.14	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Chemistry (North Wing)
								Kitchen	10.89	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	477.45	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Low Energy Laboratory	68.23	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	133.26	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Circulation/Lobby Spaces	633.73	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	560.37	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	69.42	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
0708	Goodwin North	Social/Commercial	2492.8	B	B	No	1960-1979	Lecture theatres	848.62	☐	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Goodwin North
								General Offices	87.9	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	Goodwin South
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	978.15	☐	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	10.24	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	473.55	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Back of House	330.6	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	533.76	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1105	Claremont Crescent 18	Faculty of Medicine, Dentistry and Health	142.98	B	C	No	1840-1913	Lecture theatres	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Claremont Crescent 18
								General Offices	64.25751263	✓	☐	☐	☐	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Glossop Road 317
								Classrooms/Seminar Rooms	56.12988066	✓	☐	☐	☐	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Glossop Road 388 (Husband Building)
								ICT Suite	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Glossop Road 301
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Victoria Street 45/51
								Kitchen	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Victoria Street 55
								High Energy Usage Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Victoria Street 40
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Victoria Street 36>38
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Victoria Street 53
								Circulation/Lobby Spaces	40.84008855	✓	☐	☐	☐	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Humanities Research Institute
								Back of House	13.45981287	✓	☐	☐	☐	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	7.742705292	✓	☐	☐	☐	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commision cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1204	Western Bank (Firth Hall Block)	Faculty of Science/ Professional Services	1317.05	E	B	Yes	1840-1913	Lecture theatres	397.26	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	288.39	✓	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	✓	☐	
								Classrooms/Seminar Rooms	98.8	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	27.84	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	135.46	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	25.87	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	219.8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	443.81	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	209.82	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	47.64	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Type and Interventions applicable to:

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures
1207	Western Bank (Edwardian Block)	Faculty of Science/ Professional Services	3590.19	F	B	Yes	1840-1913	Lecture theatres	0	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								General Offices	528.88	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Classrooms/Seminar Rooms	192.68	✓	✓	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								ICT Suite	90.68	✓	✓	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Kitchen	0	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								High Energy Usage Laboratory	2020	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓
								Low Energy Laboratory	204.84	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓
								Clean Room Laboratory	163.96	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓
								Circulation/Lobby Spaces	882.34	✓	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Back of House	765.16	✓	✓	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Accommodation	0	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Library	30.52	✓	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Toilets and Changing Areas	46.86	✓	✓	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
								Cold Room	0	☐	☐	☐	☐	✓	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1208	Alfred Denny Building	Faculty of Science	5614.1	D	B	No	1960-1979	Lecture theatres	70.19	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	Hicks Building (Neutron Block)
								General Offices	954.25	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	✓	☐	
								Classrooms/Seminar Rooms	547.58	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	✓	☐	
								ICT Suite	23.29	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	77.46	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Kitchen	8.24	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								High Energy Usage Laboratory	2314.52	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Low Energy Laboratory	935.86	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	105.96	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Circulation/Lobby Spaces	1919.43	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Back of House	1890.49	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	238.76	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	19.41	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1209	Western Bank (Central Block)	Faculty of Science/ Professional Services	1447.69	C	B	Yes	1960-1979	Lecture theatres	359.9	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Western Bank (Electricians Workshop)
								General Offices	15.56	✓	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	240.57	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	685.29	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	33.88	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	55.95	✓	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	233.22	✓	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1210	Addison Building	Faculty of Science	924.61	E	B	No	1960-1979	Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	368.22	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	401.21	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	49.85	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	4.77	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	376.07	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	156.31	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	21.02	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commision cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1212	Chemistry (North Wing)	Faculty of Science	3445.48	F	C	No	1960-1979	Lecture theatres	0	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Chemistry (North East Wing)
								General Offices	241.71	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	Hicks Building (South East Wing)
								Classrooms/Seminar Rooms	178.32	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	
								ICT Suite	131.72	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	
								Retail and Leisure	126.47	☐	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	27.96	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	
								High Energy Usage Laboratory	398.04	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	
								Low Energy Laboratory	1600.38	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	163.71	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Circulation/Lobby Spaces	821.97	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	834.41	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	99.45	✓	✓	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	✓	✓	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1216	Western Bank (Rotunda)	Professional Services	587.5		B	Yes	1840-1913	Lecture theatres	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	459.14	✓	✓	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	2.27	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	245.58	✓	✓	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	13.74	✓	✓	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	7.67	✓	✓	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	✓	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1220	Western Bank (West Wing)	Faculty of Science	3696.94	D	B	Yes	1840-1913	Lecture theatres	166.07	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								General Offices	902.34	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Classrooms/Seminar Rooms	308.51	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								ICT Suite	75.14	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	19.51	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	1998.05	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	7.79	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	84.96	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	1247.63	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	331.58	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	17.8	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	19.54	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commision cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1221	Western Bank (North Wing)	Faculty of Science	3443.34	C	B	Yes	1840-1913	Lecture theatres	12.98	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								General Offices	557.44	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Classrooms/Seminar Rooms	69.24	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								ICT Suite	13.48	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	2515.16	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	80.4	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	140.56	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	946.45	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	119.25	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	22.42	✓	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	37.44	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1222	Zebrafish Aquarium	Faculty of Science	138.81		B	No	1840-1913	Lecture theatres	0.40571664	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	17.42393557	✓	✓	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Classrooms/Seminar Rooms	2.16423884	✓	✓	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								ICT Suite	0.42134517	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	78.61650724	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	2.513067631	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	4.393492365	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	29.58324451	✓	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	3.727404415	✓	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	0.700783287	✓	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	1.170264329	☐	☐	☐	✓	✓	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1224	Perak Biology Laboratory	Faculty of Science	2575.4	E	B	No	1980+	Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	17.95	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	559.11	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	1546.54	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	521.92	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	514.78	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	113.56	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	170.57	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1225	Florey Building	Faculty of Science	1532.67	E	A	No	1980+	Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bio Incubator Building
								General Offices	215.49	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Chemistry Richard Roberts Building (Eas
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	18.67	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	891.17	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	10.08	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	81.42	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	534.2	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	407.04	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	24.31	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	43.62	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1303	Hicks Building (Main Block)	Faculty of Science	4817.9	F	C	No	1960-1979	Lecture theatres	209.34	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Chemistry (Lecture Theatre Block)
								General Offices	1723.66	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hicks Building (Lecture Theatre Block)
								Classrooms/Seminar Rooms	1522.05	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	264.21	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	143.22	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	15.88	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	334.77	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	300.58	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	141.39	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	1615.54	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	1030.28	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	106.84	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1304	Octagon Centre	Social/Commercial	2012.44	D	C	No	1980+	Lecture theatres	881.86	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	Students Union (Link Building)
								General Offices	581.17	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	70.55	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	31.96	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	625.01	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	772.8	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	209.47	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	107.59	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1308	Students Union (Graves Building)	Social/Commercial/Professional Services	874.17	F	C	No	1940-1959	Lecture theatres	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Students Union (University House)
								General Offices	447.7	✓	✓	☐	☐	☐	✓	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	9.75	✓	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	240.41	☐	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	✓	✓	☐	✓	☐	✓	☐	☐	
								Kitchen	78.45	☐	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	286.42	✓	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	159.69	✓	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	105.34	✓	☐	☐	☐	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1622	CETLE (Portobello)	Faculty of Social Sciences	328.65		A	No	1960-1979	Lecture theatres	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	New Spring House
								General Offices	110.71	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elmfield, Northumberland Road
								Classrooms/Seminar Rooms	108.52	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	Bartolome House
								ICT Suite	99.79	✓	✓	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	4.83	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	111.21	✓	✓	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	99.47	✓	✓	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	25.87	✓	✓	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1624	St Georges Church	Learning Infrastructure/Residential Accommodation	839	B	B	Yes	pre-1840	Lecture theatres	252	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	New Spring House
								General Offices	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	22.86	✓	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	74.94	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	644.64	✓	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	1078.7	✓	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	410.08	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	55.21	✓	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commision cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1626	Sir Henry Stephenson (32 Mappin Street)	Faculty of Engineering	1057.75		B	No	1980+	Lecture theatres	312.0889891	☐	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								General Offices	25.49571234	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	259.0901125	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	141.8205708	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	5.367518387	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	186.3924435	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	195.4850196	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	425.901849	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	90.1743089	✓	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	81.98347584	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1631	Portobello Centre	Faculty of Engineering	3143.67	C	B	No	1960-1979	Lecture theatres	39.33050061	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	812.4437727	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	856.073235	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	102.1053388	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	46.42878618	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	3.169234544	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	398.2638084	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	525.303125	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	808.8346444	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	199.0219308	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	244.6109198	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	104.7347037	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1631	Portobello Centre	Faculty of Engineering	3143.67	C	B	No	1960-1979	Lecture theatres	39.33050061	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	812.4437727	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	856.073235	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	102.1053388	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	46.42878618	☐	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	3.169234544	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	398.2638084	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	525.303125	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	808.8346444	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	199.0219308	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	244.6109198	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	104.7347037	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1641	Management & Economics Building	Faculty of Social Sciences	2180.56	C	B	No	1980+	Lecture theatres	0																							BSI Innovation Centre (Regent Terrace)
								General Offices	1313.13	✓	✓																					
								Classrooms/Seminar Rooms	498.74	✓	✓																					
								ICT Suite	222.95	✓	✓																					
								Retail and Leisure	55.67		✓																					
								Kitchen	0																							
								High Energy Usage Laboratory	0																							
								Low Energy Laboratory	0																							
								Clean Room Laboratory	0																							
								Circulation/Lobby Spaces	797.53																							
								Back of House	162.49	✓																						
								Accommodation	0																							
								Library	0																							
								Toilets and Changing Areas	192.34	✓	✓																					
								Cold Room	0																							

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1642	Hawley Building	Faculty of Arts and Humanities	190.43		B	No	1914-1939	Lecture theatres	175.45	☐	✓	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	6.66	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	8.32	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	24.85	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	2.75	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	9.6	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1643	Northgate House (West Street)	Faculty of Arts and Humanities	989.94	D	B	No	1940-1959	Lecture theatres	56.11	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Chemistry (Dainton Building)
								General Offices	303.96	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	77.76	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	20.53	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	389.4	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	67.64	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	286.97	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	52.59	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	38.16	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	33.36	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1644	West Court (2 Mappin Street)	Faculty of Arts and Humanities	529.44		B	No	1940-1959	Lecture theatres	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	225.51	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	128.18	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	13.76	☐	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	2.5	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	21.07	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	165.72	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	44.35	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	79	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	23.93	✓	✓	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1648	Minalloy House	Faculty of Arts and Humanities	773.68	B	B	No	1914-1939	Lecture theatres	240.24	☐	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	340.64	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	127.12	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	6.71	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	153.79	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	90.34	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	75.77	✓	✓	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
#	Recently Refurbished/Built		3250.77	A-B	A	Varies	1980+	Lecture theatres		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	The Edge
								General Offices		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Arts Tower
								Classrooms/Seminar Rooms		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Information Commons
								ICT Suite		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	ICOSS
								Retail and Leisure		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Health Centre
								Kitchen		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Jessop Building
								High Energy Usage Laboratory		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Jessop West & Visitor Centre
								Low Energy Laboratory		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Soundhouse
								Clean Room Laboratory		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1600	St Georges Library	Learning Infrastructure	1520.94	F	B	No	1980+	Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	Western Bank Library
								General Offices	94.52	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	✓	✓	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								ICT Suite	8.64	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	271.95	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Back of House	247.38	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Accommodation	234	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Library	1127.02	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	☐	
								Toilets and Changing Areas	35.34	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
#	St Georges Mappin Campus	Faculty of Engineering	3907.91	C				Lecture theatres		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Frederick Mappin)
								General Offices		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Broad Lane Block)
								Classrooms/Seminar Rooms		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Central Wing)
								ICT Suite		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Amy Johnson Building)
								Retail and Leisure		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Sir Robert Hadfield Buildin
								Kitchen		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	St Georges (Rainfall Chamber)
								High Energy Usage Laboratory		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	✓	
								Low Energy Laboratory		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	✓	
								Clean Room Laboratory		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	✓	
								Circulation/Lobby Spaces		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	
								Back of House		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	
								Accommodation		☐	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	
								Library		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	
								Toilets and Changing Areas		✓	✓	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	
								Cold Room		✓	☐	✓	✓	✓	☐	✓	☐	✓	✓	✓	✓	☐	☐	✓	✓	✓	✓	✓	✓	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
#	To be Demolished		1723.67					Lecture theatres	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	St Georges (Amy Johnson Annexe)
								General Offices	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	St Georges (Mining Block)
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	St Georges (New Caledonia Workshop)
								ICT Suite	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1806	St Georges (Chemical Engineering Buildi	Faculty of Engineering	3586.98	C	C	No	1960-1979	Lecture theatres	539.88	☐	✓	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								General Offices	822.31	✓	✓	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	347.38	✓	✓	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								ICT Suite	63.68	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Kitchen	23.01	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	1008.83	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	✓	
								Low Energy Laboratory	303.6	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	784.44	✓	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Back of House	1220.84	✓	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	89.12	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	
								Cold Room	10.83	☐	☐	☐	☐	☐	✓	✓	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1903	Kroto Research Institute	Faculty of Engineering/ Faculty of Science	3123	F	B	No	1960-1979	Lecture theatres	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	712.03	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	✓	☐	
								Classrooms/Seminar Rooms	526.05	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	✓	☐	
								ICT Suite	27.55	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	14.4	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	1479.36	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	80.66	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	
								Clean Room Laboratory	206.08	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	775.35	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	✓	☐	
								Back of House	1481.11	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	✓	☐	☐	
								Accommodation	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	67.46	✓	✓	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	20.32	☐	☐	☐	☐	✓	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1904	Nanoscience and Technology Centre	Faculty of Engineering/ Faculty of Science	2155.08	F	A	No	1960-1979	Lecture theatres	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Central Annexe
								General Offices	601.54	✓	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	90.37	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	26.74	✓	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Retail and Leisure	39.05	☐	✓	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	
								Kitchen	24.81	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	179.64	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	797.97	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	✓	
								Circulation/Lobby Spaces	654.76	✓	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	711.14	✓	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	39.12	✓	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1905	George Porter Building	Faculty of Engineering/ Faculty of Science/ Professional Services/ Faculty of Social Sciences	4806.77	F	C	No	1960-1979	Lecture theatres	424.45	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								General Offices	807.83	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	1164.64	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								ICT Suite	92.13	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Retail and Leisure	167.09	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Kitchen	89.11	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								High Energy Usage Laboratory	216.68	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Low Energy Laboratory	247.2	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	1454.4	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Back of House	2711.04	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	255.38	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	3.91	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
1906	North Campus Graduate Research Centre	Learning Infrastructure	868.29	C	B	No	1960-1979	Lecture theatres	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	50.65	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	747.9	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	11.67	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	19.54	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	195.75	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	75.28	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	46.45	✓	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	✓	✓	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
305	15 Endcliffe Avenue	Residential Accommodation	2929.74	B				Lecture theatres	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								General Offices	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								ICT Suite	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Retail and Leisure	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Kitchen	661.4851434	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Low Energy Laboratory	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	1057.880735	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	741.5900858	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	2518.350743	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	103.5032933	✓	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	0	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Building Code	Building	Faculty	Net Building Area (m2)	DEC Rating	HEFCE Condition Rating	Listed Building?	What year was the building constructed?	Building Room Type	Room Type Area (m2)	PIR lighting control	Daylight Linking lighting control	Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Improve U-values of walls	Improve U-values of roof	Improve air tightness of building	Installed double/secondary glazing	Change heating fuel to a low carbon fuel source	Install local heating controls within local heat emitters.	Re-commission heating control system	Install weather compensation systems	Upgrade/replace central heating plant	Install local, automatic, cooling controls	Re-commission cooling control system	Install weather compensation systems	Upgrade/replace central cooling plant	Install external shading/improve G-value of glass.	Install local mechanical ventilation controls	Upgrade/replace central mechanical ventilation plant	Employ heat recovery within ventilation plant	Change to natural ventilation strategy.	Laboratory efficiency measures	Building Type and Interventions applicable to:
8219	School of Clinical Dentistry	Faculty of Medicine, Dentistry and Health	2660.37	F	A	No	1980+	Lecture theatres	95.80844089	☐	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								General Offices	1426.908913	✓	✓	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Classrooms/Seminar Rooms	182.0090438	✓	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								ICT Suite	69.32440041	✓	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Retail and Leisure	72.05378624	☐	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Kitchen	4.399010121	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								High Energy Usage Laboratory	453.7878873	☐	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Low Energy Laboratory	285.6357254	☐	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	✓	
								Clean Room Laboratory	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Circulation/Lobby Spaces	595.2060649	✓	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Back of House	866.3350546	✓	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Accommodation	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Library	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
								Toilets and Changing Areas	73.49346228	✓	☐	☐	☐	☐	☐	☐	☐	✓	✓	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	
								Cold Room	7.948211469	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

B2 Buildings Options

B2.1 Intervention Assumptions

Energy reduction Intervention	Applied to spaces	% reduction in energy consumption	% reduction attributable to:	Assumption
PIR lighting control	Assumed to be applicable to general offices, classrooms/seminar rooms, circulation spaces, back of house areas, library spaces and toilet and changing areas.	10-15%	Lighting Electrical Load	The energy savings attributed to the use of PIR lighting control will vary depending upon frequency of use, room geometry and type of PIR sensor used. Based upon the savings achieved with a range of sample rooms and buildings, a range of % reductions was determined.
Daylight Linking lighting control	Assumed to be applicable to all spaces with exception of laboratories and kitchens and those with good daylight levels.	5-25%	Lighting Electrical Load	The energy savings attributed to the use of lighting control will vary depending upon glazing design, orientation of the building, and shape of room. Based upon the savings achieved with a range of sample rooms and buildings, a range of % reductions was determined.
Replace inefficient fittings with high efficacy fittings producing the same lighting levels	Assumed to be applicable to all spaces where inefficient fittings are being implemented.	15-25%	Lighting Electrical Load	Modern high frequency electronic control gear in general terms uses less energy than older switchstart control gear. In terms of lamp technology T5 lamps can produce an inherently more efficient installation than a larger diameter T8 or T12 as they allow for a better optical design of the actual luminaire. T5 lamps also have a better lamp lumen/circuit watt output and less lumen depreciation over time than T8/T12 lamps allowing for lower installed energy for a given lighting level. Overall the above factors can contribute to a saving of up to approximately 25%.
Improve U-values of walls	Applicable to buildings where the building fabric was deemed to be of poor thermal performance through visual inspection.	3-10%	Space Heating Fossil Thermal Load	It was assumed that insulating the wall improved the U-value from 1.37W/m^2.K to 0.56W/m^2.K. U-values were based upon Table 3.49 and 3.50 within CIBSE Guide A. The reduction in space heating energy consumption is a function of the building height and perimeter. The change in heat loss coefficient is calculated by the user defining the number of storeys within the building along with its total area. The tool will calculate the perimeter of the building based upon the assumption that this is equal to the total building area multiplied by 0.13. The tool will assume a storey height of 4m and a glazed area of 40%.
Improve U-values of roof	Applicable to buildings where the building fabric was deemed to be of poor thermal performance through visual inspection.	5-30%	Space Heating Fossil Thermal Load	It was assumed that insulating the wall improved the U-value from 2.19/m^2.K to 0.25W/m^2.K. U-values were based upon Table 3.49 and 3.50 within CIBSE Guide A. The tool will assume that the roof area is equal to the building footprint height, i.e. total building area divided by the number of storeys.
Improve air tightness of building	Applicable to buildings where the building fabric was deemed to be of poor thermal performance through visual inspection.	10-30%	Space Heating Fossil Thermal Load	Reduction in space heating energy associated with air tightness is based upon improvement from a “leaky” building to a “Part L 2002” standard building as defined within CIBSE Guide A Table 4.15.
Installed double/secondary glazing	Applicable to buildings with single glazing.	10-30%	Space Heating Fossil Thermal Load	Reduction in space heating energy associated with improved glazing is based upon replacement of Pilkington K Glass 10mm single glazing (5.5 W/m^2.K) with Pilkington Low E Double Glazing (1.8W/m^2.K)
Install local heating controls within local heat emitters.	Applicable to rooms with no evidence of TRVs or local thermostats. The presence of motorised two-port control valves within heating system was not investigated.	10-25%	Space Heating Fossil Thermal Load	The reduction in space heating due to improved controls is a function of a number of factors including heating set points, comfort requirements for occupants, external weather condition, and the thermal performance of the building fabric. The reduction is heating energy through the use of control was therefore based upon data captured from a previous project as outlined in a case study provided within CIBSE Knowledge Series document KS4: Understanding controls.
Re-commission heating control system	Applicable to areas where there was evidence of over or under provision of heating, e.g. portable heaters or through conversations with building occupants.	10%	Space Heating Fossil Thermal Load	CIBSE Guide H – (1-4) states that through examination of a number of buildings across the UK shows that avoidable waste levels reduce from 25-50% to 15% when a building is well managed and controlled building.
Install weather compensation systems	Applicable to buildings where there was no evidence of variable temperature circuits within the central plant room.	3%	Space Heating Fossil Thermal Load	The tool assumes that the implementation of weather compensation circuits will reduce circulation losses within the building. The tool assumes that the introduction of weather compensation reduces system losses from 10% to 7% losses by reducing flow and return temps by 20degC.

Upgrade/replace central heating plant	Applicable to buildings with heating plant in poor operational condition.	15%	Total Heating Load	The tool assumes that boilers with 75% seasonal efficiency are replaced with 90% seasonal efficiency boilers.
Install local, automatic, cooling controls	Applicable to spaces with no evidence of automatic control. Evidence was also determined through conversations with building occupants.	10-25%	Cooling Electrical Load	The reduction in cooling energy due to improved controls is a function of a number of factors including cooling set points, comfort requirements for occupants, external weather condition, and the thermal performance of the building fabric. The reduction in cooling energy through the use of improved control was therefore based upon data captured from a previous project as outlined in a case study provided within CIBSE Knowledge Series document KS4: Understanding controls.
Re-commission cooling control system	Applicable to areas where there was evidence of over or under provision of cooling through conversations with building occupants.	10%	Cooling Electrical Load	CIBSE Guide H – (1-4) states that through examination of a number of buildings across the UK shows that avoidable waste levels reduce from 25-50% to 15% when a building is well managed and controlled building.
Install weather compensation systems	Applicable to buildings where there was no evidence of variable temperature circuits within the central plant room.	3%	Cooling Electrical Load	The tool assumes that the implementation of weather compensation circuits will reduce circulation losses within the building. The tool assumes that the introduction of weather compensation reduces system losses from 10% to 7% losses by increasing flow and return temperatures.
Upgrade/replace central cooling plant	Applicable to buildings with cooling plant in poor operational condition.	33%	Cooling Electrical Load	The tool assumes that a low efficiency chiller unit with a COP of 2 is replaced with high efficiency units (VRF) with 3.5.
Install external shading/improve G-value of glass.	Rooms deemed to be exposed to large quantity of solar gain that do not currently have means of shading.	12%	Cooling Electrical Load	The reduction in energy consumption was based upon a slice of a sample room, 7m deep, 1m wide and 4m tall. The sample room was assumed to have 40% glazing, with a G-value of 0.64. The incident solar gain is as defined within CIBSE TM37 and internal gains were assumed. A reduction of glazing G-value to 0.43 was assumed which equate to a reduction in total internal heat gain of 12%.
Install local mechanical ventilation controls	Applicable to rooms with no evidence of control panels or sensors within the room. The presence of sensors mounted within extract ducts was not investigated. Evidence was also established through conversations with building occupants.	10-25%	Ventilation Electrical and Thermal Load	The reduction in ventilation electrical and thermal energy due to improved controls is a function of a number of factors including ventilation rates, comfort requirements for occupants, external weather condition, and the thermal performance of the building fabric. The reduction in energy associated with ventilation through the use of control was therefore based upon data captured from a previous project as outlined in a case study provided within CIBSE Knowledge Series document KS4: Understanding controls.
Upgrade/replace central mechanical ventilation plant	Applicable to buildings with ventilation plant in poor operational condition.	30%	Ventilation Electrical and Thermal Load	Where air handling plant has varying air volume duties variable speed drives can be employed to match load. This assumes more efficient fans along with low pressure drops through components.
Employ heat recovery within ventilation plant		65%	Ventilation Thermal Load	Thermal wheels typically achieve a thermal efficiency of 65%.
Change to natural ventilation strategy.	Applicable to rooms where mechanical ventilation is not typically required or internal gains are not significant, for example offices, classrooms/seminar rooms, circulation spaces, accommodation and libraries. Applicability only relied upon spaces with external facades and those that did not rely on mechanical ventilation for their heating.	100%	Ventilation/ Cooling Electrical Load	It is assumes that all energy consumption associated with a mechanical ventilation and cooling system is mitigated.

B2.2 Laboratory Interventions

Laboratories are high energy and water users, often using three to four times the energy per square metre than an office block. The energy usage tends to be dominated by the ventilation load - both the fan energy and the associated heating and cooling loads for the fresh air. The energy associated with laboratory ventilation typically accounts for 40%+ of total laboratory energy.

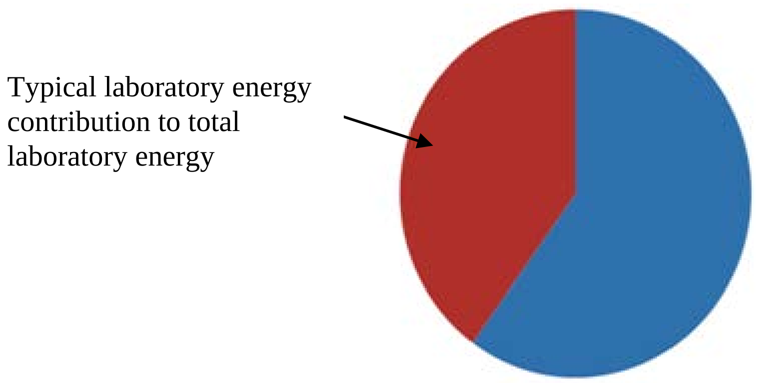


Figure 46: Laboratory energy breakdown

Therefore when looking at opportunities for reducing energy consumption in laboratories, ventilation is the key factor to consider.

B2.2.1 Drivers of Laboratory Design

The design of laboratory systems differs from more conventional buildings such as offices as they are not driven by occupant comfort. There are two main drivers in the design of laboratory systems:

- Health and safety – ensuring that a safe, contained environment is maintained within the laboratory for occupants, and that the external environment is protected from any potentially harmful discharges from the processes within the laboratory.
- Scientific function – providing the necessary conditions for the science that is being carried out.

B2.2.2 Health & Safety

Maintaining a safe working environment within a laboratory is a key driver for any operator. A contained environment is achieved through ventilation and the use of high air change rates, typically between 6-20 air changes per hour (ach).

In order to prevent recirculation of potentially hazardous chemicals, ventilation systems are typically once-through systems, which result in high heating and cooling loads.

There is no hard and fast rule for setting appropriate air change rates, and a lot of figures are historical rather than scientifically proven. Ideally all potentially hazardous activities – e.g. use of volatile chemicals, chemicals that present a risk to human health, high odour chemicals etc – are carried out within a fume cupboard. A fume cupboard provides a local contained environment, and if all hazardous work can be taken off the open bench and put into a fume cupboard, then there is a very compelling argument to greatly reduce the air change rate within the open laboratory.

B2.2.2.1 Scientific Function

The type of science carried out within a laboratory can have a significant impact on the energy consumption. Physical science laboratories tend to have much lower energy demands as they do not have the same reliance on fume cupboards as chemical laboratories, and have more work on the open bench.

Chemistry laboratories tend to have the highest energy consumption because the high density of fume cupboards drives the air change rates up, which in turn increases fan energy and heating and cooling loads.

The other main source of energy consumption related to the science is the small power, or plug, loads. In a typical office the plug load is around 20-25W/m², but in a laboratory this can be anything from 40-300W/m². In order to bring the impact of the plug loads down it is necessary to apply appropriate diversities. Diversity can be applied quite aggressively if a thorough understanding of the client's business is obtained, and an appropriate figure can be agreed.

B2.2.3 Benchmarking

There is very limited benchmarking data against which to compare facilities, due in part to the wide variety of laboratory processes and activities, but also because historically laboratory operators have not measured energy usage, or shared such data with other operators.

Some work has been carried out recently to benchmark energy usage through the Higher Education Environmental Performance Improvement (HEEPI) initiative. HEEPI have gathered data from 41 laboratories within nine UK-based universities and derived a set of proposed energy benchmarks, shown in the table below[3].

[3] www.heepi.org.uk

Table 18: HEEPI benchmarks

Laboratory Type	Typical Practice Energy Performance (kWh/m^2)		Good Practice Energy Performance (kWh/m^2)		Best Practice Energy Performance (kWh/m^2)	
	Fossil Fuel	**Electricity**	**Fossil Fuel**	**Electricity**	**Fossil Fuel**	**Electricity**
All Labs	296	312	135	227	79	143
Medical/bioscience (with secure facility)	397	362	(198)	(227)	100	245
Medical/bioscience (w/o secure facility)	289	300	196	242	130	109
Chemical Science	353	367	(244)	(333)	177	327
Physical Engineering	177	196	(104)	(86)	119	52

In practice however, it is difficult to ascertain how widely these figures can be applied as there is such diversity in laboratory usage. Some comparisons on new laboratory projects and a wide variety of figures have been found, even on laboratories that have been designed specifically to be ‘low energy’. These figures are most typically appropriate to existing higher education laboratories, rather than new build facilities.

B2.2.4 Targeting Energy Reduction in Existing Laboratories – 5 Key Steps to Reducing Ventilation Energy

When looking at opportunities for reducing energy consumption in existing laboratories it is important not to compromise the functionality or safety of the facility, as described in B2.2.1. However, there are still a number of options for reducing energy that do not compromise these fundamental requirements.

There are five keys steps to consider, listed in order of impact:

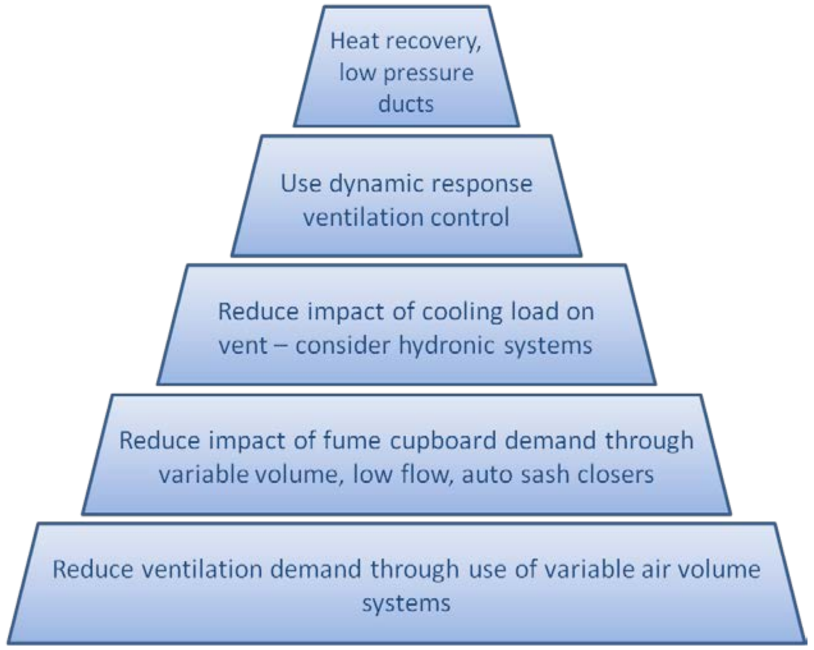


Figure 47: 5 steps for ventilation energy reduction

B2.2.4.1 Reduce Ventilation Demand Through Variable Volume Systems

Older laboratories were often designed with a constant volume ventilation system, sized to meet peak load (base air change rate + maximum heat gain). The problem with this approach is that outside of peak load conditions the air change rate is artificially high and may require re-heat to maintain room conditions.

Installing a variable volume system provides a greater level of control and energy efficiency. Typically the system is set to a minimum volume that meets the base air change rate required for containment, and a maximum air change rate based on peak load. Each room, or group of similar rooms, has a dedicated variable air volume (VAV) box which is controlled locally on temperature (room sensor or return air duct sensor). A pressure sensor control ramps the fans up or down to meet the system demands.

The impact of changing from a constant to a variable volume system is dependent on the operating characteristics of the room. If a room has relatively low occupancy and equipment is used intermittently, then savings could be substantial.

B2.2.4.2 Fume Cupboards

Fume cupboards can be a major source of energy consumption in a laboratory as a high number of fume cupboards will drive the air change rate up, often well above what is required for either heat load or safety requirements.

Traditional fume cupboard design has been based on a maximum sash opening of 500mm (up to the sash stop), with a sash override to a maximum opening of 900mm. The 900mm opening condition is generally for setting up of equipment within the cupboard, or cleaning and maintenance work, and is not considered to be a safe working environment under which containment is maintained.

Generally it has been considered that to maintain a contained environment and ensure a safe condition for the person working at the fume cupboard a face velocity of 0.5m/s is required across the full 500mm opening.

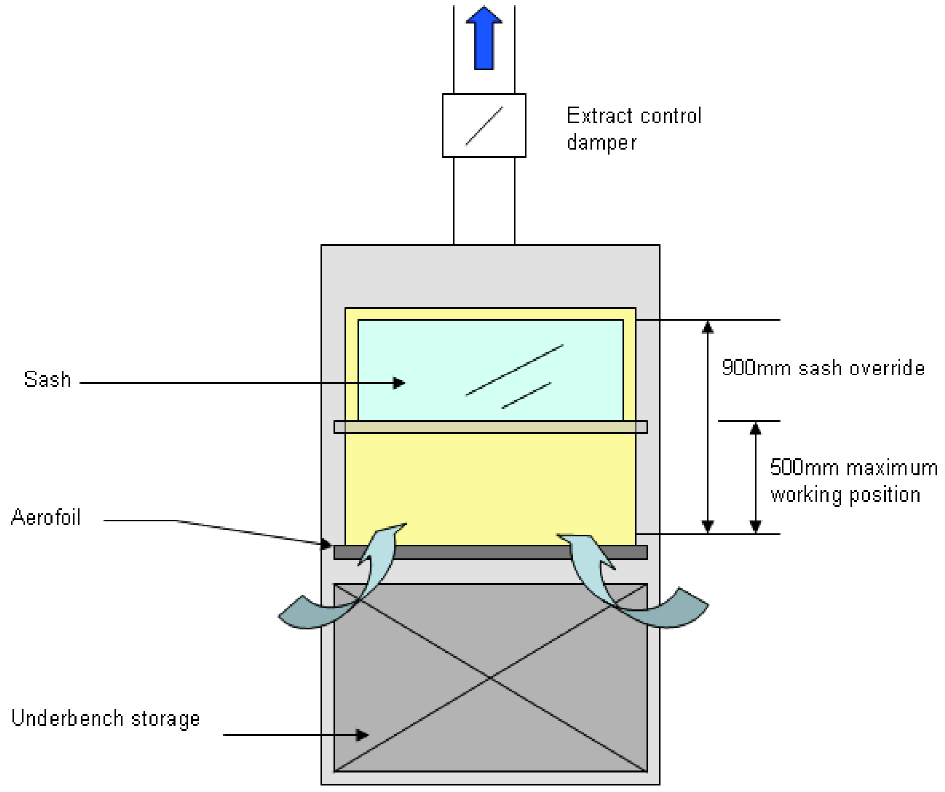


Figure 48: Fume cupboard configuration

The total extract volume through a fume cupboard is calculated as:

V = Width of f/c [m] x sash opening [m] x face velocity [m/s]

If we consider a 1m wide fume cupboard, applying this approach would result in an extract volume of 0.25m³/s, or 0.25m³/s/per linear metre of fume cupboard.

B2.2.4.3 'Low Flow' Fume Cupboards

A lot of newer fume cupboards are now designed as 'low flow' cupboards. Low flow design takes advantage of the current fume cupboard testing requirements (BS EN 14175) to reduce the face velocity across the opening, typically to around 0.35m/s, but sometimes to as low as 0.25m/s.

If we consider this over a 1m wide fume cupboard, the total extract rate becomes 0.175m³/s/per linear metre of fume cupboard. This represents a 30% reduction in air flow requirements.

If one considers that the vast majority of laboratories have full fresh air systems – i.e. no air is re-circulated – then it is easy to see how this level of reduction on the air volume can translate into a significant energy saving both in terms of fan energy and heating/cooling energy. There is a direct relationship between the percentage reduction in air volume and the percentage reduction in energy – either for heating or cooling of the fresh air into the laboratory.

B2.2.4.4 Sash Management Options

Major energy savings can be achieved through fume cupboards management. When a user is not working at a fume cupboard, the sash should be shut (or in the minimum position) to minimise the air flow through the fume cupboard. However it is common for people to walk away from fume cupboards and not shut the sash.

If one considers a 1m wide variable volume fume cupboard, with a sash opening of 500mm and a face velocity of 0.35m/s, then the total airflow at maximum flow is 0.175m3/s. When shut the flow rate through the fume cupboard will be reduced to around 0.012m3/s, i.e. more than a 90% reduction in airflow.

Scaled up over a large laboratory, sash management can have a large influence on energy consumption.

A number of options are available when considering sash management:

- Local signage / sash stickers – this sounds very simple, but having notices around the laboratory, and on the fume cupboard sash, can have a significant impact on users' behaviour. The University of California, Los Angeles (UCLA) carried out a 'Shut your Sash!' campaign in autumn 2008 which relied on basic user education and local stickers on sashes. This campaign resulted in a 40% energy reduction in the longer term[4].

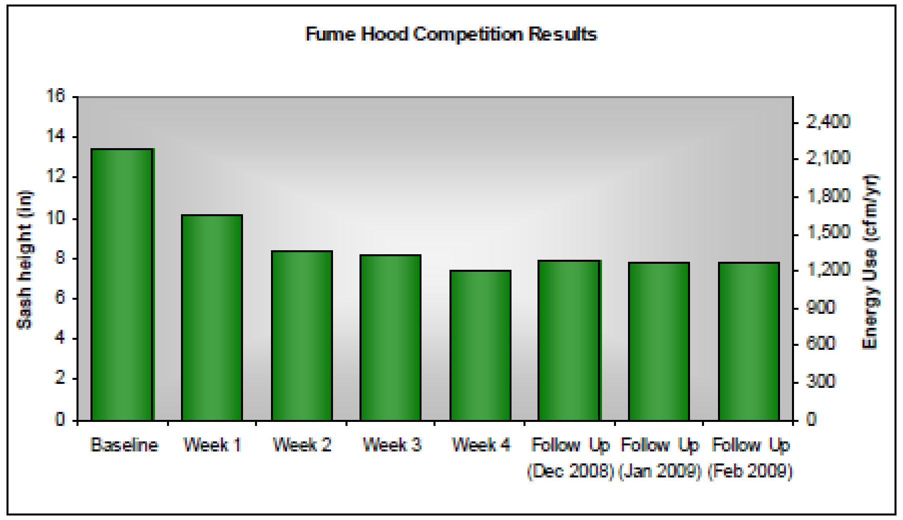


Figure 49: Results from UCLA 'Shut your Sash!' campaign

- 'Traffic light' system or local alarms – in this instance a warning light system is set up in each lab zone. The extract system is sized to allow a certain percentage of fume cupboards in the zone to be fully open at any one time, say 70% (as per the current design agreed with the users). When the extract system reaches, say 80% capacity, an amber light comes on to warn that the system is nearly fully utilised. When 100% capacity is reached the red light goes on. This encourages users to look at where they do not need sashes open in order to get the green light back on.

- Auto setback controls – this is a controller on the main damper to each fume cupboard controlled through a sensor on the fume cupboard face. The sensor picks up either motion, body heat or senses images in front of the fume cupboard. When the sensor

[4] Reference to follow

registers that no-one has been working at the fume cupboard for a set amount of time (this variable can be set by the users), the damper is closed down to a minimum setting, reducing the airflow. This does not cause a problem with containment as if no-one is in front of the fume cupboard, the reduced air volume will not be disturbed and containment will be maintained. Once a presence is detected again, the damper position is reset to maximum.

- Auto-sash closing – this is a similar approach to the auto-setback described above, but instead of setting the damper back, it actually closes the sash. Optical sensors on the sash prevent it closing on glassware etc that is sticking out of the fume cupboard. Both auto setback and auto sash closing can generally be retrofitted onto variable volume fume cupboards.

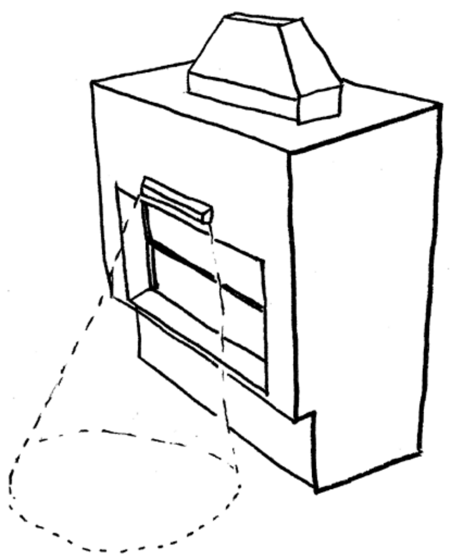


Figure 50: Principle of fume cupboard presence detection

B2.2.4.5 Decouple Cooling Load from Ventilation System

As laboratories are often all-air systems, high cooling loads, as a result of high plug loads, can result in elevated ventilation rates. As a rough rule of thumb, a ventilation rate of 1 air change per hour (ach) will offset $10W/m^2$ of internal heat gain. In a laboratory requiring 6ach for containment, a plug load of $100W/m^2$ will drive the air change rate up to 10ach.

The key is to decouple the ventilation rate from the internal heat gains, leaving the ventilation sized to deal with containment issues only. This can be done by introducing hydronic cooling systems to the laboratory – generally either chilled beams or fan coil units. Fan coil units have a higher W/m^2 output, but require more maintenance and therefore chilled beams can be more appropriate in the environment.

B2.2.4.6 Dynamic Response Ventilation Control

Demand controlled ventilation is generally applied to areas with varying occupancy levels, such as auditoria, where CO_2 sensing is used to monitor the quality of the air in a space and to adjust the fresh air supply rate accordingly.

In a laboratory environment, measuring CO_2 is not relevant as it is not likely to be the primary 'contaminant' in the air. A company called Aircuity in the US have developed a system called OptiNet which is marketed as providing demand controlled ventilation for laboratory environments. Optinet is not a control system. It is not a control system in itself - it provides information to the BMS based on sampling small volumes of air from each room at a given internal. These packets of air are then returned to a central analyser which checks the ppm levels of various compounds compared to the supply air measurements. If any level is found to be above a set limit then the Optinet system sends a signal to the BMS that the air volume to that room should be increased.

The BMS uses this data to determine whether the temperature or ppm levels should be used to set the air volume for each space and varies it accordingly.

This allows the background air change rate to be much lower than standard laboratories for 90+% of the time, with it only increasing when required by the activity in the laboratory.

This principle is shown in the system architecture diagram below.

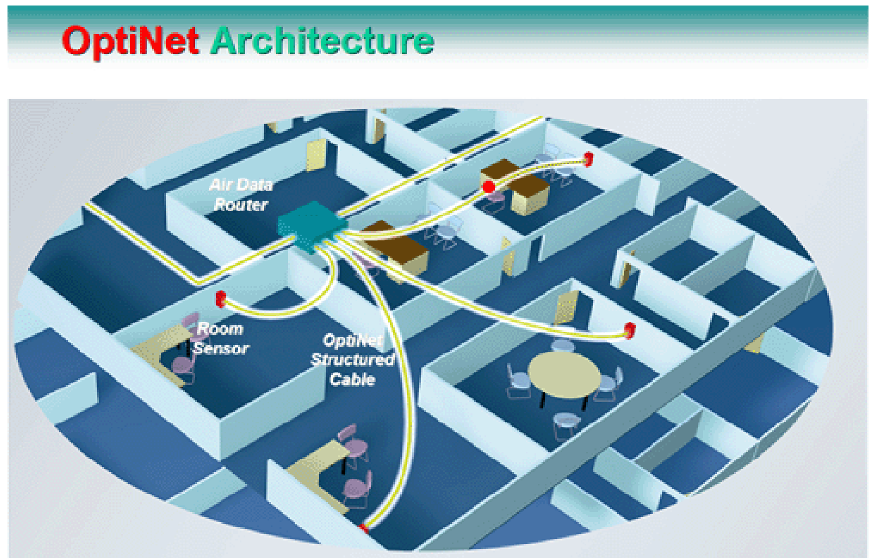
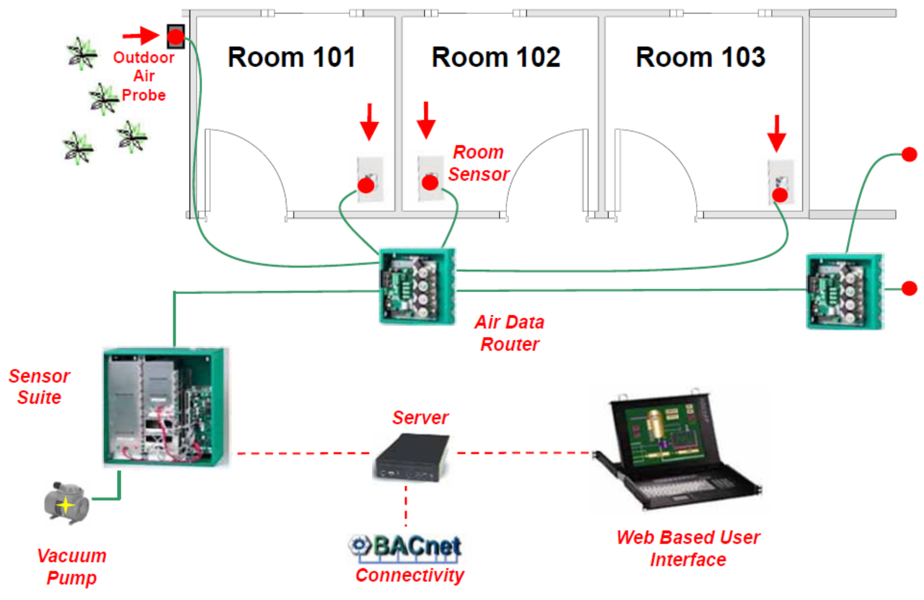


Figure 51: OptiNet Architecture (from Aircuity website)

The Aircuity Optinet demand controlled ventilation system has been on the market since 2005and will received CE approval in June 2011, making it a viable product for use in the UK and Europe. There are over 250 international installations that are operational, including laboratory installations in the Food and Drug Administration (FDA), National Institute of Health (NIH), and Harvard (HSPH) in the USA. 50% of Aircuity's business is in retrofit projects.

B2.2.4.7 How Does it Work?

Optinet works by taking samples of air from a control zone at predetermined regular intervals of time. These samples are taken via an ‘air data router’ to a ‘sensor suite’ via a small tube (approx 10mm diameter) as a result of the use of a vacuum pump.



The air data router can be connected to up to 4 air sampling locations. It is approximately 300mm wide x 300mm long x 150mm deep and can therefore be located in an accessible ceiling.

Up to 20 rooms can be connected to each sensor suite with a maximum distance of tube of 165m and a maximum control zone of 100m^2. The suites are best located in plant rooms as they require regular maintenance. The vacuum pumps can also be noisy.

In the sensor suite the air sample is tested for Volatile Organic Compounds, Ammonia, CO, CO_2, relative humidity and particulates. The data from the sensors is turned into a digital or analogue signal that if necessary sends a flow override signal to the building BMS defining the air change rate required in the control zone.

B2.2.4.8 Sensor Suite

The OptiNet system relies on central sensor suites, which gets away from the need for hundreds of individual sensors in every room. It also minimises maintenance as the sensors are located centrally and are ‘plug and play’, which allows for simple replacement.

Sensors are available to monitor:

- Carbon dioxide
- Dew point temperature
  - Relative humidity
  - Enthalpy
- Airborne particle
- Total volatile organic compounds (TVOCs)
- Carbon monoxide

The critical sensors for demand controlled ventilation in a laboratory environment are the particulate and VOC sensors.

B2.2.4.9 Benefit of Dynamic Ventilation Control

Laboratory air change rates are often set based on historical data or standards. There is no overarching guidance for what constitutes a safe working environment. Therefore lab air change rates are often higher than required, but cannot be reduced without ‘proof’ of safety. Having a sensing system, such as OptiNet, provides the ‘proof’ that has previously been missing – at any time the air quality in a space can be demonstrated and hence the air change rate reduced accordingly. Extensive research by Aircuity, which has been published by ASHRAE, indicates that laboratories environments are no more onerous than office environments for 90%+ of the time.

Therefore this would suggest that for a significant proportion of time, laboratories can be operated more like offices without compromising safety, and generating significant energy savings.

B2.2.4.10 Other Considerations

B2.2.4.11 Heat Recovery – General Laboratory Ventilation

As laboratory ventilation systems are generally once-through full fresh air systems, heat recovery should be a consideration. It is low down on the 5-step system because the overall impact is lower than the earlier steps, but is a relatively simple system to install, and should always be considered in a new design.

The main consideration with heat recovery is the risk of contamination between supply and exhaust air streams. As the exhaust air stream is generally considered ‘contaminated’ it is important not to allow mixing of air streams, which rules out the more efficient heat recovery systems such as thermal wheels.

The most common form of heat recovery on laboratory vent systems is a run-around coil, but these often have efficiencies as low as 40%. Air-to-air heat exchangers do have a risk of air leakage between the two air streams, but it is very low and can be considered a suitable technology for most extract systems. However these tend to be large items of equipment which can make air handling units very long.

Newer forms of heat recovery worth considering are the FlaktWoods Econet system, which is effectively a development of the run-around coil, and thermal wheels with a purge, or molecular sieve.

B2.2.4.12 Heat Recovery – Fume Extract

Heat recovery on fume extract is more difficult due to the nature of the exhaust stream, which is often considered to be more corrosive of contaminated than general laboratory exhaust. Often fume extract fans are not located adjacent to the main air handling plant, and this can also give rise to concerns over the effectiveness of using the recovered heat.

If heat recovery is considered for fume extract, it is often with a plastic heat exchanger – polypropylene or similar – in which case the effectiveness is even lower than for a standard system.

Figure 52: Thermal Wheel with Molecular Sieve Coating

Figure 53: FlaktWoods Econet System

B2.2.4.13 Low Pressure Ductwork Design

Part L 2010 is already driving designers towards larger, lower pressure ductwork, as a result of the tighter specific fan power requirements. Whilst this approach results in lower pressure drops, fewer noise concerns, and greater energy efficiency, it has to be balanced against architectural implications such as riser sizing, ceiling void depths and impact on net / gross ratios.

B2.2.5 Energy Associated with Laboratory Equipment

Energy usage associated with laboratory equipment is harder to address than ventilation energy as it is not controlled by the designer or laboratory user. There are however a few considerations that can help reduce energy consumption.

B2.2.5.1 Behavioural Change

This is the simplest consideration, but one that can have a huge impact. Stressing the importance of behaviour on energy usage to end users - such as turning off equipment when not in use, shutting fume cupboard sashes, turning off lights – costs virtually nothing and can elicit significant benefits.

B2.2.5.2 Diversity on Small Power Loads

This is more of a consideration when designing a facility, than when refurbishing, but equipment diversity can have a significant effect on central plant sizing. This can have a beneficial impact on both electrical and mechanical plant sizes and efficiencies.

A study was carried out in ASHRAE in 2000 (Wilkins and Hosni) to look at heat gain from office equipment. It compared nameplate ratings against actual drawn current for each item of equipment, and then compared this with the average overall drawn current for the floor. The results are shown in the graph below:

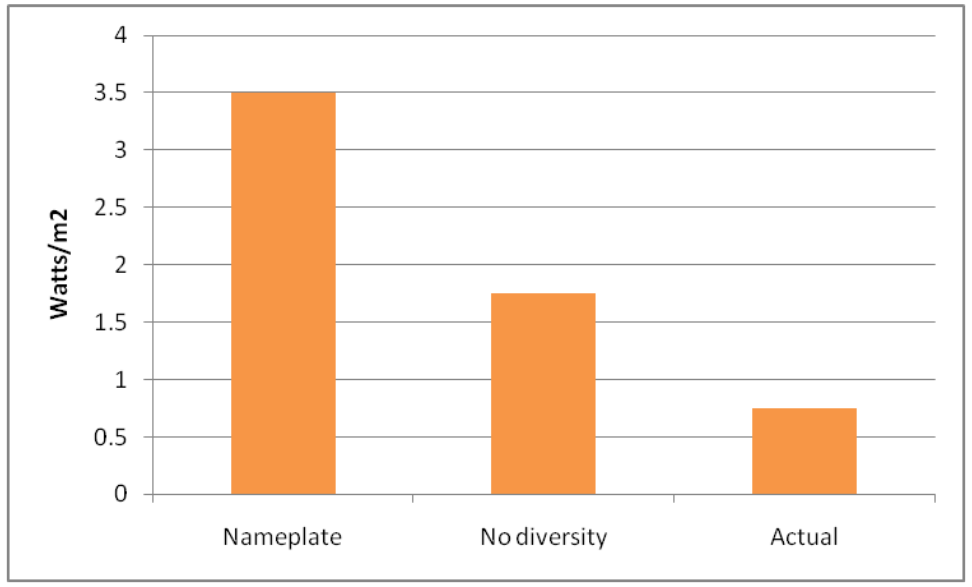


Figure 54: Heat Gain from Office Equipment

This study shows potential for diversity when considering equipment heat gains. Although laboratory equipment operates differently to office equipment, the potential and validity of diversity can be clearly seen.

B2.2.5.3 Equipment Cooling

Some items of equipment require direct liquid cooling and in the past this has often been done by running a hose from the cold water tap and letting the 'waste' water run to drain. This should be avoided due to the level of water wastage. It is preferable to install a closed loop process cooling system. Due to differing water temperature and pressure requirements for equipment, generally the closed loop system will feed heat exchangers local to each item of equipment, which then connects in to the secondary side of the heat exchanger.

It is also worth considering what temperature to run this process chilled water loop at. 6/12°C is typical for an HVAC chilled water loop, but this can be raised to, say 12-16°C for a process cooling loop.

B2.2.5.4 Room Hydronic Cooling

When equipment has high heat outputs to air (rather than to a water cooling system), it is worth looking at installing a local water-cooled system in the room, rather than relying on air cooling alone. Decoupling the heat load from the ventilation system, as described earlier, helps to reduce the ventilation energy and makes use of more efficient heat exchange by water. Often equipment dominated laboratory spaces (such as microscopy suites) do not have the same contamination concerns as open laboratory spaces and therefore do not need high air change rates.

B3 Behavioural Options

B3.1 Enablers and Interventions

The line-items in the model are split into enablers and interventions as indicated below:

Enablers	Interventions
Removing middle management barriers Formalise energy officer role Improve perceived support of FM team Improve perceived senior level support Communications strategy and implementation plan	Personal heating at work Addressing accommodation temperature levels Foyer display into accommodation buildings Competitive elements for accommodation Increased / continued use of power rangers Energy audit of research projects Rewards & incentives "Turn things off" - optimised operating ICT - only used when necessary Portal communication tool Develop and roll-out online learning module Energy saving within the procurement process

Enablers do not directly result in energy savings. They increase the effectiveness of the interventions. Interventions that are undertaken without the core enablers being undertaken are highly unlikely to be effective as there will be no culture of energy saving within the university to build upon.

B3.2 Source of percentage savings

There is no data in existence where a behaviour change programme has been applied in isolation of all other possible effects on energy consumption. A comprehensive literature review paper in 2007 that examined 2,000 references estimated that behaviour change can potentially save approximately 19% (±5%) of energy consumption[5].

It is this maximum potential saving that has been used to inform the model. Reductions to this saving have been made based on experience and judgement considering the scope of the energy being affected by a potential action and the use of the enablers.

B3.3 Percentage savings included in the model

Specific targeted actions

Personal heating at work; addressing accommodation temperature levels

5% saving of affected energy estimated. No dependency on enablers as it is thought that such targeted campaigns could, if communicated well enough, could be successful on their own merit.

[55] UITDENBOGERD, EGMOND, JONKERS, KOK Energy related intervention success factors: a literature review, paper at the 2007 ECEEE summer study, France, 2007

Accommodation actions

Foyer display; competitive elements; power rangers

The savings achievable are dependent on how many of the three are implemented. Savings for each of the actions reduce as more are implemented as the saving energy becomes more difficult once consumption has already been reduced. A combined maximum saving of 10% is considered possible.

In addition, the savings are significantly reduced (to 33% of their previous amount) if the senior level support enabler is not implemented. It is thought that this aspect of the overall change management culture will be the most important in engaging with accommodation users.

In summary:

	With senior level support implement	Without senior level support implement
One action implemented	5% saving	1.7% saving
Two actions implemented	4% saving for each action (8% in total)	1.3% saving for each action (2.7% in total)
Three actions implemented	3.3% saving for each action (10% in total)	1.1% saving for each action (3.3% in total)

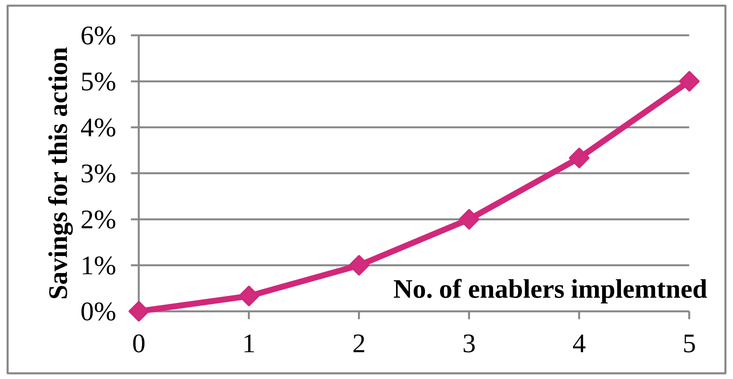
Research process load action

Energy audits

The maximum potential saving is considered to be 5% given the importance of research activities to the university.

The maximum potential saving decreases depending on the number of enablers implemented as shown below:

No. enablers implemented	Proportion of saving realised	Resultant saving for action
0	0%	0%
1	7%	0.3%
2	20%	1%
3	40%	2%
4	67%	3.3%
5	100%	5%



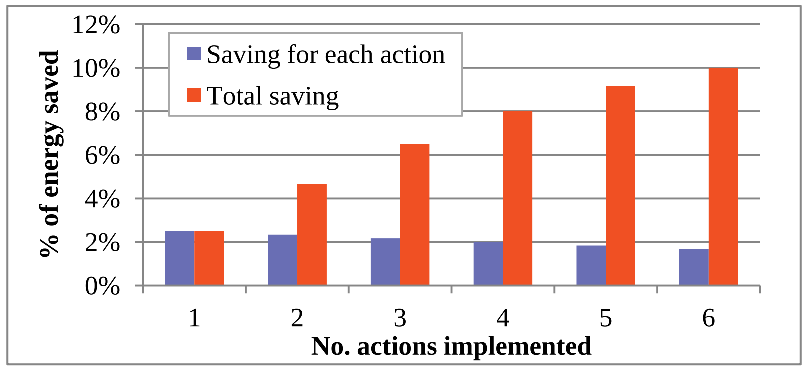
The effect of the enablers increases as more are implemented. This is to represent the fact that, as more enablers are implemented, a culture of energy conservation will begin to pervade throughout the university, meaning that building users are more receptive to increased evidence of support from central university services.

Faculty actions

Rewards & incentives; ‘turn things off’; ICT reductions; portal communication; online learning module; procurement

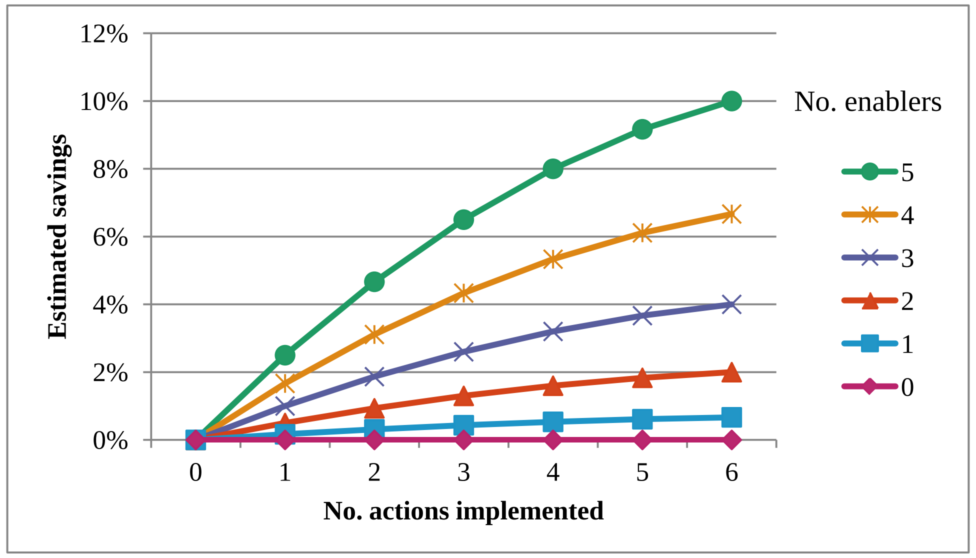
These six actions all act on faculty energy consumption and, as such, are linked into one group with diminishing returns as more actions are implemented to reflect the fact that energy that has already been targeted is more difficult to reduce further. A combined maximum saving of 10% is considered possible.

No. actions implemented	Saving for each action	Total saving
1	2.5%	2.5%
2	2.3%	4.7%
3	2.2%	6.5%
4	2.0%	8.0%
5	1.8%	9.2%
6	1.7%	10.0%



These potential maximum savings are also affected by the number of enablers implemented using the same relationship as the Energy Audits to result in the grid below.

		No. enablers implemented					
		0	1	2	3	4	5
No. actions implemented	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	1	0.0%	0.2%	0.5%	1.0%	1.7%	2.5%
	2	0.0%	0.3%	0.9%	1.9%	3.1%	4.7%
	3	0.0%	0.4%	1.3%	2.6%	4.3%	6.5%
	4	0.0%	0.5%	1.6%	3.2%	5.3%	8.0%
	5	0.0%	0.6%	1.8%	3.7%	6.1%	9.2%
	6	0.0%	0.7%	2.0%	4.0%	6.7%	10.0%



Realising the maximum potential of behaviour change

Finally, there is the option to strive for the maximum estimated potential saving of 20% of total energy use. This saving replaces the previous savings as opposed to being in addition to them but the increase in savings are still significant over the maximum possible with the previously discussed separate actions and enablers.

This maximum saving only applies if all of the enablers and actions are implemented. It is based on an all-encompassing coherent and effective change management incorporating communications, rewards, incentives and accountability at a department level being developed that will require significant investment and involvement from all staff and students but has the potential to realise significant savings at a cost lower than most self-generation or buildings interventions.

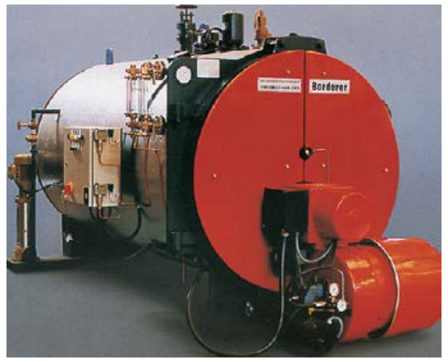
B4 Self Generation Technology Options

B4.1 Boilers

Boilers capture the heat produced during the combustion of fuel and are used in both space heating and process applications. A number of boiler solutions are available on the market which could potentially help to reduce the carbon emissions associated with operations across the University of Sheffield Campus. These options are summarised within this section.

B4.1.1 High-Efficiency Low NO_x Gas Boiler

Gas boilers are the most common solution to meeting thermal energy demands and are a very mature and efficient process. As advancement in boiler technology become available on the market it is possible to improve the environmental impact of such plant by upgrading to newer and more efficient systems. High-efficiency low NO_x boilers utilise automatic control systems to ensure efficient pre-heating and mixing of air and fuel to obtain homogenous combustion thus reducing the amount of greenhouse gases produced while offering improved combustion efficiencies. Gas boilers offer a high level of flexibility and allow rapid heat generation so are suitable for operation as back-up plant to other low and zero carbon technologies and for meeting fluctuating and peak heat demands.



Little or no infrastructure work would be required to replace existing boilers on site and therefore capital costs would be very low. Similarly operation and maintenance requirements are low resulting in small operating costs although many institutions are expecting gas prices to increase in the long-term.

Plant footprint would be small per unit of installed capacity as existing gas infrastructure means no fuel storage would be required and the high turn-down levels ensure no need for a thermal store.

The major limitation of high-efficiency low NO_x boiler technology is that the reduction seen in carbon emissions is limited to the improvement in combustion efficiency over the existing plant onsite and is therefore relatively small. High efficiency gas boilers benefit from no incentives currently available.

High-Efficiency Low NOx Boilers	
Available Capacity	10 – 20,000kW
Capital Costs	£25 - £35/kW_{th}
Fuel Costs	2.5p/kWh
Operating & Maintenance Costs	0.1 – 0.3 p/kWh
CO_2 Reduction Potential	Very low

B4.1.2 Biofuel Boiler

Biofuel boilers operate to produce heat by burning organic material. This can help to reduce the carbon emissions associated with the site as the carbon emission released during combustion are offset by the carbon absorbed by the material during its growth thus resulting in a decrease in net emissions.

However, potential emissions of particulates and noxious trace elements must be carefully determined and controlled.

B4.1.2.1 Biomass Boiler

As a proven alternative to gas-fired heating systems, biomass fuelled heating utilises the stored energy of solid organic material to generate thermal energy via combustion.

Biomass boilers use solid fuel, typically woodchip or pellets although a range of feedstocks may be utilised, and require a longer time to reach full heat output capacity than an equivalent gas-fired boiler. Similarly, biomass boilers do not respond quickly to rapid fluctuations in demand.

Biomass fuels include: energy crops (especially grown for the purpose, such as willow, hazel, poplar and miscanthus), straw, crop fibres, forestry waste and any other wood wastes. Wood sourced biomass is the most common non-waste biomass resource.

Biomass boilers generally operate more efficiently under a constant load; as stated they suffer from reduced levels of potential output turn-down compared to gas-fired plant. Biomass boilers are typically operated as base load plant with gas-fired boilers providing a back-up and supplementary supply of heat due to the flexibility they provide. Thermal storage is not unusual for inclusion with biomass systems to improve load consistency and therefore plant utilisation although this increases the required plant footprint.

Biomass boiler systems of a wide range of capacities are available across the market and are considered a reasonably mature technology with a long history of use across the continent. The feedstock used within a biomass system is a key variable which will impact upon the viability of a system and should be considered from an early stage of project development. Similarly to gas boilers biomass systems could be easily integrated into the existing site infrastructure.

Unlike natural gas, solid biomass fuel must be delivered from suppliers, usually by lorry although delivery method will differ depending upon requirement for fuel. As a result the site road infrastructure and the desire to have multiple external deliveries of fuel per week will require assessment.

Fuel costs for biomass are currently highly dependent upon the volume of fuel supplied but are broadly in line with natural gas on a per unit of energy basis. Biomass prices are also expected to increase with natural gas prices overtime.

Capital costs for biomass boiler systems are generally higher than for gas-fired equivalent although are still comparatively low compared with other low and zero carbon technology options. Similarly operating and maintenance requirements are higher than for equivalent gas systems due to the nature of the fuel used. Spatial requirements for biomass systems are substantially greater than for gas-fired plant due to the requirement for fuel storage and the possibility of using thermal storage to cater for fluctuating demand.

Carbon reduction of biomass systems provide significant carbon emission reductions in comparison to equivalent gas fired plant although again this depends upon the type and source of fuel used within the system.

Biomass boiler systems are proposed to benefit under the governments Renewable Heat Incentive (RHI) which is proposed to begin in June 2011. No details are yet available as to the level of support proposed for the systems.

Biomass Boilers	
Available Capacity	10 – 5,000kW$_{th}$
Capital Costs	£200 - £350/kW$_{th}$
Fuel Costs	1.5 p/kWh
Operating & Maintenance Costs	1.0 – 2.0 p/kWh
CO_2 Reduction Potential	Low

B4.1.2.2 Biogas Boiler

Biogas boilers in many cases are identical to equivalent natural gas fired boilers due to similarities in the fuel. The efficiency and the carbon emission benefit of biogas boilers are largely dependent upon the fuel utilised although generally provide a high level of turn-down and rapid heat output in comparison to biomass systems.

Biogas systems are most commonly used in conjunction with biogas production processes. As a result the operation and maintenance demands of a system will depend upon the fuel quality and type produced.

Biogas can be purchased on the market but is not available through national infrastructure like natural gas. As a result on site storage of fuel and distribution infrastructure is required. Alternatively, self generation of biogas is an option for consideration, see section 4.6 below.

Due to the similarities with natural gas boilers (in many gases gas boilers may run on biogas) the systems are generally easily available with good support in the market. Similarly to gas boiler systems a biogas boiler system could be easily integrated into existing infrastructure although an assessment of the delivery infrastructure would be required to ensure on site deliveries of biogas could be approved if biogas cannot be produced onsite.

Capital and operating and maintenance costs for boiler plant are similar to natural gas boiler plant but depend upon the fuel type and quality. Carbon reduction potential is also primarily defined by the fuel type, quality and source.

Similarly to biomass boilers, biogas combustion systems are also proposed to benefit under the RHI. Similarly no details on the current level of incentives have been made available.

Biogas Boilers	
Available Capacity	30 – 5,000kW$_{th}$
Capital Costs	£25 - £80/kW$_{th}$
Fuel Costs	0.0 – 6.0 p/kWh
Operating & Maintenance Costs	1.0 – 5.0 p/kWh
CO_2 Reduction Potential	Low

B4.2 Combined Heat and Power

CHP is the simultaneous production of both heat and power. Several different processes are utilised within CHP packages ranging from reciprocating engines to gas and steam turbines. CHP results in higher total efficiencies than power-only production and as a result represents a significant opportunity for reduction of carbon emissions.

B4.2.1 Gas Combined Heat & Power

Gas CHP is available in a variety of different types depending upon the capacity of generation required and the ratio of thermal to electrical energy. Reciprocating engine CHP packages are the most common with heat to power ratios generally dependent upon the capacity of system selected.

Burning natural gas in a reciprocating internal combustion engine produces rotational motion and heat. This rotational motion is used to operate a generator package and produce electricity whilst the heat produced as a by-product of the engine is captured from the engine casing and exhaust within a medium such as water.

CHP packages are generally designed to be operated continuously and generally sized to maximise overall efficiency by meeting the base-load thermal demand of a site. Any production of excess heat has to be dispersed to atmosphere thereby reducing overall efficiency whereas excess electricity produced may be exported back to the distribution network and receive income for doing so.

Gas CHP packages are well developed with many suppliers operating throughout the UK market. A gas CHP package could be easily integrated into the existing site infrastructure although the thermal output would have to be matched to a particular operation(s) across the site to ensure all heat produced was utilised. This issue could be overcome with the integration of site district heating (discussed in section 4.7).

Capital costs for CHP packages are higher than boiler plant but provide significant scope for both cost savings and carbon reduction due to the production of electrical power. Operational and maintenance requirements are also more arduous than for boiler plant due to a more complex process although spatial requirements are only slightly larger than for a gas boiler system.

CHP systems qualifying as ‘Good Quality’ under the CHPQA scheme are eligible for enhanced capital allowances (ECA).

Gas CHP	
Available Capacity	4 – 5,000 kW_e (Reciprocating Engine)
Capital Costs	£500 - £580/kW_e
Fuel Costs	2.5 p/kWh
Operating & Maintenance Costs	1.2 p/kWh
CO_2 Reduction Potential	Medium

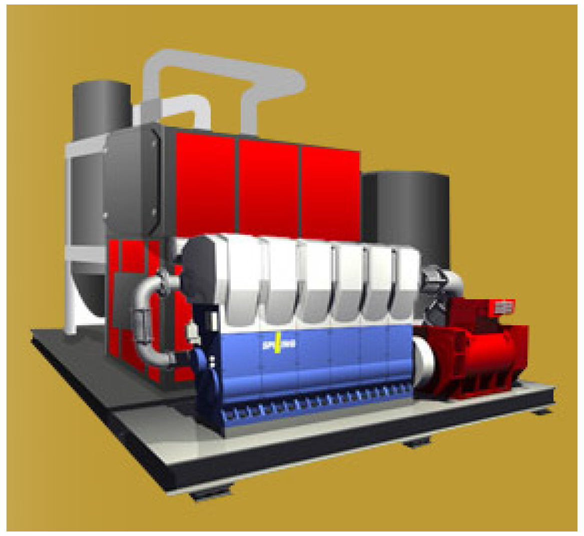
B4.2.1.1 Biomass Combined Heat & Power

Four processes are generally used to convert solid biomass fuel into both heat and electricity;

- Steam Turbine
  Fuel is combusted in a boiler to raise steam which then drives a turbine. Typically used in plants of greater than 2MWe due to the complexity and cost of plant.
- Gasification
  Production of biogas from solid biomass fuel which is then burnt within an engine (covered in section 4.6.2). Available in a range of module sizes allowing for good flexibility in capacity.
- Air Turbine
  Similar to a steam turbine cycle but with the use of an air turbine rather than a steam turbine. Not a very well technology and only available up to capacities of 100kWe.
- Organic Rankine Cycle
  Similar to a steam turbine cycle but with the use of a high molecular mass transport medium rather than steam to improve efficiency. Typically used in smaller applications than a steam turbine process and a more developed technology than the air turbine system.

The capital cost of biomass CHP is high ranging from £2,000-4000/kWe. Similarly to boiler plant biomass CHP have more arduous and therefore more costly operation and maintenance requirements than the gas-fired equivalent.

Again the need for fuel delivery and storage will require both a large area and an assessment of the viability across the site. Ideally plant would be located close to buildings of high thermal demand to limit the requirement for district heating infrastructure.



It should be noted that no British standards are currently in place for the quality of biomass fuel and demands for biomass fuel are likely to increase dramatically in the future which will impact upon security of supply uncertainty.

As biomass fuel has a very low added carbon production potential biomass CHP can have a significant positive effect on the environment with a very large reduction in the emissions of the site.

Biomass CHP systems can currently claim incentives as part of the Renewables Obligation. Systems qualifying as ‘Good Quality’ may claim double Renewable Obligation Certificates (2 ROCs) which may be sold to electricity supply companies. ROCs are currently valued at around £50. Biomass CHP systems may also be able to benefit under the proposed RHI although no details are available. It is likely that systems claiming incentives under the RHI will receive a reduced level of support under the Renewables Obligation scheme.

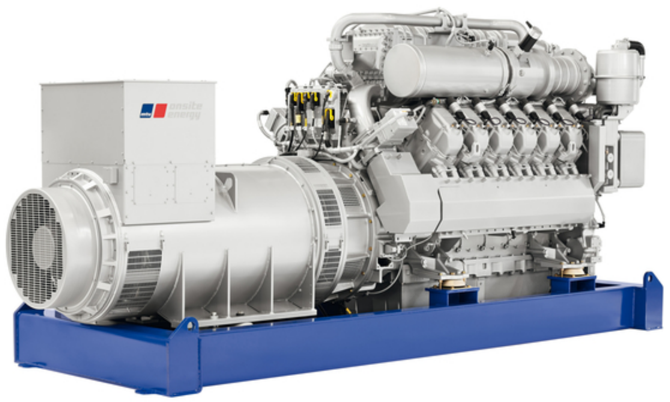
Biomass CHP	
Available Capacity	100 – 20,000kW_e

Capital Costs	£2,500 - £4,500/kW$_e$
Fuel Costs	2.0 – 3.2 p/kWh
Operating & Maintenance Costs	3.0 – 4.0 p/kWh
CO_2 Reduction Potential	Very High

The availability of biomass within the region has still to be confirmed and it is recommended that a small study is commissioned to confirm fuel availability as this may have an effect on any servicing strategy.

B4.2.1.2 Biogas Combined Heat & Power

Biogas CHP packages are similar to their boiler counterparts in that they are more of less identical to equivalent natural gas plant. As a result if good quality biogas fuel can be sourced biogas CHP engines provide significant scope for the reduction of carbon emissions across a site.



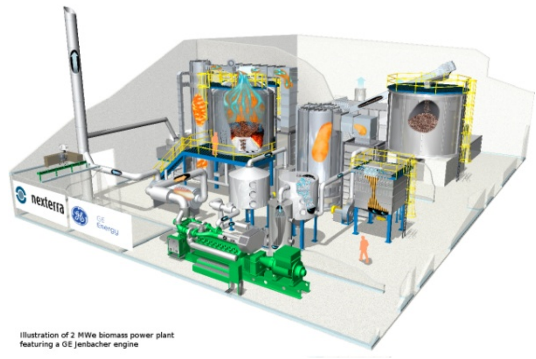
As previously mentioned the quality of the gas utilised within the plant will have a direct impact upon both the capital and operational costs of a system. Ideally a biogas CHP package would be used with an onsite process producing biogas from waste or other freely available feedstock (see section 4.6) although if required biogas can be purchased from the general supply market and stored on site. Biogas CHP systems benefit from many of the same incentives as biomass CHP systems with an additional but small added revenue element of digestate.

Biogas CHP	
Available Capacity	30 – 5,000kW$_e$
Capital Costs	£1,000 - £2,500/kW$_e$
Fuel Costs	0 – 6.0 p/kWh
Operating & Maintenance Costs	3.0 – 7.0 p/kWh
CO_2 Reduction Potential	High

B4.2.2 Energy from Waste Combined Heat & Power

EfW CHP plants are much more common place than EfW boiler systems across the energy infrastructure industry. This is typically as EfW systems are generally only available in larger capacities and as such lend themselves well to the production of steam and therefore power.

Similarly to biomass CHP, a number of EfW processes are available. Steam turbine system are the most common plant configurations found, although there are an increasing number of gasification plants being commissioned across the country and the continent.



EfW CHP would be constrained by many of the same implications of a biomass CHP system and more as the waste industry is heavily regulated to ensure compliance with UK and European Directives.

Under many incentives schemes and operating Directives, EfW systems may claim incentives for the organic and renewable fraction of the fuel stream utilised. As a result sampling, measuring, and audit procedures are required, these can only usually be justified on economic grounds at scale.

Energy-from-Waste CHP	
Available Capacity	2,000 – 30,000kW$_e$
Capital Costs	£4,800 –£9,000/kW$_e$
Fuel Costs	0 – 3.5 p/kWh
Operating & Maintenance Costs	6.5 – 7.5 p/kWh
CO_2 Reduction Potential	Medium

B4.3 Photovoltaics

A PV system converts solar energy into electricity through the use of semi-conductor materials. A PV system or array is typically made up of PV cells arranged into panels although a number of new and emerging methods of implementing PV technology are appearing on the market.

A PV cell is typically made from several layers of semi-conducting material arranged to absorb the maximum range of solar radiation falling on an area. When the solar radiation falls upon the cell an electric field is created across each layer resulting in a flow of electricity.

The modular nature of PV systems allows for large arrays to be built up. Arrays can be designed to be installed in a range of locations ranging from building facades and roof spaces to standalone field arrays.

PV systems may currently benefit under both the Renewables Obligation and the current Feed-in Tariff (FiT) scheme. Currently the FiT scheme provides good levels of support to PV systems compared to the Renewables Obligation although the government have proposed a review of the support to large scale PV systems at the first review of the scheme.

PV	
Available Capacity	1 – 5,000kW
Capital Costs	£2,000 - £10,000/kW_e
Fuel Costs	N/A
Operating & Maintenance Costs	0.1 – 0.6 p/kWh
CO_2 Reduction Potential	High

B4.4 Heat Pumps

Heat Pumps are a method of either extracting heat stored in the ground to provide domestic hot water and heating or to reject excess heat from cooling. Heat pumps take in heat at a certain temperature and raise it to a higher temperature using the same process used in refrigeration. Renewable contributions from heat pumps depend where electricity is sourced from. They are estimated as the difference between electricity input and heat output.

Low CO_2 reductions are typically calculated when the source of the electricity required is assumed to be supplied from the grid. With this assumption, long payback periods would be expected for a ground source installation even though would be incentivised as part of the Renewable Heat Incentive.

B4.4.1 Ground Source

Ground source heat-pumps (GSHP) are best suited to buildings with roughly equal summer cooling and winter heating requirements, so that across a year the heat extracted and returned to the ground has a neutral thermal polluting effect in the ground. Typically they can serve air conditioned buildings of up to about 4 storeys from the ground below the building, so they are best suited to lower density developments. The Coefficient of Performance (COP) of a heat pump is very much dependant on the temperatures of the heat source and sink. GSHP can be installed horizontally in trenches or vertically in boreholes. The viability of each of these types of GSHP is highly subjective to an assessment of ground conditions and potential complexities with installation.

B4.4.2 Air Source

Air source heat pumps (ASHP) use the air as a heat sink. This heat sink is far lower in the winter when heat is demanded most, giving rise to worse energy performance compared to GSHP. Due to the low temperature of the air when ASHP operate it can bring the heat sink to below freezing temperature. The ASHP then has to use electric heat elements to remove ice, to ensure continuous performance. These two factors lead to a far lower Coefficient of Performance over the heating season compared to GSHP.

B4.4.3 Water Source

Water source heat pumps use the same principal as air source or ground source; however a local moving or static body of water is used as the heat source or heat sink. This type of heat pump is more often used for cooling rather than heating either as an open loop (extracting water from source) or closed loop (using a secondary heat transfer medium) system. The efficiency of water source heat pumps is dependent on the type of system used, the temperatures, movement and size of the body of water and its application within the building(s). The viability of each of these types of GSHP is highly dependent to an assessment of any local water source.

B4.5 Wind Energy

Wind turbines extract kinetic energy from air movement which is then converted to electricity by a generator. Power outputs are determined via a combination of turbine swept areas and wind speeds. Wind turbines are one of the most proven renewable technologies with the main barriers to developments being political rather than technical.

Wind turbines are available from on-shore applications in capacities ranging from 1kW to 5MW and both vertical and horizontal axis turbines are readily available. Horizontal axis turbines are the most usual form and have turbine blades spinning perpendicular to the ground with the turbine shaft horizontal to the ground. Vertical axis turbines spin horizontal to the ground with the turbine shaft perpendicular to the ground.

Wind Turbine	
Available Capacity	1kW –5MW
Capital Costs	£500-£2,000/kW_e
Fuel Costs	N/A

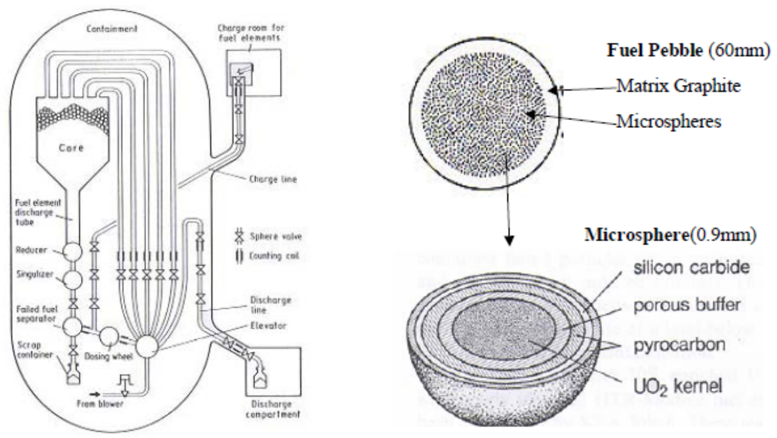
Operating & Maintenance Costs	0.5 – 1.5p/kWh
CO_2 Reduction Potential	High

B4.6 Nuclear

Nuclear power utilises the energy of nuclear reactions as the energy source for producing both heat and electricity, typically through a steam turbine cycle. For the University of Sheffield site a Pebble Bed Reactor (PBR) has been reviewed in more detail due to the fuel source being unable to reach dangerous conditions through the way it is designed and constructed. The main company that leads research in PBR is currently PBMR, in South Africa. Unfortunately the reduction of PBMR staff and work load makes the likelihood of purchasing a reactor in the near future very low.

Little information is available on the capital cost of small scale nuclear power generation due to no systems currently being commercially available for heat and power production. Increased demand in Uranium is likely to lead to variable, and high, fuel costs and operating requirements are likely to be high due to the high level of compliance required with government and international legislation.

Additional cost of decommissioning plant at the end of its operational life must also be accounted for within the development of any business case.



With the leading PBR company reducing the research carried out procuring this technology would be very difficult and guaranteeing supply of fuel and replacement parts even more so.

With the nuclear plant sitting separate from the conventional plant more space is required to house the plant leading to a large footprint. As this plant would be a single site wide resource extra electricity and heating infrastructure would be required increasing cost and complexity. As nuclear power does not burn fuel and nuclear waste would be removed from site this technology has a significant positive effect to the local environment and a capability to greatly reduce the carbon production of the site.

Nuclear Generation	
Available Capacity	$165MW_e$
Capital Costs	~£3,600/kW_e

Fuel Costs	2.3 p/kWh
Operating & Maintenance Costs	0.7 – 5.7p/kWh
CO_2 Reduction Potential	Very high

B4.7 Fuel Cells

A fuel cell is an electrochemical device that converts the chemical energy of a reaction into electrical energy, with heat produced as a by-product. Fuel cells can produce electricity and heat for use in a wide range of applications due to their high operational temperatures.

As fuel cells are a relatively new and still maturing there are relatively few products currently available on the market.

Fuel cell currently available includes;

- Solid Oxide Fuel Cells (SOFC)
  A SOFC produces electricity by direct oxidisation of a fuel via a solid oxide or ceramic electrolyte. These fuel cells provide high efficiency, stability, flexibility and low emissions.
- Molten Carbonate Fuel Cells (MCFC)
  These are high temperature fuel cells which use molten carbon electrolytes to produce electricity. MCFC fuel cells provide good efficiency and are less prone to poisoning. The high temperature of operation allows for internal conversion of energy-dense fuels removing the need for an external reformer.
- Proton Exchange Membrane Fuel Cells (PEMFC)
  PEMFCs operate at much lower temperature than MCFCs and SOFCs meaning they are less suited to CHP applications. PEMFCs utilise a polymer electrolyte member to facilitate the chemical production of electrical power.

Production of the hydrogen may use carbon intensive resources in the production meaning that the 'green' qualities of hydrogen fuel cells may be questioned. Fuel cells that operate at the lower temperature range require more purified hydrogen gas, whilst the hotter temperature range fuel cells operate with gas with CO_2 impurities.

The higher operating temperatures, above 700°C, can reform some hydrocarbons. This means in solid oxide fuel cells natural gas, from the grid, can be used as the raw fuel.

Due to the relative immaturity of fuel cell technology the range of available capacities are limited and the capital costs associated with the technology are high. As a result security of replacement parts and support are also limited currently.

Operation and maintenance requirements although minimal for the majority of fuel cell technologies can be costly due to the components used within technologies. Spatial requirements vary between technology types but are generally comparable with CHP plant unless onsite fuel storage is required.

Fuel cells are generally not supported under government incentives schemes as other technologies are considered more appropriate for helping to reduce carbon emissions.

Fuel Cells	
Available Capacity	5 – 250kW$_e$
Capital Costs	£2,000 - £20,000/kW$_e$
Fuel Costs	2.5 – 10p/kWh
Operating & Maintenance Costs	7 – 8p/kWh
CO_2 Reduction Potential	Medium

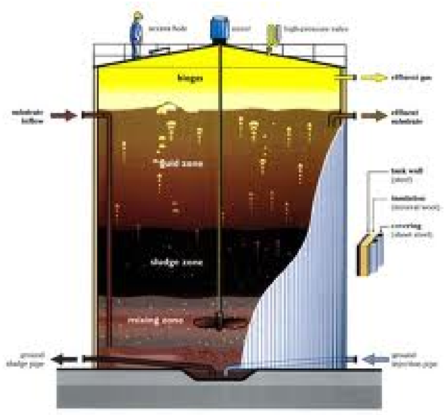
B4.8 Biogas Production

As previously suggested it may be possible to produce a biogas onsite through the use of various processes and feedstocks. Each of these processes are considered within this section.

B4.8.1 Anaerobic Digestion

Anaerobic digestion (AD) uses microorganisms to breakdown organic material, including waste paper, grass clippings, food and sewage, in the absence of oxygen to produce bio-gas, and secondary products of digestate and liquor. This mixture of gases is a combination of Methane (CH_4), Carbon Dioxide (CO_2) and Nitrogen (N_2) as well as other trace gases.

AD is conducted within enclosed vessels which are maintained within temperature and acidity ranges defined by the type of organisms being utilised. The required retention time for material within the process is also defined by the process type, conditions and the organisms utilised.



The bio-gas produced during the AD process can be utilised as a fuel source within combustion plant or fuel cells as previously mentioned. The quality of the gas produced may be further refined with the use of scrubbing processes to remove excess CO_2 and improve the concentration of the high energy methane and hydrogen gas.

The nutrient rich digestate and liquor can often be utilised as a fertiliser (subject to quality and market controls) or maybe dewatered and treated aerobically to produce compost.

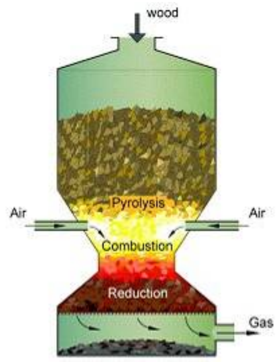
Anaerobic digestion like other energy-from-waste technologies is used in order to both manage waste streams and recover energy and therefore provides significant benefits if a commercially feasible scheme can be developed.

Anaerobic Digestion	
Available Capacity	250 – 10,000kW
Capital Costs	£1,500 - £9,000/kW$_e$
Fuel Costs	0 – 7.7p/kWh
Operating & Maintenance Costs	0.9 – 2.3p/kWh
CO_2 Reduction Potential	N/A

B4.8.2 Gasification & Pyrolysis

Gasification is the production of gas from organic material via heating and partial combustion within carefully regulated conditions. Gasification results in the production of syngas (synthetic-gas, a mixture of nitrogen, hydrogen, oxygen, carbon dioxide and methane) of a variable composition dependent upon process and feedstock.

Gasification is typically characterised as thermal degradation of material in the presence of an oxidising agent at sub-stoichiometric conditions, this is in contrast to Pyrolysis which is completed in the absence of an oxidising agent.



Pyrolysis is the process where organic material is heated or partially combusted to produce secondary fuels in the absence of oxygen. The outputs range from syngas (methane, hydrogen etc.), bio-oil (similar to diesel), tar and ash. These products can be further refined to produce more specific products. An example of this would be gasification to produce more syngas.

Gasification/Pyrolysis	
Available Capacity	300 – 10,000kW
Capital Costs	£2,200 - £3,200/kW$_e$
Fuel Costs	0 – 8.5p/kWh

Operating & Maintenance Costs	0.5 – 1.5p/kWh
CO_2 Reduction Potential	N/A

Appendix C

Workshop Notes

C1 Workshop One

ARUP

Subject Workshop One – High Energy Users Ideas Capture

Date 23 January 2012 Job No/Ref 218999/PT

1 Behaviour

	Energy Saving Measure Idea
1	Implement a “Staff Awareness” to Staff Researchers,
2	“A” rated equipment procurement monitored. (Can only buy from specific dealers)
3	Smart monitoring electricity.
4	Knowledge of procurement best practice – what is being purchased & is it the most energy efficient?
5	Cross charging Depts. / Research.
6	Practice & Preaching as justification for improving basics.
7	Dashboard for Faculty/Dept.Heads, but based on good data.
8	PAT testers to have colour coded stickers to identify appliances that can be switched off.
9	Procurement: A widely publicised pot of money (& training for procurers) which makes up the cost difference between standard & energy efficiency appliances.
10	21 times
11	Dash board Metric > relate to building users $ ☺ KWh J
12	We need to set up more people out in Faculties on the Energy Remote Monitoring (online data system) Devolve energy Data.
13	Making sure that keen staff at grassroots level have the confidence to feel they can spend staff time making environmental change.
14	Not just University Leadership but key middle management (Dept. Managers, Lab Managers etc) being seen to support this.....so grassroots. See that they can make change: issues Permission / Culture.
15	To strongly re-iterate Mike H’s point, (all the points) sorting Heating & Cooling will overcome the behaviour / disbelief barriers, (it’s too emotive to ignore).
16	Can local metering be included in the research grants to assist in monitoring & behaviour change on each new research project?

2 Buildings

	Energy Saving Measure Idea
1	Remove asbestos etc as a constraint.
2	Core Lab functions (inc animal houses) constrained interventions to refurb only.
3	Fume cupboards replace high velocity with new low velocity F.C’s.
4	No reversible heat pumps for offices: Policy procedure.
5	Refurbishment to be more focussed on improving energy efficiency.
6	Closer liaison between Estates & Faculties to have joint energy objectives.
7	Heating, environmental issues a must!!

8	Building Services are inadequately controlled. Constrained by major investment needs.
9	We need rolling processes of : Lights changing, windows HVAC etc. & make sure that when these are maintained, it doesn't revert to inefficient kit.
10	Plogging to understand local electrical energy usage patterns & magnitudes.
11	Local billing (by Lab) of energy usage.

3 Self Generation

	Energy Saving Measure Idea
1	Academic / Education, Agreement, Not Primary Reason
2	Don't forget the PR / behaviour benefits of installing highly visible, small scale wind / solar, (even if the KWH is not so good, the PR is...)
3	Scalable Energy Centre
4	Absorption Chilling Options.
5	Large off-site wind – City Centre, Off Shore.
6	North Campus Carpark. Energy Centre Option.
7	£22M annual depreciation (Buildings) - Need smart monitoring. - Timing of machines / kit – what can / can't be switched off? - Engaging researches in making these decisions, empowering & motivating. - AC – biggest energy consumption? - We must deal with the asbestos problem, (it is a barrier to us doing what we need to do). - £17M, (that's 2 years of energy & water bills). - Uni to procure x tonnes Biomass & sell to Veolia ? Extra Notes:- Strategy needs to be resilient to the expected growth – eg:, teaching, research, students. - Practice what we preach – get the basics right so people will buy into energy saving. - Systems need to be controlled & controllable. - Heating & cooling & ventilation systems are not adequately engineered. - Info on energy saving – needs to be at the level where people have responsibility. - Need to be able to control the environmental conditions. - Significant infrastructure refurb. Required before we will see a real change. - Empowering & enabling those who are responsible. - Being "allowed", eg, to switch off.

ARUP

Subject University of Sheffield – Energy Strategy
Workshop One – Faculties High Energy Users Workshop Meeting Notes

Date 19 January 2012 Job No/Ref 218999/OP

Attendees
Terry Croft – Faculty of Science
Phil Riley - Faculty of Science
Tim Allen – UoS Environmental Team
Mike Hounslow – UoS Pro-Vice Chancellor
Harry Adams – Faculty of Engineering
Malcolm Butler – Director of Operations, Faculty of Engineering
Darren Rose – Faculty Estates Coordinator
Steve Ward – University of Sheffield
Martin Mayfield – Arup
Mark Anderson – Arup
Amanda Harrison – Arup
Pete Thompson – Arup
Oliver Pitchers – Arup

UoS Background

1. Question raised around metering and recording of energy use within the Medicine department, due to NHS link/co-presence.
2. General belief that UoS is set to grow significantly in the coming years, requiring a scalable approach to infrastructure and self-generation aspects of strategy.
3. Energy use within Science set to increase regardless of expansion, due to progression in technology used.
4. Faculties currently compiling a 'foresight toward 2022' document.
5. Engineering of existing Faculty heating systems felt to be inadequate, with a historic lack of maintenance.
6. Use of electrical heaters prevalent during regular winter heating control issues, as additional heating is required for some spaces whilst other still require cooling.
7. Lack of ventilation a key element in both summer and winter internal temperature problems.

Behavioural Change

8. Scale of responsibility felt to be key, in order to achieve lower-level buy-in.
9. Recommended that responsibility sit at lab group level, with requirement for additional sub-metering in order to adequately record and display data at this level.
10. Research groups currently pay based on capital costs and estimated energy use for their work ***but*** no incentives are offered for savings achieved.

Buildings

11. New planned atrium 'heart space' within Faculty of Engineering proposed.
12. Regular change of building usages throughout the Faculties poses a challenge to adequate buildings services.
13. Initial introduction of adequate heating system controls important for both energy savings and as a visible statement of intent for future improvements and energy saving.
14. Current campus-wide building depreciation of £22 million per year.

15. Presence of asbestos within plant rooms problematic, with a large associated spend required to remediate. UoS desire to see a strategic link being drawn to its removal in order to incentivise this spend.

Self-Generation

16. Faculty of Science's Hicks building has a solar farm mounted on its roof, with an according display of energy generated which has reportedly attracts considerable interest.
17. Existing boilers serving Goodwin site are oil-fired.
18. Faculty of Engineering very keen to investigate potential to operate CHP, in part for the link of the technology as something of an educational example.
19. Sustainable cooling a big target so consideration of absorption chilling potential required.
20. Suggestion of UoS purchase of biomass fuel for use by Veolia in their existing network, with associated carbon savings being claimed by UoS.
21. With UoS fundamentally land-constrained, offsite generation is preferred for larger projects.
22. Further offsite wind being considered, possibly via a purchasing of some offshore generation (subject to DECC and HEFCE acceptance in terms of carbon reporting).

ARUP

Subject Workshop One – University Faculty Ideas Capture

Date 23 January 2012 Job No/Ref 218999/PT

1 Behaviour

	Energy Saving Measure Idea
1	More visible feedback on impact of energy saving measures.
2	Formalising the role of Green Champion (Team Leader/ Budget Holder shoulder respon.)
3	Pay back energy cost reductions to research funds.
4	Constraints Faculty Leaders worried that energy saving measures will interfere with research.
5	Incentives based on improvements and targeted awards.
6	Increase initiative impacts by advertising magnitude of savings & congratulations from Senior Level.
7	Staff surveys for faculties.
8	Finance department understand what reward scheme can be implemented.
9	Carbon, a regular reporting item in the VC's meetings with HoD's. (A good idea from Susan B).
10	Devolved budgets for energy saving measures.
11	Policies & procedures to ensure better design, procurement & post- occupancy.
12	Feedback Loop/ time lag of EFM next steps.
13	A simple one on ICT:- Currently if staff put computers to "sleep" or "hibernate" while they have documents open, will lose the full connection to that document : A disincentive.
14	Environmental Issues / carbon Reduction in Job Descriptions of: - Head of Departments & other Environmental Champions.

2 Buildings

	Energy Saving Measure Idea
1	Minimum Building Standards as part of University building design.
2	Post- Occupancy on all new builds.
3	Thermo Graphic imaging.
4	Whole lifecycle costings on integral part of refurbs process.
5	Value Eng. Out compromises user satisfaction.

3 Self Generation

	Energy Saving Measure Idea
1	
2	

Subject General Energy Users Faculties workshop - behaviour change notes

Date 23 January 2012 Job No/Ref 218999/AMS

Communication

- One of the challenges is to demonstrate to people that individual behaviour has an impact on energy consumption.
- There's a lack of a feedback loop
- The message of the cost effectiveness of behaviour change actions needs to be communicated more effectively.
- Possibly have an item of report on the monthly Heads of Department meetings to raise awareness of the importance.

FM / Estates support

- A key problem is the speed of reaction from the Estates department when maintenance issues are reported. E.g. one faculty participated in Green Impact last year but there was frustration that ideas (e.g. thermostats) weren't acted on. The timelag between the idea and FM acting on it meant that all momentum was lost.
- **IDEA:** Separate small FM budget for reactive interventions that means that there's no need for sign-off etc. (or is it another problem – resource, overall budget, procurement speed, processes?)
- Tim Allen – There's a survey going out in Feb to get information from building users on any improvements they have ideas on.

Implementation

- There's no formal level of senior staff support – needs more. TimA said that a high up member of the leadership team had attended the Green Impact awards ceremony. This was not seen as being sufficient to garner support for programmes from the masses.
- The programmes rely too much on the keen individuals. Behaviour change and energy efficiency must be brought into the mainstream. Formally give someone the role and put it on their job description. Bring it onto the same level of importance as the safety officer or fire officer.
- Heads of Department are seen as a key barrier. They will need financial incentives to act or more formal monitoring and report of departmental performance on energy.
- Anyone who is keen out of the staff receive no recognition from their Heads of Department so interest wanes and only carries on if there is no impact whatsoever on operations.
- **IDEA:** Link the performance in Green Impact to resource allocation in some way.

Progress

- There are plans to develop ways to determine every department's energy use. This will start with those that are in stand-alone buildings.

ARUP

Subject	University of Sheffield – Energy Strategy Workshop One – Veolia Workshop Meeting Notes
Date	24 January 2012
Job No/Ref	218999/PT

Attendees
Dermot Egan – Sheffield City Council
Andy Nolan – Sheffield City Council
Nigel Williams – Veolia
Laurence Hurre - Veolia
Steve Ward – University of Sheffield
Mark Anderson – Arup
Martin Mayfield – Arup
Pete Thompson – Arup

1. Veolia currently run seven District Heating Schemes in the UK.
2. Management of the network in recent years has been 'casual' and Veolia are looking to improve provision of services for users of the network.
3. There will be a meeting on the 1st February with Sheffield City Council and Veolia. Mark was invited to attend as the University of Sheffield representative.

District Cooling

4. Veolia discussed the possibility of a district cooling network. Steve Ward suggested the use of this district cooling network to supplement new air-cooled chiller plant.
5. Veolia would provide cooling to the district cooling network via absorption cooling plant.
6. Thermal storage could be used during night time to power district cooling during the day.
7. It was suggested that the University's ratings on the Green League tables and their CRC costs outweigh the financial constraints associated with implementing a low carbon heat/cooling source. We need to find a cost effective way of implementation.

Heat Capacity of Network

8. There is currently a shortage of capacity.
9. The University need to run the backup gas fired boiler most mornings to supplement supply. Could a biomass boiler be used instead?
10. Heat accumulators could be used to reduce peaks.
11. Veolia have been in discussions with Dalkia to incorporate Biomass CHP into the network as a means of decarbonising the supply. No conclusion has been reached as yet, particularly in terms of locations of plant and financial commitment.
12. There are currently two parts to the district heating network. One serves the Hyde Park Flats. To increase capacity, the idea of disconnecting some of the connection points on this part of the network has been raised. This may reduce current demand by 1MW.
13. Thermal storage could be used however the location of this is TBC.
14. Can the demand on the network also be reduced by investing in energy efficiency measures within the connected buildings? Dalkia may be able to provide this consultancy service.

Carbon Intensity Factor

15. The methodology for calculating the network's carbon emission factor has been adjusted within the past year and has been verified by an external auditor. This has caused a significant increase in the carbon intensity of the energy supply.
16. Now at 0.16kgCO_2/kWh

17. The use of the CRC carbon factor for waste (275kgCO2/tonne waste), instead of the currently used International factor for waste (320kgCO2/tonne waste), will reduce the carbon factor to approx 0.14kgCO2/kWh.
18. NOFO agreement – ends Aug/September 2013. 50% zero carbon electricity.
19. The calculation of carbon factors use the z-ratio i.e. 52%, how much carbon is attributed to heat and how to elec?
20. Laurence to provide details of the carbon factor for Veolia's electricity supply.
21. The waste stream feeding the Veolia central plant includes surrounding towns in addition to Sheffield.
22. The ability for the current plant to use biomass as a means of decarbonising the fuel source has not been explored. Current constraints – biomass generates too higher temperatures, causing the combustion process to destabilise.
23. The idea of installing a biomass CHP plant adjacent to the Veolia plant was suggested – Veolia would be happy to explore the possibility of this.
24. The size of 4-5MW was mentioned as an initial estimate.
25. Extending the network to the Eon biomass plant was discussed. Veolia said that the plant is too far away from the network (5km). In addition, no one is willing to sign up to a connection along with line to underpin the investment. The Eon plant only has 5MW available and as such a connection is not feasible.

Veolia to provide low carbon electricity

26. Veolia are not a licensed supplier of electricity.
27. Laying a private wire is not feasible.
28. Private wires require back up by grid in the event of failure.
29. Arguably the best solution would be for Veolia to connect to the grid.
30. Arup to provide Veolia with electrical energy demand profiles, in particular those for the Western Bank Campus, and Engineering Faculties.

Contract and Service Model

31. New contract with Veolia should include a capped carbon emissions factor.

Operational Availability

32. There is a need for a reliable supply of heat to the hospitals and science labs of the University in particular. The success of many experiments and research, which heavily impact the reputation of the University, rely on suitable internal thermal conditions.
33. The risk of network failure needs to be mitigated.
34. The provision of back-up heat generators is required. Do Veolia provide back-up boilers locally within buildings?
35. Hospitals particularly need local back-up plant. What redundancy do they need? Is it a 6hr storage requirement?
36. Sheffield City Council suggested the used of Sheffield Homes Martin St, Ponderosa boiler house as a possible location for a back up boiler.

Waste Streams

37. There is a proposed change of the frequency of domestic waste collections from weekly to fortnightly. It was hypothesised that this may increase the amount of recycling of plastic waste and therefore may decrease the amount of waste being sent to Veolia for incineration.
38. Sheffield City Council are proposing to suspend the current free green waste collection service. This may increase the green waste component entering the Veolia incineration plant, potentially reducing the calorific value of the waste.

Other district heating mains within Sheffield

39. There is a current proposal to install a local district heating network at Kelham Island.
40. What tariff would Veolia be willing to pay per kWh provided by non-Veolia owned heat generators?
41. If the University procured and operated their own heating generating plant, Veolia mentioned that it may be unnecessary for them to buy any spare heat from the University as their peak load would be reduced significantly. The University are currently one of the largest users of the district heating energy.
42. The possibility of Veolia procuring and operating a biomass CHP plant locally within the University was also mentioned.

ARUP

Subject Workshop One – Local Stakeholders Ideas Capture

Date 23 January 2012 Job No/Ref 218999/PT

1 Behaviour

	Energy Saving Measure Idea
1	Better working / resource sharing between hospitals & University.
2	Transportation & Procurement in city re: University.

2 Buildings

	Energy Saving Measure Idea
1	Building management systems across Campus not just in new builds.
2	More wind power & solar plants on buildings & around Sport Sheffield, Edge etc.

3 Self Generation

	Energy Saving Measure Idea
1	Clean air zone around Campus (no Biomass??)
2	Identify sites for dist. Energy locations on Campus.
3	Children's Hospital expansion > share energy face of U of S.
4	Anarobic digestion Plant – 45 tonnes food waste. Local to Uni? Not likely.
5	Veolia Network – Local CHP Nodes rather than one central HT source.
6	Off – site wind options explore with SCC. "Wind Mapping" Report.
7	Wind capture on outer University sites feeds into District.
8	Recycle food waste / waste for energy.
9	Food waste ad in SCC off-site to Uni. & NHS.
10	Air quality constraint – Conservation, Planning.
11	Development site duel provision: eg: Car Parking.
12	Site identification for energy centres.
13	Previous initiative "HUMUS"

ARUP

Subject	University of Sheffield – Energy Strategy Workshop One – Accommodation Services Workshop Meeting Notes		
Date	19 January 2012	Job No/Ref	218999/OP

Attendees
Ian Jones –UoS Head of Accommodation Services
Jo Fife – General Manager, Catalyst (Higher Education)
Jenny Marshall – UoS Contracts Manager, Residential Services
Steve Ward – University of Sheffield
Mark Anderson – Arup
Craig Havenhand – Arup
Amanda Harrison – Arup
Pete Thompson – Arup
Oliver Pitchers – Arup

UoS Background

1. The accommodation offered at UoS has changed dramatically over the past 5 – 10 years, from 70% catered units owned by UoS to 70% self-catered en-suite facilities, owned and operated by Catalyst.
2. Catalyst were appointed under a 40-year PFI arrangement whereby they invested £140 million and retain the 'hard FM' elements of accommodation, whilst UoS invested £16 million and retain the 'soft FM'.
3. UoS provide energy and pass costs onto Catalyst.
4. Following operation of a 'Contract for Capacity' whereby accommodation continuity was maintained during demolishing of older UoS housing blocks, 900 beds have been retained in the city centre Opal 2 building.

Behavioural Change

5. A 'Switch Off' campaign has been underway for past 3 years, with student volunteer 'Power Rangers' leading the effort.
6. Efforts in place to incentivise energy saving for 1st years (for whom rent is *not* linked to energy consumption) via the offer of a free party for achieving of largest savings. Challenge of linking savings made during an academic year to students who will subsequently move from the accommodation the following year.
7. Suggestion to use current annual student accommodation survey (conducted each November) to raise the profile and ask related questions around energy use.

Buildings

8. 1,000 beds have been retained within UoS owned housing (predominantly Victorian in origin). Following little-or-no investment in this housing stock for some 15 years, a 5-year programme of refurbishment and improvement is now underway, focussing on boiler plant and building fabric.

   Jenny agreed to provide details of this programme.

9. Newest Catalyst accommodation features single boilers in buildings.
10. Use of electric heater remains a big issue and is prevalent.
11. Presence of asbestos within certain plant rooms currently limiting ability to adequately meter energy use.

Self-Generation

12. UoS have previously investigated viability of PV integration within its accommodation buildings but recent revisions to FiT's led to plans being shelved.

ARUP

Subject Workshop One - Accommodation Services Ideas Capture

Date 23 January 2012 Job No/Ref 218999/PT

1 Behaviour

	Energy Saving Measure Idea
1	Encourage wearing extra layers.
2	Smart phone App.
3	Constant reminder of energy being used, eg: sign-in lift saying how much energy the lift used. To encourage people not to use but use stairs.
4	Personal – Control.
5	Advertise / Communicate Uni. Initiatives. Display
6	Competition for lowest carbon accommodation block. "Student Switchoff" Prizes. Retrospective
7	Post – Grad research
8	Energy use / savings to be displayed on public screen in "The Edge"
9	Awareness to Residents re/eg: why stairwell lights are "always on". Practice what we preach.
10	Display in Edge.
11	Look into web & Application / Smartphone Data.
12	9K / year Student Fees / Will this affect behaviour & wanting to save the University energy? How to combat?
13	Electric heaters – thoughts / ideas on removal & control campaigns. Stick = Policy = Carrots??
14	Energy cost does not affect Student pockets. How do we make them aware of it – tailored incentives (not £ - but what students want to spend collectively. Carrot + Stick = Reward / bill for overuse. For underspend. How to engage / motivate Students who leave after a year. Apps. – Clothing instead of heaters. Info – knowing the £ of heaters. Cost! Accomm vs offices – need to tailor approach. Can't stop Students from bringing heaters etc. in. Staff don't pay so how do we incentivise? – fear of loss. Metering – variety, possibility of metering, technology.

2 Buildings

	Energy Saving Measure Idea
1	Retained Estate Refurbishment: PV
2	Opportunities around significant refurb / improvements to existing accom.
3	Seperate meters for personal electrical appliances.
4	Energy efficiency procurement – keeping all Stakeholders happy. Procurement Strategy requested.
5	Annual saving to include Energy & ?? out
6	Energy & Plant & Goods Procurement Policy / Procedure

7	Incorporate questions regarding comfort / energy in Student Survey.
8	Create Sub-Metering. Central Plant – Smaller Power Usage.
9	Investment in Sub-Metering for existing buildings.
10	Risk sharing on cost of energy. ? Proof of benefit.
11	Split circuit accom. rooms metered. App for room circuit.

3 Self Generation

	Energy Saving Measure Idea
1	PV considered > funding being sought to subsidise / replace reduced FiT's.
2	Future DH link & energy centre for Ranmoor & Edge.

ARUP

Subject	University of Sheffield – Energy Strategy Workshop One – Veolia Workshop Meeting Notes		
Date	24 January 2012	Job No/Ref	218999/PT

Attendees
Dermot Egan – Sheffield City Council
Andy Nolan – Sheffield City Council
Nigel Williams – Veolia
Laurence Hurre - Veolia
Steve Ward – University of Sheffield
Mark Anderson – Arup
Martin Mayfield – Arup
Pete Thompson – Arup

1. Veolia currently run seven District Heating Schemes in the UK.
2. Management of the network in recent years has been 'casual' and Veolia are looking to improve provision of services for users of the network.
3. There will be a meeting on the 1st February with Sheffield City Council and Veolia. Mark was invited to attend as the University of Sheffield representative.

District Cooling

4. Veolia discussed the possibility of a district cooling network. Steve Ward suggested the use of this district cooling network to supplement new air-cooled chiller plant.
5. Veolia would provide cooling to the district cooling network via absorption cooling plant.
6. Thermal storage could be used during night time to power district cooling during the day.
7. It was suggested that the University's ratings on the Green League tables and their CRC costs outweigh the financial constraints associated with implementing a low carbon heat/cooling source. We need to find a cost effective way of implementation.

Heat Capacity of Network

8. There is currently a shortage of capacity.
9. The University need to run the backup gas fired boiler most mornings to supplement supply. Could a biomass boiler be used instead?
10. Heat accumulators could be used to reduce peaks.
11. Veolia have been in discussions with Dalkia to incorporate Biomass CHP into the network as a means of decarbonising the supply. No conclusion has been reached as yet, particularly in terms of locations of plant and financial commitment.
12. There are currently two parts to the district heating network. One serves the Hyde Park Flats. To increase capacity, the idea of disconnecting some of the connection points on this part of the network has been raised. This may reduce current demand by 1MW.
13. Thermal storage could be used however the location of this is TBC.
14. Can the demand on the network also be reduced by investing in energy efficiency measures within the connected buildings? Dalkia may be able to provide this consultancy service.

Carbon Intensity Factor

15. The methodology for calculating the network's carbon emission factor has been adjusted within the past year and has been verified by an external auditor. This has caused a significant increase in the carbon intensity of the energy supply.
16. Now at 0.16kgCO2/kWh

17. The use of the CRC carbon factor for waste (275kgCO2/tonne waste), instead of the currently used International factor for waste (320kgCO2/tonne waste), will reduce the carbon factor to approx 0.14kgCO2/kWh.
18. NOFO agreement – ends Aug/September 2013. 50% zero carbon electricity.
19. The calculation of carbon factors use the z-ratio i.e. 52%, how much carbon is attributed to heat and how to elec?
20. Laurence to provide details of the carbon factor for Veolia's electricity supply.
21. The waste stream feeding the Veolia central plant includes surrounding towns in addition to Sheffield.
22. The ability for the current plant to use biomass as a means of decarbonising the fuel source has not been explored. Current constraints – biomass generates too higher temperatures, causing the combustion process to destabilise.
23. The idea of installing a biomass CHP plant adjacent to the Veolia plant was suggested – Veolia would be happy to explore the possibility of this.
24. The size of 4-5MW was mentioned as an initial estimate.
25. Extending the network to the Eon biomass plant was discussed. Veolia said that the plant is too far away from the network (5km). In addition, no one is willing to sign up to a connection along with line to underpin the investment. The Eon plant only has 5MW available and as such a connection is not feasible.

Veolia to provide low carbon electricity

26. Veolia are not a licensed supplier of electricity.
27. Laying a private wire is not feasible.
28. Private wires require back up by grid in the event of failure.
29. Arguably the best solution would be for Veolia to connect to the grid.
30. Arup to provide Veolia with electrical energy demand profiles, in particular those for the Western Bank Campus, and Engineering Faculties.

Contract and Service Model

31. New contract with Veolia should include a capped carbon emissions factor.

Operational Availability

32. There is a need for a reliable supply of heat to the hospitals and science labs of the University in particular. The success of many experiments and research, which heavily impact the reputation of the University, rely on suitable internal thermal conditions.
33. The risk of network failure needs to be mitigated.
34. The provision of back-up heat generators is required. Do Veolia provide back-up boilers locally within buildings?
35. Hospitals particularly need local back-up plant. What redundancy do they need? Is it a 6hr storage requirement?
36. Sheffield City Council suggested the used of Sheffield Homes Martin St, Ponderosa boiler house as a possible location for a back up boiler.

Waste Streams

37. There is a proposed change of the frequency of domestic waste collections from weekly to fortnightly. It was hypothesised that this may increase the amount of recycling of plastic waste and therefore may decrease the amount of waste being sent to Veolia for incineration.
38. Sheffield City Council are proposing to suspend the current free green waste collection service. This may increase the green waste component entering the Veolia incineration plant, potentially reducing the calorific value of the waste.

Other district heating mains within Sheffield

39. There is a current proposal to install a local district heating network at Kelham Island.
40. What tariff would Veolia be willing to pay per kWh provided by non-Veolia owned heat generators?
41. If the University procured and operated their own heating generating plant, Veolia mentioned that it may be unnecessary for them to buy any spare heat from the University as their peak load would be reduced significantly. The University are currently one of the largest users of the district heating energy.
42. The possibility of Veolia procuring and operating a biomass CHP plant locally within the University was also mentioned.

ARUP

Subject Workshop One – Local Stakeholders Ideas Capture

Date 23 January 2012 Job No/Ref 218999/PT

1 Behaviour

	Energy Saving Measure Idea
1	Better working / resource sharing between hospitals & University.
2	Transportation & Procurement in city re: University.

2 Buildings

	Energy Saving Measure Idea
1	Building management systems across Campus not just in new builds.
2	More wind power & solar plants on buildings & around Sport Sheffield, Edge etc.

3 Self Generation

	Energy Saving Measure Idea
1	Clean air zone around Campus (no Biomass??)
2	Identify sites for dist. Energy locations on Campus.
3	Children's Hospital expansion > share energy face of U of S.
4	Anarobic digestion Plant – 45 tonnes food waste. Local to Uni? Not likely.
5	Veolia Network – Local CHP Nodes rather than one central HT source.
6	Off – site wind options explore with SCC. "Wind Mapping" Report.
7	Wind capture on outer University sites feeds into District.
8	Recycle food waste / waste for energy.
9	Food waste ad in SCC off-site to Uni. & NHS.
10	Air quality constraint – Conservation, Planning.
11	Development site duel provision: eg: Car Parking.
12	Site identification for energy centres.
13	Previous initiative "HUMUS"

C2 Workshop Two

ARUP

Subject	High Energy and Accom workshop 2- notes		
Date	21 February 2012	Job No/Ref	218999-00/AH

1 High Energy Users – General Notes

- Currently no added value in the projects for energy saving, no adjustment on costing, and no intervention for addressing energy
- Need to link 'added value' with energy consumption
- Need to decouple carbon and energy
- Need a Green Find to ensure environmental measures are included and not value engineered out
- Need to reflect best practice (e.g. Project Sunshine, Arthur Willis Centre).
- Need to link academic performance to investment (check Susnet – has this been done before in Arup?)
- Survey of building usage and categorisation has not been invested in enough – high level review so limited outputs. Need more accurate data. Teaching and research data needs to be more robust, so can equate energy use to the space used.
- Space also impacted by doing charity research, for which the faculties receive no £ input (it's about the Uni's reputation)
- Roof top wind turbines may not create much energy but they are a strong visible indication of the Uni's commitment to carbon reduction

2 People/Behaviour Notes

- People need to have adequate controls to be able to turn things off
- Enabling people (e.g. to pull down the sash windows), establishing habits. Need to achieve this in the research environment as well as in teaching.
- Finance need to be involved – people would be more inclined ot respond if they knew the £ impact
- Faculties/Depts need to see a return *to them* for their efforts (currently there is not a direct return)

3 Accommodation – Self Gen notes

- Wind not possible due to land conservation
- Ground source – a possibility?
- PV – payback of 15 years is appealing – need to explore further

4 Accommodation – Behavioural notes

4.1 Heating

- Heating default set to 20 degrees C in rooms, 19 degrees in shared areas. Students can turn down (via radiator valve) but cannot turn up.
- Lack of control may mean they are more likely to use heaters (take-back factor)
- Could install a 'Boost button' – being able to effect a small increment in heating would give students control

4.2 Communications

- " we need to look at what we tell students, how we explain what we do and why, especially the foreign students"
- Info provided as part of the induction and welcome packs, but then nothing further through the year. Needs to be regular, consistent campaigns
- **Online induction training** has energy and environment element but it is only minor
- **If communicated about energy use during the cold snaps** (or just prior to), this may limit complaints and increase understanding of heating
- Too few lifts across the accommodation for any campaign on these to have significant impact (but can be useful as another element of overall campaign)
- Switch off campaign targets appliance use
- Need to improve information gathering and feedback in a timely way if want to be able to create a competition element
- Emails – students soon stop reading them (unless the subject heading is really enticing!)
- Facebook – an option – but do students really want to join the group? Tends to tail off.
- **Residential Mentors** – a team of volunteer staff who do 15 hours a week, and get their accommodation free in return. They currently just do visits, walk arounds etc but could have a formalised element to the role (e.g. 1 hour a week on student switch off). They are managed by a team of ex-students called Residential Coordinators, some of whom are full time, and again they could have energy incorporated into their roles.

- Ice-cream rewards for lowering energy use per accommodation block has worked well; rewards need to be directly impacting on the students, savings should not just go into the accommodation as then the students don't reap the benefits, but if it were invested in common rooms or places they would still use, early enough in the year, before they leave then that would be better

4.3 IT/Systems

- Smart Phone App: energy use for the accommodation block – but needs to be more timely, so people can react to it (currently gives the previous year?). also, few blocks currently have energy data.
- **Campus App:** there is already a Campus App up and running – has a news section and we could use this to communicate energy messages!
- **Also there is currently a system being developed (with external provider),** info displayed on screens around The Edge. The system has a forced return to the Homepage every 24 hours, so the home page could feature key energy messages. Students have to log in to this to be able to use the wifi in The Edge
- The system above (Ian could not remember what it is called) cold also run termly competitions, rather than the current once a year one (energy use compared to previous year), but need good meter data to be able to do this

4.4 Other /General

- Corridors are on PIR, currently already on the lowest allowable Lux levels and timings (but the rationale is not known to students, needs to be communicated)
- Kitchen areas currently not PIR but could be.
- Domestic meter readers don't fit the cabling in accommodation blocks, to be able to measure energy use
- Most accommodation blocks are not Sub metered and if they are this is not done by individual flat, so cannot compare flats
- May want to survey some of the Residential buildings e.g. Victorian properties and mixed builds (e.g. Victorian with new build extensions), and Stephenson building

Appendix D

IRM Analysis

D1 Self-Generation Analysis Criteria

Definitions	1. Capital Costs		2. Operating Costs		3. Spatial Requirements		4. Technology Integration		5. Supply Chain & Market Availability		6. Development Timescale		7. Locational Suitability		8. Carbon Reduction Potential		9. Available Incentives		10. Research / Teaching Links		11. Future Proofing		12. Stakeholder Perception		13. Planning Considerations	
Very Bad	Very high capital costs per unit of installed capacity	VB	High gross cost in operating technology	VB	Very Large footprint per unit of isntalled capacity required to house plant	VB	Difficult to integrate requiring substantial works and new infrastructure.	VB	Technology is new to the market and/or very difficult to procure. Difficulties in guaranteeing supply of required consumables.	VB	Technology entails significant development and implementation timescales	VB	Plant has significant detremental effect on or lack of synergy with location	VB	Little or no change to the sites emissions.	VB	Little or no opportunity to benefit from incentives	VB	No link to ongoing University research and activities.	VB	Technology provides no level of future-proofing for energy provision.	VB	Highly negative stakeholder perception of technology.	VB	Strict planning conditions surrounding implementation of solution.	VB
Bad	High capital costs per unit of installed capacity	B	Moderate gross cost in operating technology	B	Large footprint per unit of installed capacity require to house plant	B	Not easy to integrate into the current systems with moderate works required.	B	Technology is reasonably new to the market and some effort is required in order to procure systems. Consumables are not mainstream but can be secured.	B	Technology entails notable development and implementation timescales	B	Plant has detremental effect on or lack of synergy with location	B	A small change to the sites emissions	B	Small opportunity to benefit from incentives	B	Minor link to ongoing University research and activities.	B	Technology provides a small level of future-proofing for energy provision.	B	Negative stakeholder perception of technology.	B	Difficult planning conditions surrounding implementation of solution.	B
Average	Moderate capital costs per unit of installed capacity	A	No gross cost or revenue in operating technology	A	Moderate footprint per unit of installed capacity required to house plant	A	Requires some works to integrate but little modification or change to existing services required	A	Technology is maturing and supply is available. Consumables are available from multiple sources.	A	Technology entails normal development and implementation timescales	A	Plant has no effect on the location	A	A moderate change to the sites emissions	A	Moderate opportunity to benefit from incentives	A	Moderate link to ongoing University research and activities.	A	Technology provides a reasonable level of future-proofing for energy provision.	A	Neutral stakeholder perception of technology.	A	Moderate planning conditions surrounding implementaiton of solution.	A
Good	Low capital costs per unit of installed capacity	G	Moderate gross revenue in operating technology	G	Low footprint per unit of installed capacity required to house plant	G	Easy to integrate, requiring some additional works but fits in with majority of existing services	G	Technology is supplied by multiple companies and is well proven. Consumables are available.	G	Technology entails shorter-than-normal development and implementation timescales	G	Plant has a positive effect and good synergy with its location	G	A large reduction in the emission of the site.	G	Large opportunity to benefit from incentives	G	Notable link to ongoing University research and activities.	G	Technology provides a good level of future-proofing for energy provision.	G	Positive stakeholder perception of technology.	G	Planning conditions to do not impose any barriers against development of technology.	G
Very Good	Very low capital costs per unit of installed capacity	VG	High gross revenue in operating technology	VG	Very low footprint per unit of isntalled capacity required to house plant	VG	Little or no work required to integrate system into current services	VG	Technology is widely avilable across the market with substantial choice available. Consumables are widely traded and freely available.	VG	Technology entails very short development and implementation timescales	VG	Plant has a significant positive effect and good synergy with its location	VG	A very large reduction in the emissions of the site.	VG	Very large opportunity to benefit from incentives	VG	Strong link to ongoing University research and activities.	VG	Technology provides a significant level of future-proofing for energy provision.	VG	Strongly positive stakeholder perception of technology.	VG	Planning encourages the development of solution.	VG

D2 Building-Integrated Analysis Outputs

Type	Categories	Technology	1. Capital Costs	2. Operating Costs	3. Spatial Requirements	4. Technology Integration	5. Supply Chain & Market Availability	6. Development Timescale	7. Locational Suitability	8. Carbon Reduction Potential	9. Available Incentives	10. Research / Teaching Links	11. Future Proofing	12. Stakeholder Perception	13. Planning Considerations	Score	Priority
Building-integrated	Boiler																
	CHP																
	Heat Pumps																
	Biogas																

D3 Stand-Alone Analysis Outputs

Type	Categories	Technology	1. Capital Costs	2. Operating Costs	3. Spatial Requirements	4. Technology Integration	5. Supply Chain & Market Availability	6. Development Timescale	7. Locational Suitability	8. Carbon Reduction Potential	9. Available Incentives	10. Research / Teaching Links	11. Future Proofing	12. Stakeholder Perception	13. Planning Considerations	Score	Priority
Campus / Stand-alone Scale	Boiler	[illegible]														[illegible]	[illegible]
		[illegible]														[illegible]	[illegible]
		[illegible]															
	CHP	[illegible]														[illegible]	[illegible]
		[illegible]														[illegible]	[illegible]
	[illegible]	[illegible]														[illegible]	[illegible]
	Heat Pumps	[illegible]															
		[illegible]															
	[illegible]	[illegible]														[illegible]	[illegible]
	[illegible]	[illegible]															
	[illegible]	[illegible]															
	Biogas	[illegible]															
		[illegible]															

D4 Offsite Analysis Outputs

Type	Categories	Technology	1. Capital Costs	2. Operating Costs	3. Spatial Requirements	4. Technology Integration	5. Supply Chain & Market Availability	6. Development Timescale	7. Locational Suitability	8. Carbon Reduction Potential	9. Available Incentives	10. Research / Teaching Links	11. Future Proofing	12. Stakeholder Perception	13. Planning Considerations	Score	Priority
Offsite	Boiler	[illegible]															
		[illegible]															
		[illegible]															
	CHP	[illegible]														[illegible]	[illegible]
		[illegible]														[illegible]	[illegible]
	[illegible]	[illegible]														[illegible]	[illegible]
	Heat Pumps	[illegible]															
		[illegible]															
	[illegible]	[illegible]														[illegible]	[illegible]
	[illegible]	[illegible]														[illegible]	[illegible]
	[illegible]	[illegible]															
	Biogas	[illegible]														[illegible]	[illegible]
		[illegible]														[illegible]	[illegible]