The University of York

Heslington East

Renewable Energy Strategy for Heslington East, Cluster 1

The University of York

Heslington East

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November 2008

This report takes into account the particular instructions and requirements of our client.
It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party

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Renewable Energy Strategy Statement

"To satisfy the proposed City of York Council planning condition of providing 10% of the Cluster 1 building energy consumption from on-site renewable energy sources, the University are committed to delivering in excess of 950,000kWh/year from an on-site, centralised biomass boiler."

1 Introduction

The University of York is in the early stages of a major expansion of its facilities and business onto the new, 65 hectare Heslington East site. When developed this will double the geographical area of the Heslington Campus and increase existing numbers of students by around 50%.

The Heslington East site will be developed in several phases, and the development of the first phase, known as Cluster 1, is underway. Cluster 1 consists of a residential college, four academic buildings, an IT Server building and several Knowledge Transfer buildings.

This report presents the University's renewable energy strategy for Cluster 1 and articulates the University's long term site-wide renewable energy strategy. The report has been compiled with the primary objectives of outlining to the City of York Council, the University's site-wide energy strategy and the approach to addressing Council requirements for on-site generation of energy from renewable sources at Heslington East - as required by the Council's adopted Interim Planning Statement (IPS): "Sustainable Design and Construction" and application specific conditions.

The requirement for further clarification on these details has been raised in the context of the most recent planning application for Cluster 1 to provide an academic building for Theatre, Film and Television (TFTV) department.

The report has been prepared by Arup Utilities & Energy Consulting, on behalf of the University. Arup is a world leading consultancy in the field of strategic energy solutions and renewable energy technology.

2 Planning Context

2.1 City of York Renewable Energy Policy

In November 2007, the City of York Planning Committee approved the Interim Planning Statement (IPS): "Sustainable Design and Construction."

The IPS defines 'renewable energy' as follows:

> Renewable energy is the generation of heat, hot water or electricity from renewable resources such as the sun, wind and earth. Government grants are now available for many technologies and for different development types including commercial. More information can be found on the *Low Carbon Buildings Programme* website www.lowcarbonbuildings.org.uk. In order to qualify for a grant the development must first demonstrate energy efficiency and have planning consent for the technologies.

Figure 1 - Excerpt from IPS: Sustainable Design and Construction – Definition of 'Renewable Energy'

The IPS considers new build developments in terms of the following two relevant categories:

1. Large-scale Commercial: >500m^2
2. Residential: >1 dwelling

The associated requirements for on-site renewable energy generation to serve each category are presented in the IPS excerpts below:

Residential:

> **Minimum Standard (Renewable Energy)**: The applicant must demonstrate that a % of the expected energy demand for the development will be provided for through on site renewable generation for heat and/or electricity. For developments of 5 dwelling units and above, 10% of energy will be expected to be produced on site, for developments of 4 dwellings and under, 5% of energy will be expected to be produced on site. In addition parts of the development should be identified that could accommodate renewable energy installations in the future, for example the number/area of south facing roofs.

Large-scale Commercial:

> **Minimum Standard (Renewable Energy)**: The sustainability statement must demonstrate that at least 10% of the expected energy demand for the development will be provided for through on site renewable generation for heat and/or electricity. In addition parts of the development should be identified that could accommodate renewable energy installations in the future, for example the number/area of south facing roofs and potential wind turbine locations.

Figure 2 - Excerpt from IPS: Sustainable Design and Construction – On-site Renewable Energy requirements

2.2 Building Specific Planning Conditions

Each Cluster 1 building is subject to the submission of an individual, detailed reserved matters application to the City of York Council.

In response to the latest major planning submission for the erection of a building for the Theatre Film and Television (TFTV) department, the Council have proposed the following planning condition for the provision of on-site renewable energy generation:

> No building work shall take place until details have been submitted to and approved in writing by the local planning authority, to demonstrate how the development will provide from on site renewable sources, 10% of the development's total energy demand. The development shall be carried out in accordance with the submitted details unless otherwise agreed in writing by the local planning authority (as part of an energy strategy for Heslington East campus).
>
> Reason: In the interests of sustainable development

Figure 3 Extract from Planning Committee report

The reserved matters application for the TFTV building is currently pending a decision.

2.3 University Interpretation of Planning Conditions

With respect to Cluster 1, the University interpret the City of York renewable energy planning conditions as follows:

1. **10% of the total annual building energy consumption of each Cluster 1 building shall be provided via on-site generation from renewable energy sources.**
2. **On-site renewable energy generation technology may be located within/upon individual buildings. Installed capacity shall satisfy 10% requirement for associated individual building.**
3. **On-site renewable energy generation technology may be located in a central location and shall utilise appropriate heat and/or electricity distribution networks to supply energy to connected buildings. Installed capacity shall satisfy the 10% requirement for the summation of Cluster 1 buildings.**
4. **'Renewable Energy' is that generated from a naturally available resource that is constantly replenished and can be harnessed for human benefit.**
5. **'Building energy' includes all energy associated with space heating, domestic hot water, space cooling, ventilation, lighting and small power devices. Measured in 'kilowatt hours per year' (kWh/year).**
6. **'On-site' refers to within/upon individual buildings and/or within the development site boundary.**

3 Renewable Energy Strategy Development

In accordance with University corporate sustainability targets and in response to emerging legislation, local planning policy and commercial pressures, the University are developing a holistic '***Sustainable Energy & Utility Strategy***' for the Heslington East and Heslington West sites.

Thus far, this strategy has been progressed in two stages – an initial scoping stage and a secondary development stage. The initial scoping stage defined the following technical priorities for the University, which are required to achieve and sustain targeted CO_2 emissions reductions and maintain security of supply:

Priority 1	**In-use Energy Consumption Reduction**
Priority 2	**Low Carbon Building Design**
Priority 3	**On-site Infrastructure Scale LZC Technology**
Priority 4	**Building Integrated LZC Technology**
Priority 5	**Off-site LZC Technology**

Figure 4 - Sustainable Energy & Utility Strategy Priorities

LZC = 'Low & Zero Carbon'

In recognition of these priorities, the University have committed to and invested in operational energy consumption reduction initiatives and the pursuit of low carbon building design for all new buildings.

In addition, the University are currently progressing a *site-wide* approach to the adoption of on-site renewable energy generation. The result shall be a comprehensive *site-wide* ***'University of York Renewable Energy Strategy'.***

This strategy will define a deliverable, cost-effective, flexible and robust approach to the on-site generation of energy from renewable sources and the accessibility of that energy for consumption within new and existing University buildings.

The long-term details of the site-wide strategy are subject to continuous feasibility testing over time as the site energy demand profile evolves, technologies mature and energy markets vary. However, the main principles of the site-wide renewable energy strategy have been defined.

The '***Renewable Energy Strategy for Heslington East, Cluster 1***' as presented by this document, adopts these main principles and thus will form an integral, fully compatible part of the site-wide '*University of York Renewable Energy Strategy*'.

3.1 Key Drivers for Renewable Energy

In developing the site-wide renewable energy strategy and defining the Cluster 1 strategy, the University have considered the short and long-term influencing factors or '*key drivers*' in order to develop a flexible and robust approach to providing long-term benefit to new and existing buildings. These primary key drivers are:

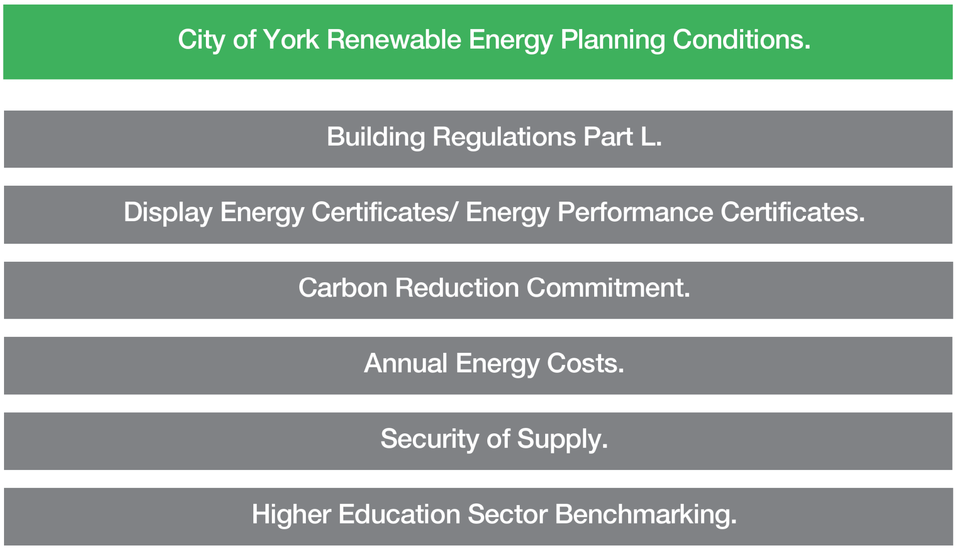


Figure 5 - Key drivers for Renewable Energy Strategy

A summary of each key driver follows.

3.1.1 City of York Renewable Energy Planning Conditions.

The City of York "Sustainable Design and Construction" Interim Planning Statement and building specific planning conditions are clear mandatory drivers for the renewable energy strategy.

The primary objectives of UK policy requiring the adoption of renewable energy technologies are **carbon emissions reduction** and **security of supply**. In response to increasing environmental and energy supply pressures on UK Government, it is anticipated that the current 10% requirement for on-site renewable energy capacity may increase in the future to 20% and beyond.

The Renewable Energy Strategy shall be adaptable to enable the University to satisfy current and future planning conditions for new build and building refurbishments.

3.1.2 Building Regulations Part L

UK Building Regulations Part L is associated with the 'Conservation of Fuel & Power' in buildings. The regulation specifies minimum design requirements, and maximum limits for Carbon Dioxide (CO_2) emissions associated with annual building energy consumption (kgCO_2/year). The regulation applies to new build and building refurbishment.

Adoption of renewable energy technology assists in achieving compliance with the regulation. The current 2006 edition of the regulation is anticipated to be revised on a revolving, three-year basis. Future revisions to the regulation will further constrain the permitted building CO_2 emissions requirements.

The Renewable Energy Strategy shall support long-term compliance with regulatory CO_2 emissions reduction requirements.

3.1.3 Display Energy and Energy Performance Certificates

From 1 October 2008 all UK buildings whenever sold, built or rented will need an Energy Performance Certificate (EPC). The certificate provides energy efficiency A-G ratings and recommendations for improvement. The ratings are standard so the energy efficiency of one building can easily be compared with another building of a similar type.

From 1 October 2008 Display Energy Certificates (DECs) are required for buildings with a total useful floor area over 1,000m^2 that are occupied by a public authority and institution providing a public service to a large number of persons and therefore visited by those persons. DECs show the actual energy usage of a building, the operational Rating, and help the public see the energy efficiency of a building. The DEC must be clearly displayed at all times and clearly visible to the public.

The Renewable Energy Strategy shall support the improved energy performance certification of University buildings.

3.1.4 Carbon Reduction Commitment

The Carbon Reduction Commitment (CRC) is a mandatory, legally binding CO_2 emissions trading scheme intended to have a significant impact on reducing UK carbon dioxide emissions from large business and public sector organisations.

Imposed by UK Government Department for Environment Food and Rural Affairs (DEFRA) and administered by the Environment Agency, the scheme will require organisations to purchase an annual CO_2 emissions allowance each year associated with building energy consumption.

At the end of each year, company performance, mainly based on absolute carbon reductions since the start of the scheme, will be summarised in public league tables outlining the best and worse performers in terms of carbon emissions and reduction. Revenues generated through the sale of allowances will be recycled back to participants, with companies receiving payments back, plus or minus a bonus or penalty dependent on their position in the league table.

The Renewable Energy Strategy shall reduce the financial burden of the CRC on University operations and support high-ranking in public league tables.

3.1.5 Annual Energy Costs & Security of Supply

The future availability of limited fossil fuel resources is affecting all consumers of energy. As fossil fuel resources continue to be depleted, competition for use increases and the cost of delivered energy increases.

As the University estate grows, secure supply of energy via multiple sources at affordable rates is critical for the University to continue to serve it's staff and students in the long-term.

The Renewable Energy Strategy shall support and facilitate cost-effective on-site alternatives to conventional energy supplies utilising a combination of multiple, sustainable fuel sources.

3.1.6 Higher Education Sector Benchmarking

By virtue of the University's position in the UK Higher Education sector, their environmental credentials are subject to ongoing comparison with other institutions via University Associations and funding council initiatives. Of particular relevance to the renewable energy strategy, the Higher Education Environmental Performance Improvement (HEEPI) benchmarking initiative provides a distinct public ranking of a University's energy and environmental performance.

Whilst the University of York perform highly in certain sectors of HE sector benchmarking, emissions reduction and adoption of innovative low and zero carbon technologies are areas of particular focus for the future.

The Renewable Energy Strategy shall support a higher ranking of the University within HE sector benchmarking initiatives.

3.2 University Activities

Throughout the design development process of Heslington East, The University has considered the adoption of renewable energy generation in consideration of the key drivers. The key activities and development milestones are summarised below:

2006	Heslington East Masterplan considers on-site renewable energy
2007	Outline Planning Consent granted for Heslington East
	University commission site-wide energy consultant
	University issue Sustainability Strategy to planning:
	Cluster 1 building design proposals consider building integrated and site-wide renewable energy technologies
	High level, site-wide energy strategy prepared by Consultant:
	City of York adopt Sustainable Design and Construction Interim Planning Policy
2008	University consider long-term cost benefits between 'building integrated' and 'site-wide' approaches to adoption of renewable energy technology
	University commit to of energy & utility interconnection and distribution networks within Heslington East
	Cluster 1 building contracts stipulate requirement for BREEAM 'very good' rating with a target of achieving BREEAM 'excellent'; *and* 10% improvement upon 2006 UK Building Regulations Part L
	Tenders invited for installation of energy & utility interconnection
	TFTV Planning Application submitted in July 2008
	University commit to installing biomass boiler to supply at least 10% renewable energy to Cluster 1 buildings via district heating network
	University submit £3m funding application to HEFCE for redevelopment of Central Energy Centre including Biomass Combined Heat & Power
	Site-wide renewable energy strategy presented to support TFTV planning application
2009	Installation of energy & utility interconnection and distribution networks within Heslington East
	Installation of re-locatable biomass boiler on Heslington East
	University conduct detailed feasibility work for redevelopment of existing Central Energy
	Goodricke College Occupation
	University pursue feasibility of additional 'Centralised' renewable energy technologies
	Biomass Boiler renewable energy generation available to supply 10% of energy requirement
2010	University commence preliminary design for redevelopment of Central Energy Centre
	Target occupation date for TFTV, Law & Management, Computer Science & Hub buildings
	Phased expansion and refurbishment of site-wide district heating and electricity networks
	Phased redevelopment of existing Central Energy Centre to include renewable energy
	Heslington East Biomass boiler relocated to Central Energy Centre
	University adopt additional 'Centralised' renewable energy technologies
2026	Target completion date for Heslington East masterplan

3.3 Technology Considerations

In developing the renewable energy strategy, the University has considered the technical and economic characteristics of a broad range of renewable energy technology options. A summary review of these options is presented in Appendix B of this report, in the context of the evolving Heslington East site and existing Heslington West site.

The University recognise that the strategy must focus on adopting those technologies which are:

1. **Efficient** and **reliable** in the generation of zero carbon energy.
2. **Dependable** with respect to security of supply contribution.
3. **Compatible** with new and existing building design.
4. **Supportive** of and **compatible** with existing, effective energy infrastructure.
5. **Robust** against continuous use.
6. **Flexible** to increasing energy demand and regulatory capacity requirements.
7. **Adaptable** to emerging advances in renewable energy technology.
8. **Cost-effective** on a whole-life basis.

As such, the appropriate technical solution must comprise a combination of proven, viable technologies, utilising multiple fuel sources and capable of modular implementation and expansion.

The University's Renewable Energy Strategy will satisfy the above criteria through the adoption of appropriate, proven, economically viable technology.

3.3.1 Approach to installation of technology

The University recognise the need to adopt the most efficient and cost-effective approach to the installation and operation of any particular technology in terms of location, capacity and connected building energy load. This is critical in order to obtain efficient generation of energy and maximise site-wide utilisation within new and existing buildings.

The two primary options for the installation of renewable energy technologies are:

1. **Building Integrated**
   Small scale devices or systems installed within or mounted upon individual building(s). Generated energy supplied to individual building. Most suited to small developments with multiple building ownership and energy distribution networks not available.

2. **Centralised**
   Medium-large scale devices installed in a central location in conjunction with site-wide distribution network(s). Generated energy supplied to buildings via site-wide distribution networks. Most suited to large-scale, mixed use developments with single ownership of buildings.

Both approaches have their mutual advantages and disadvantages and the effectiveness of each is dependent on the nature of a development within which a technology is to be utilised. With regard to the compatibility of the two approaches, electricity generating technologies are generally compatible, but hot water generating, building-integrated technologies present a counter-productive effect on the utilisation and operation of Combined Heat and Power (CHP)[1] plant. This is because hot water generated locally will displace part of the thermal 'base-load' which CHP plant require in order to utilise all 'waste heat' from the process of generating electricity. The result is that with broad adoption of hot water generating, building integrated technologies, CHP installations can become un-viable.

[1] 'Combined Heat & Power' (CHP) is the simultaneous generation of useable heat and power in a single process. As recognised by the UK Government, widespread adoption of CHP is essential objective to meeting long-term carbon reduction requirements.

The general advantages and disadvantages of the **building integrated** approach are:

Advantages	Disadvantages
✓ Systems can be installed independently on a building-by-building basis with little dependence on external works.	✗ Large spatial requirements for installation and maintenance access = significant impact on building design
✓ Off-the-shelf technologies can readily provide access to renewable energy generation for any development.	✗ Difficult or impossible to retro-fit within existing buildings – a long-term strategy consideration for developments comprising existing and proposed buildings.
	✗ Potentially low operational efficiencies and low energy generation yield.
✓ 'Bolt-on' short-term approach requires little consideration of long-term strategy and future requirements.	✗ For thermal energy generating devices, potential conflict between installed rated capacity required to meet annual 10% generation requirement and the maximum instantaneous demand of the building. Result: surplus energy generated energy can be wasted.
✓ Energy distribution network not required.	✗ Fixed solution: Limited or no opportunity to adapt technology or expand capacity in the future.
✓ Potentially simple operation and maintenance procedures.	✗ Generally small installed capacity and limited operational effectiveness requires additional supplementary equipment to meet total demand.
✓ Can provide a discrete visible statement clearly associated with a building.	✗ High cost and small generation yields = poor whole-life cost-effectiveness and adverse impact on allocating funds to low carbon building design.

The general advantages and disadvantages of the **Centralised** approach are:

Advantages	Disadvantages
✓ Renewable energy can be distributed to and utilised by existing and new buildings.	✗ Capital cost of distribution network(s).
✓ Large number of connected buildings results in greater utilisation of generated energy.	✗ Requires long-term strategic planning.
✓ 'Future proofing' - single/small no. of central generation source(s) can be practically and economically replaced by emerging viable renewable energy technology →energy distributed utilising existing networks.	✗ Design and installation co-ordination requirements for distribution network(s).
	✗ Requires supply contracts for private tenants
✓ Provide access to those highly effective technologies which are only practical and/or economically viable at larger capacities.	✗ Requires operation and maintenance capability for larger-scale plant
✓ Small spatial requirements relative to installed capacity + no constraint on building design.	✗ Requires specialist operational planning to ensure plant configuration is robust to operational failure
✓ Provides resilient energy supply which can satisfy annual building energy demands.	✗ Potential increased complexity of planning approvals.
✓ Cost-effective benefits associated with single point of operation and maintenance.	✗ Potential public misconception of technology, scale and community impact.

3.3.2 Economics

It is vital that a large, complex organisation such as the University consider long-term legislative, sustainability and security of supply projections in order to define an appropriate and sustainable renewable energy strategy.

In the long-term, the generation of low and zero carbon electricity will become the major challenge for the UK. The adoption of Centralised technology such as renewable energy CHP and Energy Recovery from Waste must play a critical part in meeting this challenge. Large, mixed use privately owned and occupied organisations such as the University are ideal candidates for effective adoption of and to benefit from such technologies on a local scale. The recovery of 'waste' heat from these essential electricity generation processes is critical and requires a connected district heating network or heat consuming process. Via a district heating network, 'waste heat' can be effectively utilised to satisfy building heat demands and as technology matures, cooling demands – using heat to drive absorption chillers and generate chilled water i.e. 'tri-generation'.

In responding to the future increases in legislative requirements for carbon emissions reduction and effective contribution to long-term generation of zero carbon electricity, the Building Integrated and Centralised approaches yield converse economic scenarios.

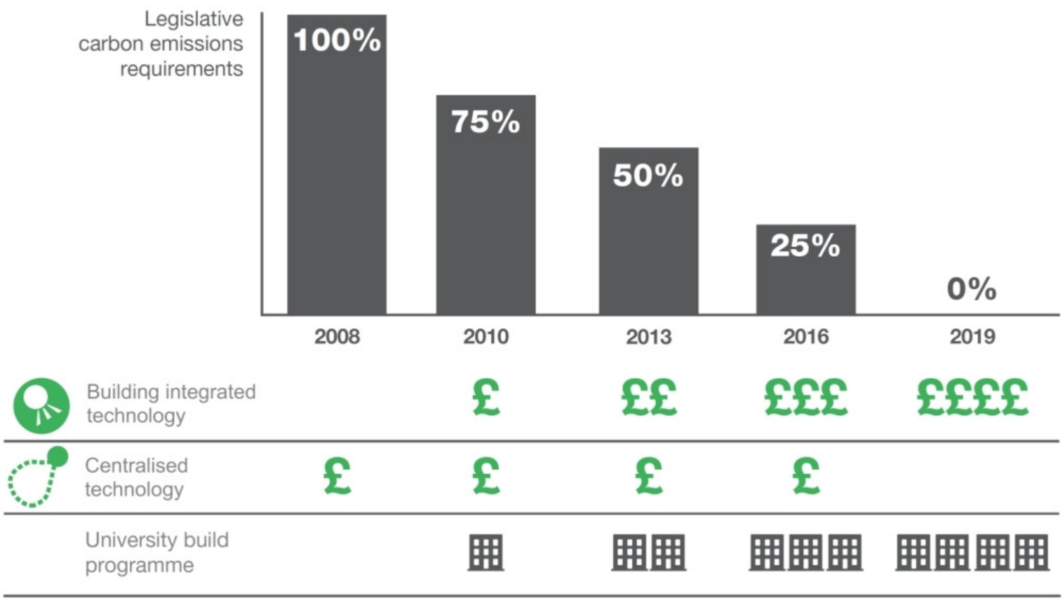


Figure 6 - Long-term economic viability of strategic approach

As demonstrated by the building research sector, current small-scale, Building Integrated or 'micro-generation' technologies are technically and economically less effective in delivering significant carbon emissions reductions on a whole-life basis, in comparison to the types, scale and operational efficiency of larger-scale Centralised technologies. This follows the proven technical and financial economies of scale associated with large-scale energy generation at 'power-station' and 'community energy' scale.

As the legislative requirements reduce the permitted maximum levels for carbon emissions for new and existing buildings, the cost of compliance via building integrated technologies will increase greatly as more complex and costly methods are required to install the required capacity. Due to practical constraints associated with structural and architectural design, secondary system design (e.g. space heating, space cooling systems requiring certain grades of heat) and visual appearance, achieving zero carbon buildings via Building Integrated technologies *alone* is generally assessed to be impractical and cost-prohibitive in comparison to alternative Centralised options. It follows therefore, that whist it is technically possible to achieve current requirements for 10% on-site renewable energy via the building integrated approach, it will become increasingly difficult, impractical and cost-prohibitive to meet increased percentage requirements for on-site renewables via building integrated technologies alone.

Conversely, capital invested upfront in larger-scale Centralised technology and site-wide distribution networks will ensure that legislative carbon emissions requirements and sustainability of energy supply are achieved in the most cost-effective way. Achieving zero carbon buildings via a Centralised approach is technically and economically feasible. This is demonstrated by growing Government commitments to Centralised Combined Heat & Power plant utilising district heating networks and large-scale wind utilising the electricity networks.

3.3.3 Conclusions

Whilst a combination of solar thermal and photovoltaic Building Integrated technologies can potentially, technically satisfy the planning conditions for renewable energy these are not considered the most appropriate solution for Heslington East, Cluster 1 nor the most appropriate approach to satisfying long-term carbon emissions legislation and sustainability for the overall estate.

In comparison to a Centralised approach, Building Integrated technologies offer less efficient systems; have a high impact on building design; have a counter productive effect on the existing CHP plant effective adoption of renewable fuel CHP plant – necessary in the long-term for production of renewable heat and electricity; have a counter-productive effect on development of existing adaptable distribution networks; and are less cost-effective, thus having an adverse effect on long-term carbon reduction provisions.

Considering the conclusions of the strategy development process and the existing district heating and electricity distribution networks within the Estate, the University recognise the short and long-term benefits associated with a Centralised approach to the installation of renewable energy technologies.

Throughout the life of the Estate, the University therefore intend that the renewable energy strategy shall focus on the principle of a 'Centralised' approach to generation of energy from on-site renewable technologies.

The University shall develop existing district heating and electricity distribution networks within Heslington East and Heslington in order to create an interconnected site.

The technically and economically viable technology considered most appropriate for Heslington East, Cluster 1 is a centralised biomass boiler.

The University shall continue to consider building integrated renewable energy technology options on a building by building basis. Those options which are considered technically suitable for the building energy demands AND complimentary to the effectiveness of established Centralised technologies AND cost-effective will be pursued as appropriate.

4 Cluster 1 Strategy

4.1 Summary

In accordance with the principles of the site-wide strategy, the Cluster 1 planning requirements for on-site renewable energy shall be satisfied via a centralised approach and distribution networks.

A new 'Utilities Corridor' shall distribute within Heslington East, Cluster 1 and inter-connect between Heslington East and Heslington West. The Utilities corridor shall contain district heating pipework which will connect to all Cluster 1 buildings.

A new centralised biomass boiler shall be installed within Heslington East. This shall inject hot water into the district heating network to supplement additional hot water fed from the existing 'Central Energy Centre' located within Heslington West.

The capacity of the biomass boiler shall be sufficient to provide at least 10% of the building energy requirements of all Cluster 1 buildings combined.

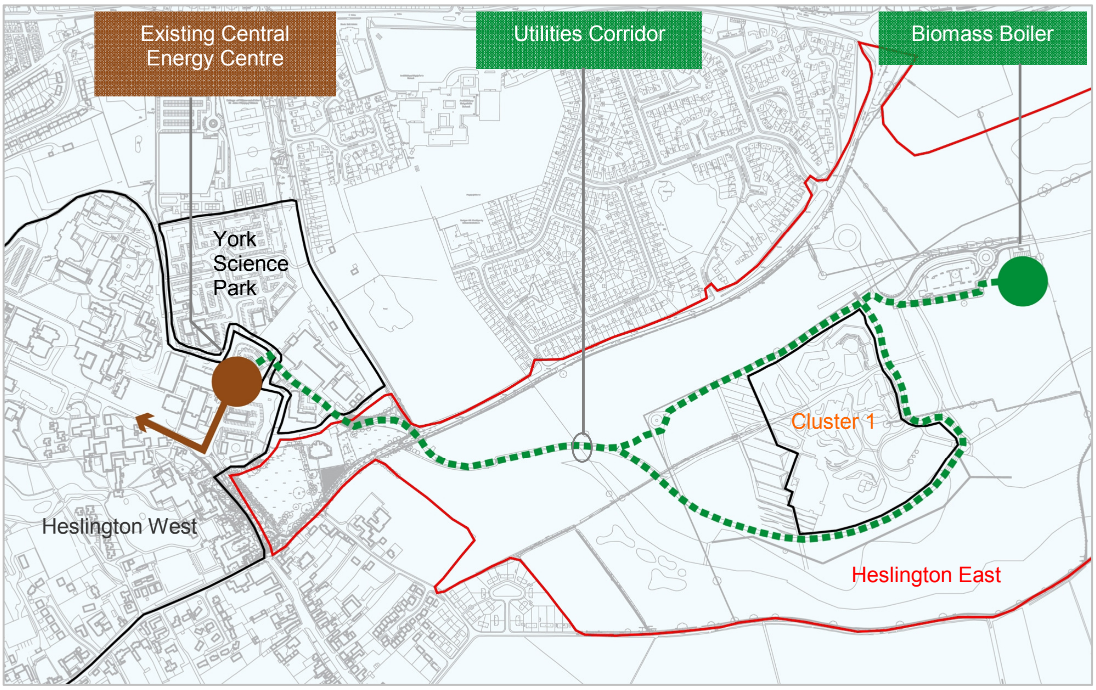
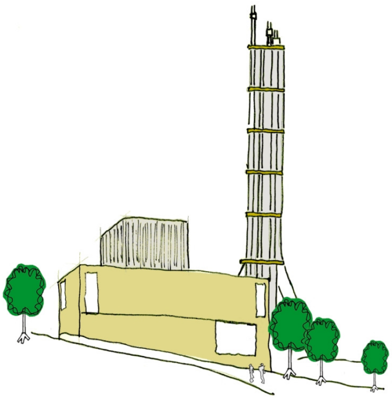


Figure 7 - Cluster 1 Renewable Energy Strategy

4.2 Existing Central Energy Centre

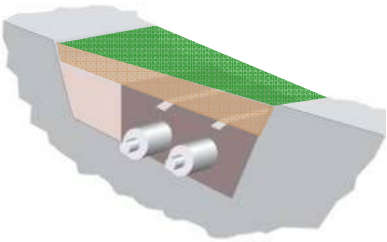


Located within Heslington West, the existing Central Energy Centre (CEC), shall act as the primary supply of heat to Cluster 1 via a district heating connection.

The CEC currently contains the following energy generating plant: gas-fired Combined Heat and Power (CHP) and supplementary gas/oil dual fuel boilers. The CEC currently serves the Heslington West site via district heating and electricity distribution networks. The existing CEC energy generating plant has sufficient spare capacity to meet the maximum instantaneous heat demand and total annual heat consumption associated with Heslington East, Cluster 1 without having an adverse effect on Heslington West supplies.

Over the next 5-10 years, the existing CEC shall be redeveloped to accommodate centralised renewable energy technologies which utilise a mixture of renewable fuels such as biomass and biogas.

4.3 Utilities Corridor



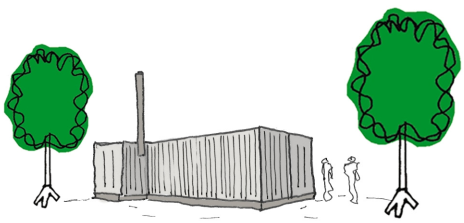
The new Utilities Corridor shall distribute within Heslington East and provide an interconnection between Heslington West and Heslington East buildings and infrastructure.

It shall comprise district heating pipework, electricity cables and communications data networks, concealed below ground.

The utilities corridor shall connect to all Heslington East buildings to provide heating, domestic hot water and electricity.

The Utilities Corridor shall be installed in phases in accordance with the construction of Heslington East. The procurement process for Utilities Corridor is currently underway and the first phase will be installed in 2009 to supply Cluster 1.

4.4 Biomass Boiler



A biomass fuelled boiler will be installed in Heslington East, to the East of the site parking facility.

The boiler will generate hot water using woodchip from local sustainable sources.

Hot water will be injected into the district heating network to support a primary supply from the Heslington West CEC.

4.4.1 Biomass Renewable Energy

Plants and trees or 'biomass' use CO_2 to grow, converting it into carbohydrate via the process of photosynthesis. When they decay or are burned, the CO_2 absorbed during growth is released back into the atmosphere.

For a *mature, unmanaged forest*, the amount of CO_2 absorbed by growing trees is equal to the amount being released into the atmosphere by decaying trees and the animals and microbes that live off the trees as they decay.

For *sustainably managed woodland or energy crops* the process can be similar. Wood is carefully removed at a rate less than or equal to the rate at which it is introduced by new growth. The net result is that the CO_2 released when the wood fuel is burned is no greater than that absorbed during growth.

A biomass boiler utilising sustainably managed woodland or energy crops is therefore recognised as a renewable energy technology - generating energy from a naturally available resource that is constantly replenished.

Unlike most other renewable energy sources biomass can be stored and used on demand to give controllable energy.

4.4.2 Capacity

The capacity of the biomass boiler will be such that the annual generation of thermal energy, shall be at least equal to 10% of the total annual building energy consumption of Cluster 1.

Total annual building energy consumption of Cluster 1 ≈ 9,500,000 kWh/year[2]

10% Renewable Energy Generation Requirement ≈ 950,000 kWh/year.

A biomass boiler in the order of 250kW rated thermal capacity operating will generate atleast 950,000kWh of renewable energy per year.

4.4.3 Design

In time, it is fully intended that the biomass boiler will be removed from Heslington East and relocated within a redeveloped Central Energy Centre within Heslington West. The design of the biomass boiler system is fully compliant with this future intention.

All equipment required to generate and inject the hot water into the district heating network shall be housed within portable, weather proof, steel containers. This will include the boiler, seven-day fuel store and the fuel feed mechanism.

The system will be capable of operating using both woodchip and wood pellet fuel types.

The system shall be designed, commissioned and operated in accordance with the British Standard for solid fuel heating boilers, BSI of EN 303-5. This standard includes requirements such as performance, efficiency, emissions, thermal output, pressure testing, safety measures and testing.

The University are in discussions with a number of specialist providers to obtain the most appropriate supply of this system.

The complete biomass boiler system shall be safely enclosed within a secure compound.

[2] Current energy estimate based on published energy consumption benchmarks and Stage D architectural design details – Refer to Appendix A for details.

4.4.4 Spatial Requirements

The boiler and fuel storage systems require a compound footprint suitable of accommodating three standard storage containers (each 6.5 m x 2.5 m) and additional flexible access space for fuel delivery and maintenance.

At this stage it is anticipated that a footprint of approximately 15 metres x 20 metres will be sufficient, as indicated below.

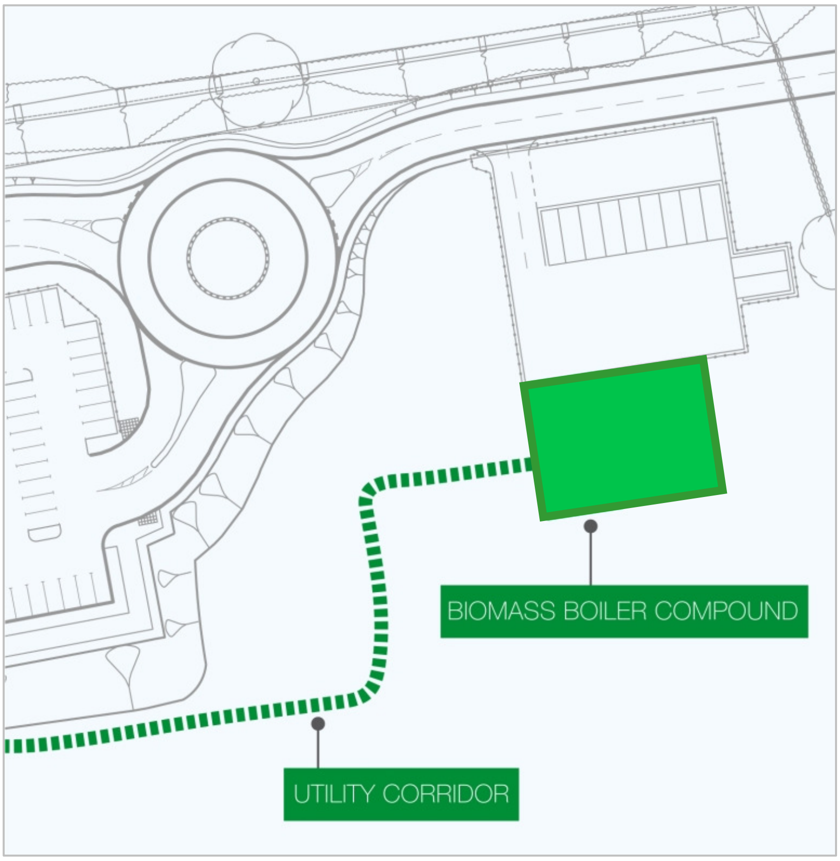


Figure 8 - Indicative spatial requirements for Biomass Boiler Compound

4.4.5 Visual Appearance

The containerised design of the biomass boiler results in a neat, compact installation. An example installation of a boiler in the order of 250kW is shown below.

Figure 9 - Example installation of containerised biomass boiler (C/O Econergy)

The biomass boiler installation will be significantly smaller in scale than the existing Central Energy Centre. The figure below provides a sense of scale.

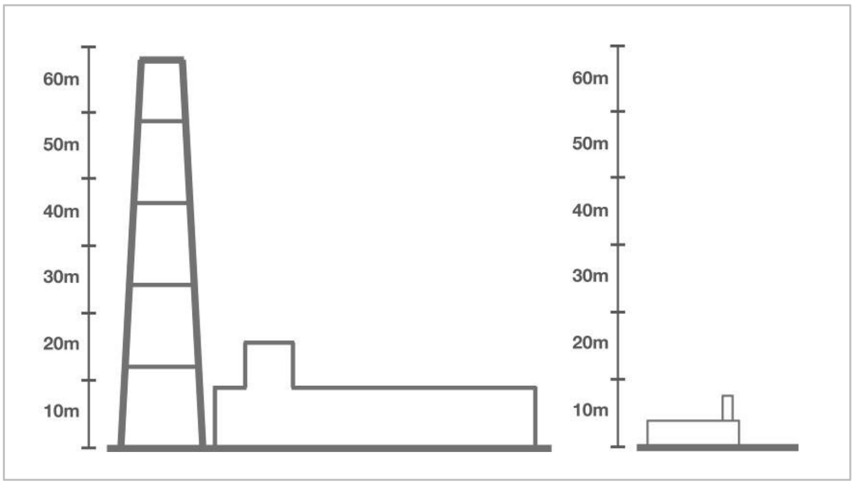


Figure 10 - Indicative scale of biomass boiler

4.4.6 Emissions

The system shall be designed, commissioned and operated in accordance with all relevant UK environmental legislation local planning policy and British Standards for solid fuel heating boilers. This includes the Clean Air act and Pollution Prevention & Control Regulations.

As demonstrated by a large number of successful planning approvals and proven installations within the UK and Europe, a biomass boiler of this scale with appropriate selection and operation will not present a hazard in terms of atmospheric emissions.

The UK Building Regulations and UK Government Department for Environment Food & Rural Affairs (Defra) state that the CO_2 emissions associated with generating energy from biomass is assumed equal to 0.025kgCO_2/kWh.year. The University are fully committed to ensuring the in-use CO_2 emissions of the biomass boiler meet or exceed this approved assumption through the use of sustainable biomass fuel supplies, appropriate selection of boiler system capacity and specification and effective operation and maintenance of the system.

Whilst within the requirements of environmental legislation, it is recognised that the operation of a biomass boiler will generate slightly higher Nitrous Oxide (NOx) levels than a conventional gas-fired boiler. However this outcome will be limited on Heslington East as far as possible via careful system design of boiler and flue to maximise cleanliness of emissions and minimise 'part-load' operation i.e. operation of the boiler below it's rated capacity.

As a result, for an installation of this capacity in the proposed location with the correct design and operational provisions, this relatively small increase in NOx levels is widely considered to be a manageable and acceptable characteristic in comparison to the overall broader environmental benefits.

The University shall liaise with the City of York Environmental planning officer to communicate and refine the design of the biomass boiler system to meet and where possible exceed all local emissions requirements.

4.4.7 Fuel Supply

Whilst the system is flexible to use both wood chip and wood pellets, it is intended that in use the biomass boiler will utilise sustainable woodchips sourced from the local area.

In accordance with an installed capacity in the order of 250kW and the required annual generation of energy, the boiler will consume approximately 60 cubic metres of woodchip per week. This volume of fuel consumption will require one to two fuel deliveries per week via a 12 – 15 tonne truck.

The woodchip shall be obtained from the following sources:

- ✓ Forestry management arisings
- ✓ Energy crops e.g. Short rotation coppice and grasses
- ✓ Non-hazardous post consumer waste originally produced from sustainable wood source.

The University will make every effort to ensure the fuel type conforms with the appropriate standards being drafted by the various European Technical Committees and Working Groups (Referred to as CEN/TC 335) and the future adoptions by the UK Government.

Sustainably sourced biomass fuels processed within 25 miles of the point of use are currently regarded as 'carbon neutral'. The University are therefore engaging with local suppliers and forestry partnerships within the Yorkshire and Humber region to establish a robust and sustainable fuel supply within a 25 mile radius.

To assist, the University have engaged with the 'Yorwoods' organisation, based in Ripon. Supported by Yorkshire Forward, Yorwoods is a partnership-based organisation that works with all parts of the forest industry to improve the sectors contribution towards sustainable rural development in the Yorkshire & the Humber Region. Whilst Yorwoods do not supply fuel directly, they do offer a co-ordination role, linking customers to the most appropriate fuel suppliers. Yorwoods believe that sourcing woodchip produced from locally grown sources would be 'reasonably straightforward' for the University.

To date, the University have engaged directly with the following potential suppliers:

1. **Renewable Fuels Ltd**

   Based at Escrick, within a 5 mile radius of the University.

2. **Manco Energy Ltd**

   Based at North Newbald, approximately 20 miles from the University.

3. **Renewable Fuel Growers**

   Based at Market Weighton, approximately 20 miles from the University.

Each of the above suppliers has stated that they alone could readily supply the University's woodchip fuel requirements to satisfy the peak and annual operation of the proposed biomass boiler system for Cluster 1. Indeed, regardless of future development of their supply infrastructure, each of the suppliers has stated that they could readily supply woodchip volumes which are significantly in excess of those required for Cluster 1. Whilst there will be inevitable competition for supply in this market, this provides a degree of confidence for satisfying future increased volumes of woodchip as the University consider increasing biomass plant capacities on site.

The University are continuing to seek additional suppliers to those above and progress discussions with all in order to secure an appropriate, sustainable supply for the needs of the Cluster 1 system. The University will also discuss the options for potentially securing longer-term supply agreements.

In the long-term, the University intend to explore opportunities for utilising existing off-campus land-holdings for the production of sustainable energy crops – most likely in partnership with locally based agricultural expertise. Crops to be considered include willow and poplar 'Short Rotation Coppice' (SRC) and 'Miscanthus' (Elephant Grass). Whilst SRC require between 3-5 years before first productive harvest, Miscanthus crops can be harvested on a two-year cycle from planting.

4.4.8 National Initiatives & Incentives

An extensive range of national UK Government initiatives and incentives exist which support the adoption of biomass as a source of sustainable renewable energy. The key statements from those considered most prominent are:

4. **UK Government White Paper on Energy, 2007**

   The Government Biomass Strategy aims to "expand the supply and use of energy from this renewable fuel source in a sustainable way."

5. **UK Government Biomass Taskforce 2005**

   "the potential of biomass is significant… Biomass is unique as the only widespread source of high-grade renewable heat …"

6. **UK Government Strategy for non-food crops and uses, Defra 2004/2007.**

   "We need to continue today to take action to optimise the environmental, economic and social benefits we can obtain from the increased, but sustainable, use of biomass for energy…"

7. **A Woodfuel Strategy for England, Forestry Commission 2007**

   Provides a framework which supports UK Government objective to build a viable and sustainable biomass industry

   Environmental Target: "Greatly increased generation of renewable energy with biomass and photovoltaics providing mainstay of this."

With regard to central funding, UK Government capital grants are already playing a key part in the development of biomass, including wood fuel. Grant support for UK land managers has been available in the form of the Natural England Energy Crop Scheme for specific energy crops and wider woodland creation through the England Woodland Grant Scheme. The Forestry Commission-managed Harvesting, Marketing and Processing Pilot Grant and the Defra Biomass Infrastructure Support Grant both support capital investment in the supply chain.

4.4.9 Regional Initiatives & Incentives

The Yorkshire and Humber region is fortunate in that it has a number of established organisations that have considerable experience of biomass in the UK.

A variety of key initiatives and incentives exist within the region, which provide a solid foundation for the growth of energy generation using biomass and development of sustainable fuel supply infrastructure. These are endorsed, promoted and supported by a combination of UK Government departments, Local Authorities, the Regional Development Agency (Yorkshire Forward) and operational subsidiary organisations. They incentivise and support developments across the region to provide a solid foundation for the sustainable growth in biomass sourced energy generation.

The key points to note are:

1. **Yorkshire and Humber Vision for Biomass, 2008**

   Key Objective: "Enable biomass to make a contribution to the region's target to reduce GHG emissions by 20-25% by 2016"

   Key Objective: "Facilitate and support initiatives to encourage the use of biomass-based local heat and power supply"

2. **The Regional Economic Strategy & Climate Change Action Plan**

   Target increased role for biomass as an important resource for reducing emissions and achieving regional energy and climate change targets

3. **The Yorkshire and Humber Regional Spatial Strategy to 2026**

   Environmental Target: "Greatly increased generation of renewable energy with biomass and photovoltaics providing mainstay of this."

   Forestry, tree and woodlands policy plans, strategies and investment decisions should "Increase planting for biomass and encourage the management of woodland for wood fuel".

4. **Yorkshire and Humber Regional Energy Infrastructure Strategy for 2020**

   "*To meet the region's 2020 Vision for Energy supply an objective is set to establish an extensive regional bioenergy infrastructure that includes the widespread production and use of biomass and biofuels*."

5. **Regional Forestry Strategy for Yorkshire and The Humber Region, 2005.**

   "Priority for action: 'increase the use of wood in sustainable construction and as a source of renewable energy'"

6. **Yorwoods**

   A partnership based organisation supported by Yorkshire Forward that works with all parts of the forest industry to improve the sectors contribution towards sustainable rural development in the Yorkshire & the Humber Region.

7. **Future Energy Yorkshire (FEY)**

   FEY (part of 'SFCo' - 'a wholly owned subsidiary of Yorkshire Forward) has been established to secure the economic opportunities arising from new and renewable energy technologies across the Yorkshire and Humber region.

   With funding from Yorkshire Forward, FEY are in the process of developing a wood fuel infrastructure programme for the purpose of developing a robust wood fuel supply chain within the region.

5 Site-wide Strategy

5.1 Summary

The renewable energy strategy for Cluster 1 forms part of a broader site-wide renewable energy strategy. In turn the site-wide strategy contributes to an over-arching ‘Sustainable Energy & Utility Strategy’ being developed by the University.

As demonstrated in the Cluster 1 strategy, the University have committed to supplying electricity and hot water to Heslington East via extensions to the existing district heating and electricity networks.

It is proposed that the CEC be the central ‘heat’ source for the complete site and a primary source of electricity generated via Combined Heat & Power (CHP) systems. A phased redevelopment programme for the CEC is proposed to incorporate high efficiency, low and zero carbon centralised technologies for the generation of heat and electricity.

The district heating and electricity distribution networks within Heslington West and East shall be extended to maintain security of supply and facilitate the site-wide distribution of low and zero carbon energy to all buildings.

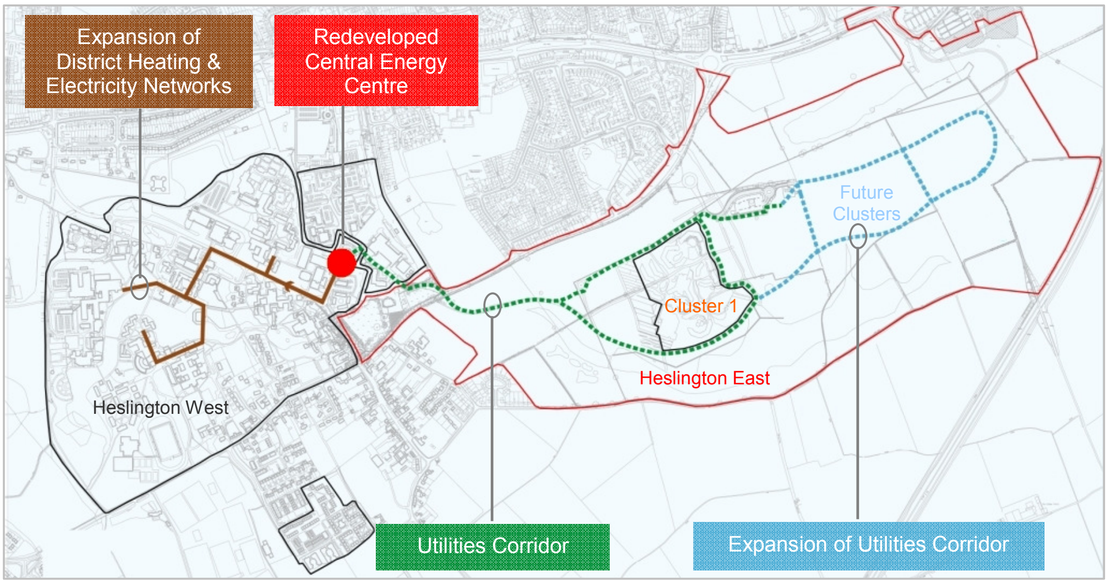
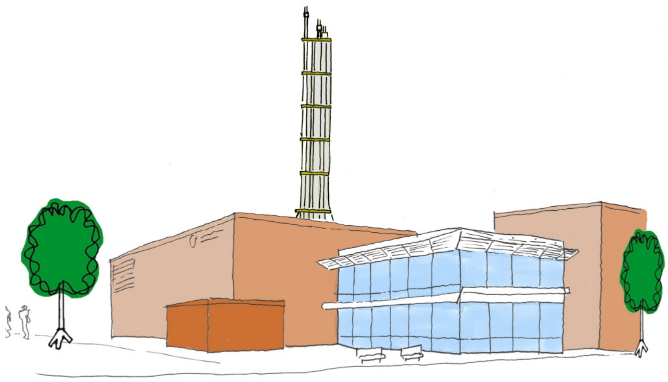


Figure 11 - Site-wide Renewable Energy Strategy

5.2 Redevelopment of the Central Energy Centre

The Central Energy Centre (CEC) provides an efficient, flexible and adaptable central source of energy generation for the University.



Over the next 5-10 years, the type and capacity of new energy generation technology within the CEC shall be determined in consideration of technical, economic and environmental feasibility; business continuity and security of supply; planning, regulation and legislative requirements.

In the long-term the University will commit to the replacement of resilient low carbon technologies, such as condensing gas-fired boilers, gas CHP and thermal storage, and installation of new renewable energy technologies.

In the first instance, the biomass boiler installed on Heslington East shall be re-located to the CEC. Additional technologies under consideration during development of the CEC are biomass CHP and bio-gas CHP via on-site anaerobic digestion of waste. Furthermore, the University intend to investigate the opportunities for configuring the CEC to enable multiple gaseous fuel types to be utilised by common CHP engines.

5.2.1 Higher Education Funding

The University have applied for a transformational fund currently available from a consortium of Salix Finance Ltd and the Higher Education Funding Council for England (hefce). The funding support is requested in order to fast-track the adoption of Biomass CHP within redevelopment of the CEC.

Biomass CHP offers significant carbon reduction savings for the University via the generation of heat and electricity. Under normal circumstances, the University intend to pursue the adoption of Biomass CHP technology in the medium to long-term as opposed to the short-term. This is due to the current relatively high capital cost of Biomass CHP and the risks associated with adopting an emerging, immature technology within the UK.

However, with the support of the hefce transformational fund and the potential for an element of risk sharing, the University are presented with an exciting opportunity to go one-step further in terms of innovative biomass technology and 'fast-track' the adoption of Biomass CHP.

If the funding application is unsuccessful, the University will continue with the Cluster 1 strategy as described in this report. The University shall continue to pursue the Biomass CHP but with a slightly longer timescale.

5.3 Expansion of Utilities Corridor

The distribution networks are key to the short and long-term distribution of low and zero carbon energy across the site.

Over the development life of Heslington East, the utilities corridor shall be developed such that district heating, electricity and communications networks are extended to serve all buildings constructed within the Masterplan.

Existing distribution networks within Heslington West shall be refurbished and extended to serve an increasing number of Heslington West buildings.

The expansion of the new and existing distribution networks shall enable low and zero carbon heat and electricity to be distributed to all buildings via Centralised generation.

6 Summary

- The University are strongly committed to the delivery of on-site renewable energy technology to deliver long-tem carbon savings for the campus and satisfy the City of York Council's adopted IPS on sustainable construction and building specific planning conditions.
- During the design development of Heslington East, the University have considered the technical and economic feasibility of a range of renewable energy technologies, both from a building integrated and centralised perspective.
- The University have commissioned Arup Utilities & Energy Consulting to develop a holistic '*Sustainable Energy & Utility Strategy*' for the Heslington East and Heslington West sites to target long-term energy consumption and CO_2 emissions reduction through the appropriate design, technology and operational approaches.
- Within this over-arching energy & utility strategy, the principles of a site-wide *'University of York Renewable Energy Strategy '* have been defined.
- Whilst a small number of 'Building Integrated' technologies can technically satisfy the planning conditions for renewable energy, these are not considered the most appropriate solution for Heslington East, Cluster 1 and indeed the broader site.
- In comparison to a 'Centralised' approach, 'Building Integrated' technologies offer less efficient systems; have a high impact on building design; have a counter productive effect on the effective adoption of renewable fuel Combined Heat & Power plant; have a counter-productive effect on the development of existing adaptable distribution networks; and are less cost-effective, thus having an adverse effect on the long-term provision of site-wide CO_2 emissions reductions.
- To achieve the effective reduction of carbon emissions long term, a Centralised approach is considered the appropriate solution.
- As part of the first phase of this 'Centralised' approach, the University propose to provide 10% of the Cluster 1 building energy consumption via a renewable energy biomass boiler and district heating network located on Heslington East.
- District heating and electricity distribution networks will be installed within the Heslington East Utilities Corridor to distribute low and zero carbon heat to Cluster 1 buildings and to provide an interconnection between Heslington East and Heslington West.
- Over the next 5 – 10 years the University are committed to redeveloping the existing Central Energy Centre on Heslington West and extending the heating and electricity site-wide distribution networks. It is intended that during this phased redevelopment, the Heslington East biomass boiler shall be relocated within the Central Energy Centre. If hefce funding is secured, the timescale for development will be accelerated.
- The Central Energy Centre will provide the ability for the University to adapt their approach to renewable energy generation technology at a cost-effective and efficient scale as technology markets develop without the need for building refurbishments.
- The district heating and electricity networks will serves to distribute low and zero carbon to existing and new buildings irrespective of the energy generating technology and fuel source. Therefore all connected buildings are provided with access to multiple renewable fuel options in the short and long-term.

Appendix A

Building Energy Assessment

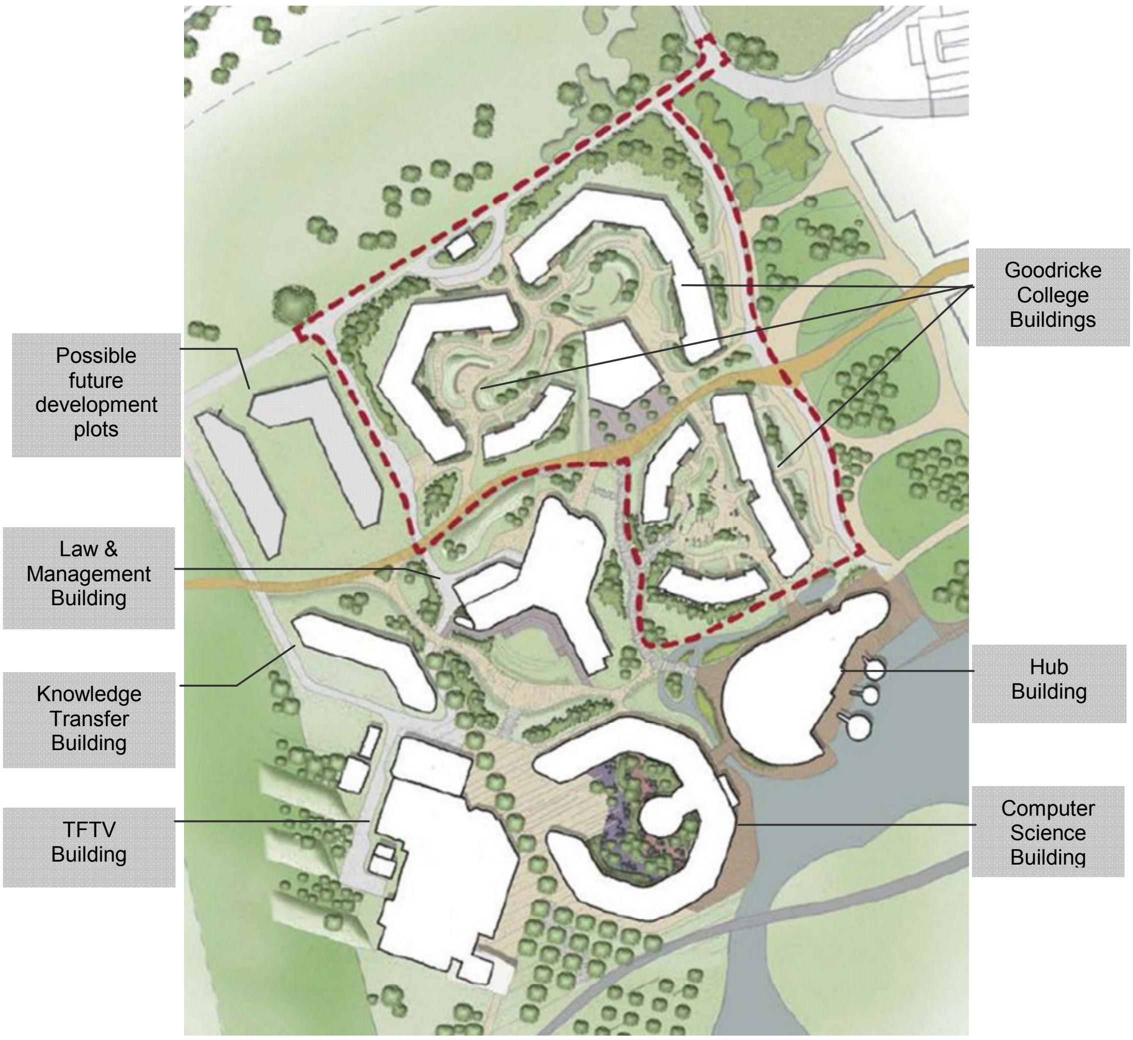
A1 Building Energy Assessment

A building energy assessment is presented for the purpose of supporting the Renewable Energy Strategy for Heslington East Cluster 1.

The assessment provides the current estimate of total annual building energy consumption for Cluster 1. It is based on architectural Stage D building area schedules and published energy consumption benchmarks.

The building energy assessment is subject to refinement at each stage of the design process. For the final design calculations, the annual energy as calculated for Building Regulation Part L compliance will be used to calculate the 10% renewable generation required and an estimate for energy from small power will be required.

A1.1 Cluster 1 Masterplan



A1.2 Building Area Schedule

Building	Gross building floor area m^2	Treatable floor area factor*	Occupied building floor area m^2
Goodricke College Buildings	14,348	0.9	12,913
Hub Building	5,057		4,551
TFTV Building	6,105		5,495
Law & Management Building	6,145		5,531
Computer Science Building	6,622		5,960
Knowledge Transfer Building	3,000		2,700
TOTAL	**41,277**		**37,150**

*Note: The treatable floor area factor accounts for untreated circulation space and un-occupied floor area associated with building construction and building services zones.

A1.3 Energy Consumption Assumptions

The following energy consumption benchmark data has been considered to estimate the annual energy requirements of the buildings:

- Econ 54 “Energy efficiency in further and higher education – cost-effective low energy buildings” 1997

The data set which forms the basis of the energy consumption benchmarks are taken from real energy data from universities collected in the 1990’s. The data includes for the following:

- Lighting
- Heating (space heating and domestic hot water)
- Cooling
- Auxiliary Energy (Pumps, fans etc)
- Small Power

At the time of writing, detailed building energy consumption calculations have not been completed for Cluster 1 buildings using the Building Regulation Part L calculation methodology. In the absence of these calculations, Econ 54 benchmark data has been used.

As Econ 54 data significantly dated, it is anticipated that the resulting energy consumption estimate will be larger than that obtained via the current Part L calculation methodology.

However, by using Econ 54 assumption benchmarks the risk of underestimating the required energy generation output of renewable technology is minimised.

Whilst energy usage from small power, is not currently included within Part L calculation methodology, electricity required for small power has been included in this assessment.

A1.4 Building Energy Summary

Building	Annual Electricity Consumption kWh/year	Annual Fossil Fuel Consumption kWh/year	Total Annual Energy Consumption kWh/year	10% Renewable Energy Requirement kWh/year
Goodricke College Buildings	1,097,622	3,099,168	4,196,790	419,679
Hub Building	163,385	879,221	1,042,606	104,261
TFTV Building	221,343	1,126,740	1,348,083	134,808
Law & Management Building	121,671	835,106	956,777	95,678
Computer Science Building	262,231	899,930	1,162,161	116,216
Knowledge Transfer Building	283,500	405,000	688,500	68,850
TOTAL	**2,149,752**	**7,245,165**	**9,394,917**	**939,492**

Appendix B

Summary Review of Renewable Technology Options

B1 Summary Review of Renewable Technology Options

The University has considered the adoption of Renewable Energy Technologies (RETs) throughout the design development of Heslington East.

Building integrated and centralised RETs have been reviewed on behalf of the University within the following specific commissions:

1. Arup Building Engineering: Concept and scheme design of Heslington East, Cluster 1 buildings.
2. Arup Utilities & Energy Consulting: Development of 'Sustainable Energy & Utilities Strategy' for the University of York.

Through these commissions the University have defined the principles of the site-wide and Cluster 1 renewable energy strategy; selected the most appropriate and cost-effective RETs for adoption in the short-term to serve Cluster 1; and developed an understanding of those RETs which shall be considered for adoption in the future.

The following summary is draws on the work contained within publications and development work produced within the above commissions.

The summary demonstrates the University's consideration of 'Building Integrated' and 'Centralised' technology options and presents the high-level technical reasoning for selection and de-selection of each RET in the short term (within 5 years) and long-term (5 + years).

The short-term selections are directly associated with the Heslington East Cluster 1 development.

The long-term selections are associated with future phases of Heslington East and refurbishment, redevelopment within Heslington West.

The review is presented in terms of 'Hot Water', 'Chilled Water' and 'Electricity' generation technologies.

The summary review should be read in conjunction with Section 3.2 "Technology Considerations" within this report.

B1.1 Hot Water Generating RETs

Hot Water Generating Technology		Appropriate Centralised RET for UofY?			Appropriate Building Integrated RET for UofY?		
		Discussion	Short-term - within 5 years	Longer-term 5 years +	Discussion	New Build	Building Refurbishment
1	Biomass Boilers	Reliable, proven technology available in broad capacity range. Sustainable local fuel sources available in region. Supports development of adaptable district heating network and Central Energy Centre. Facilitates a long-term, sustainability of utilising Biomass for onsite production of heat and electricity. Required supplementary heat generation sources can be located alongside in Central Energy Centre. Economically viable technology with short payback.	✓	✓	Heat generation plant at building integrated scale is operationally less efficient and less cost effective than centralised approach. Biomass boilers require generally require supplementary gas-fired boilers in building to provide load following and guarantee supply. Large spatial requirements within and adjacent to each building for fuel delivery & storage – adverse effect on primary building design objectives. Multiple small, fuel deliveries to individual buildings is impractical. Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant – a pre-requisite for on-site generation of low and zero electricity and long-term carbon emissions reduction.	✗	✗
2	Bio-fuel Boilers	Limited existing supply of sustainable fuel sources e.g. filtered Waste Vegetable Oil Existing operational problems with boiler burners. Possibility of regulated sustainable fuel sources available in future. Possibly cost-effective in future	✗	?	Building Integrated scale devices not commercially available.	✗	✗
3	Biomass CHP	Emerging technology in UK associated with high operational risk Sustainable local fuel source required. Short-term adoption may be possible with grant funding and sharing of technology risk High capital cost, but economically viable in long-term.	?	✓	Building Integrated scale devices not commercially available.	✗	✗
4	Bio-fuel CHP	Slowly emerging operational warranties on modified conventional CHP engines but requires high quality fuel input. Fuel supply issues as stated for Bio-fuel boilers	✗	?	Building Integrated scale devices not commercially available.	✗	✗

5	Energy Recovery from Waste: Anaerobic Digestion + Bio-gas CHP	Reliable, proven Bio-gas CHP technology available Supply of bio-gas from 3rd party not commercially feasible at present. On-site Anaerobic Digestion requires long-term feasibility assessment and planning approval process. Requires large scale application and possible site partnership to be economically viable.	✗	?	Building Integrated scale devices not commercially available.	✗	✗
6	Energy Recovery from Waste: Incineration + CHP	Requires on-site use for generated pass-out steam – odes not currently exist at University. Requires specialist management of generated steam. Requires large scale application to be technically and economically viable Requires long-term feasibility assessment and planning.	✗	?	Building Integrated scale devices not commercially available.	✗	✗
7	Solar Thermal	Technically feasible concept in theory. Generation efficiency reduced with ground level installation. Possible adverse visual impact Requires distribution network Distribution losses incurred of already low grade heat Injecting low grade generated heat (@≈65°C) into district heating flow water @ ≈90°C will have adverse effect of reducing flow temperature. Injecting into ≈60°C district heating return water will increase temperature thus reducing Centralised CHP heat recovery efficiency. May require dedicated distribution network Inefficient utilisation of developable land. Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant – a pre-requisite for on-site generation of low and zero electricity and long-term carbon emissions reduction. Possible future consideration dependent on compatibility with any employed high gain Centralised technologies. Marginal economic viability	✗	?	Technically feasible concept in theory. Approximately 7500m^2 of gross roof area required based on current energy assessment 10% annual provision from installed capacity will be greater than anticipated annual DHW consumption = mismatch between available roof area and individual building domestic hot water demand. Significant impact on building design in terms of aesthetics, installation and maintenance access space. Maintenance access complexity Supplementary plant would require premium high cost building space Requires supplementary gas-fired boilers or district heating supply to meet maximum demand, provide load following and guarantee supply. Economically viable, but counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant – a pre-requisite for on-site generation of low and zero electricity and long-term carbon emissions reduction. Possible future consideration dependent on compatibility with any employed high gain Centralised technologies.	✗	?

8	Ground Source Heat Pump: Closed Loop Heating Mode	Requires electrical input therefore not truly renewable. Heat generated @ 50-55°C means that a GSHP cannot be used in conjunction with a conventional wet radiator system and where used with air-heating systems requires increased air flow rates thus increased fan power → system limited to under-floor heating. Heat generated @ 50-55°C means that the heat pump cannot provide domestic hot water to the required temperature of 60°C to minimise the risk of legionnella. Requires distribution network Distribution losses incurred of already low grade heat Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant. Marginal economic viability	✘	✘	Requires electrical input therefore not truly renewable. In principle, suitable for consideration with New Build Cluster 1 buildings do not utilise piled foundations, therefore energy piles not possible Cannot satisfy total building demands in heating mode, therefore space and cost associated with necessary supplementary conventional systems remains Supplementary plant would require premium high cost building space Heat generated @ 50-55°C means that a GSHP cannot be used in conjunction with a conventional wet radiator system and where used with air-heating systems requires increased air flow rates thus increased fan power → system limited to under-floor heating. Heat generated @ 50-55°C means that the heat pump cannot provide domestic hot water to the required temperature of 60°C to minimise the risk of legionnella. Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant. Possible future suitability with maturing technology performance and renewable electricity supply e.g. large scale wind. Marginal economic viability	✘	?
9	Fuel Cell Technology + Methane Gas Reformer	Currently unproven, maturing technology Not currently economically viable	✘	?	Currently unproven, maturing technology Not currently economically viable Possible future adoption in the form of medium scale micro-fuel cell CHP within remote single building to serve multiple buildings via site-wide distribution networks.	✘	?

B1.2 Chillled Water Generating RETs

Chilled Water Generating Technology		Appropriate Centralised RET for UofY?			Appropriate Building Integrated RET for UofY?		
		Discussion	Short-term - Within 5 years	Longer-term 5 years +	Discussion	New Build	Building Refurbishment
1	Ground Source Heat Pump: Open Loop	Requires electrical input therefore not truly renewable. Large-scale, multiple extraction of ground water at central location may have adverse geotechnical effects Technology not suited to large-scale centralised approach Abstraction and rejection boreholes required – suitability subject to intrusive site investigation Abstraction licenses required Potential ground stability and system operation problems associated with silt extraction	✗	✗	Requires electrical input therefore not truly renewable. Sustainable borehole water supply required Abstraction and rejection boreholes required – suitability subject to intrusive site investigation Potential ground stability and system operation problems associated with silt extraction Cannot satisfy total building demands in cooling mode, therefore space and cost associated with necessary supplementary conventional systems remains Supplementary plant would require premium high cost building space Generated chilled water temperatures limits cooling system choice to most chilled beams and chilled ceilings considered most suitable Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant. Heat pump generates heat in operation which adds to building heat gains. Possible future suitability with maturing technology performance and renewable electricity supply e.g. large scale wind. Removes opportunity to adopt High efficiency central chiller plant with 'free cooling' facility Marginal economic viability	✗	?

2	Ground Source Heat Pump: Closed Loop	Requires electrical input therefore not truly renewable. Technology not suited to large-scale centralised approach possible problems with silt extraction	✘	✘	Requires electrical input therefore not truly renewable In principle, suitable for consideration with New Build Cluster 1 buildings do not utilise piled foundations, therefore energy piles not possible Cannot satisfy total building demands in cooling mode, therefore space and cost associated with necessary supplementary conventional systems remains Supplementary plant would require premium high cost building space Generated chilled water temperatures limits cooling system choice to most chilled beams and chilled ceilings considered most suitable Counter-productive effect on development and efficient operation of centralised low and zero carbon Combined Heat & Power plant. Heat pump generates heat in operation which adds to building heat gains. Possible future suitability with maturing technology performance and renewable electricity supply e.g. large scale wind. Removes opportunity to adopt High efficiency central chiller plant with 'free cooling' facility Marginal economic viability	✘	?
3	Lake water Source Heat Pump: Cooling Mode	Discussion open and closed loop heat pumps above. Rejected heat increases lake water temperature therefore inducing fungal growth and ecological imbalance Requires additional distribution pipework between buildings and lake.	✘	✘	Discussion open and closed loop heat pumps above. Rejected heat increases lake water temperature therefore inducing fungal growth and ecological imbalance Requires additional distribution pipework between buildings and lake. Possible future consideration depending on established knowledge of lake operation	✘	?

B1.3 Electricity Generating RETs

	Electricity Generating Technology	Appropriate Centralised RET for UofY?			Appropriate Building Integrated RET for UofY?		
		Discussion	Short-term - Within 5 years	Longer-term 5 years +	Discussion	New Build	Building Refurbishment
1	Wind Turbine	Large scale wind technically and economically viable for Heslington East. Complex and lengthy planning approval process Intermittent generator – wind dependent	✓	✓	Robust building research operational studies demonstrate that small scale wind is not an efficient, effective or economically viable solution.	✗	✗
2	Biomass CHP	Emerging technology in UK associated with high operational risk Sustainable local fuel source required. Short-term adoption may be possible with grant funding and sharing of technology risk High capital cost, but economically viable in long-term.	?	✓	Building Integrated scale devices not commercially available.	✗	✗
4	Bio-fuel CHP	Slowly emerging operational warranties on modified conventional CHP engines but requires high quality fuel input. Fuel supply issues as stated for Bio-fuel boilers	✗	?	Building Integrated scale devices not commercially available.	✗	✗
5	Energy Recovery from Waste: Anaerobic Digestion + Biogas CHP	Reliable, proven Bio-gas CHP technology available Supply of bio-gas from 3rd party not commercially feasible at present. On-site Anaerobic Digestion requires long-term feasibility assessment and planning approval process. Requires large scale application and possible site partnership to be economically viable.	✗	?	Building Integrated scale devices not commercially available.	✗	✗

6	Energy Recovery from Waste: Incineration + CHP	Requires on-site use for generated pass-out steam – odes not currently exist at University. Requires specialist management of generated steam. Requires large scale application to be technically and economically viable Requires long-term feasibility assessment and planning.	✗	?	Building Integrated scale devices not commercially available.	✗	✗
7	Photovoltaic Panels	Theoretically technically feasible concept. Possible adverse visual impact Generation efficiency reduced with ground level installation. Requires additional distribution network Intermittent generator – solar irradiation dependent Central CHP or large scale wind more technically and economically viable.	✗	✗	Technically feasible concept for new build and building refurbishment Cannot satisfy 10% with assumed roof area for Cluster 1 In theory could satisfy 10% if used in conjunction with Solar Thermal, but available roof area prohibits Intermittent generator – solar irradiation dependent Central CHP or large scale wind more technically and economically viable. Possible future consideration as technology matures and costs reduce	?	?
8	Fuel Cell Technology + Wind Turbine	Currently unproven, maturing technology Not currently economically viable Potential future suitability if large scale wind adopted	✗	?	Currently unproven, maturing technology Possible future adoption in the form of micro-fuel cell CHP within remote buildings.	✗	?

Appendix C

Indicative Biomass Boiler Design Details

C1 Indicative Biomass Boiler Design Details

Figure 12 - Example installation - C/O Econergy

Figure 13 - Example installation - C/O Econergy

Figure 14 - Internal view of biomass boiler installation - C/O Econergy

Figure 15 - Internal view of woodchip fuel storage container - C/O Econergy

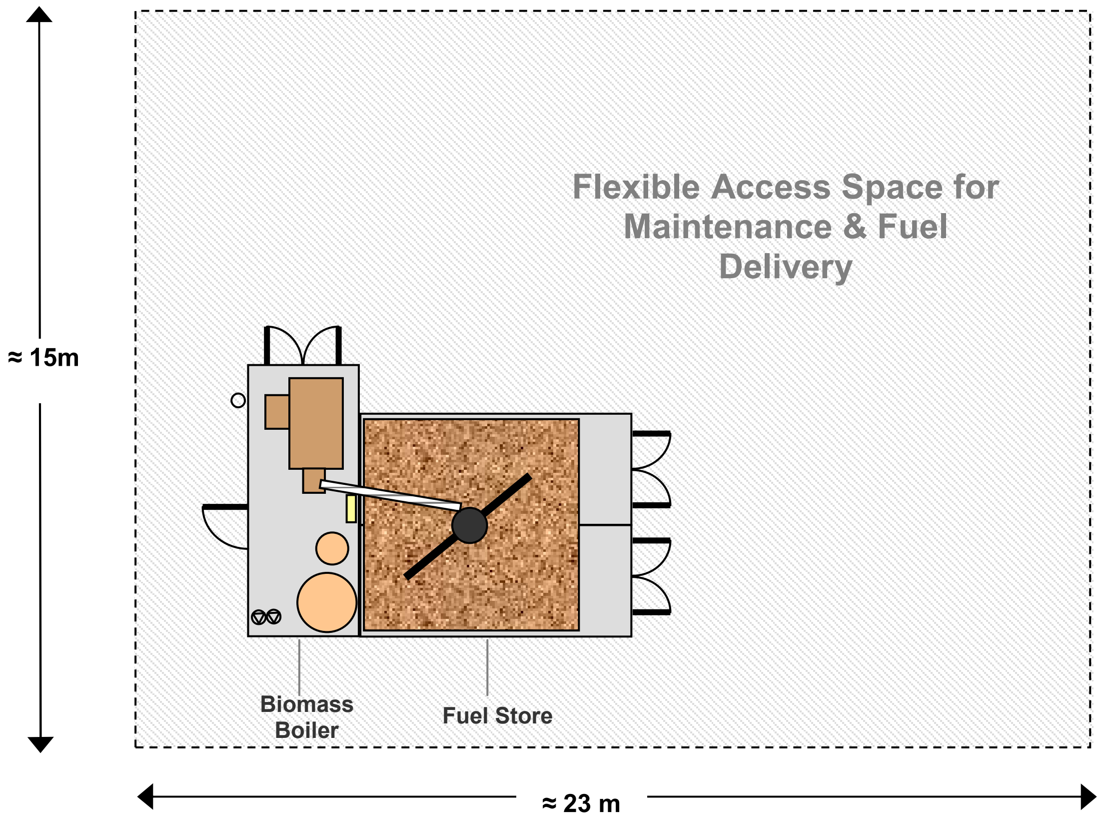


Figure 16 - Indicative biomass boiler compound layout