HILLSIDE
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Retrofit Renewable Heat Project

Case Study

The Road to Net Zero, Electrification and Decarbonizing of Campus Heat

Borders College, Galashiels

HILLSIDE
environmental services

Introduction

This case study demonstrates how an award-winning and novel approach to retrofitting renewable heat using centralised heat pumps to connect multiple buildings at the Borders College campus in Galashiels, Scotland has led to a significant decrease in carbon load. At the heart of the system is a retrofitted low temperature 4th Generation heat network driven by heat pumps, with thermal energy input coming from wastewater directly tapped from the town sewer line.

The team at Hillside Environmental worked on behalf of Borders College to provide consultancy, project management and liaison with external stakeholders including the local council, utilities & water authorities. The project was operated as a funded installation with CAPEX recovery through heat sales and energy savings.

Award-winning through both the Green Gown Awards and Scottish Green Energy Awards, Borders College has become an exemplar of technology possibilities, hosting more than 300 visits from interested parties. Energy generated is currently at approximately 1 GWH per year, with 2019 carbon savings around 180 MT.

Further developments are planned to increase benefits and deliver further carbon savings.

Hillside Environmental is proud to be a carbon-negative business.

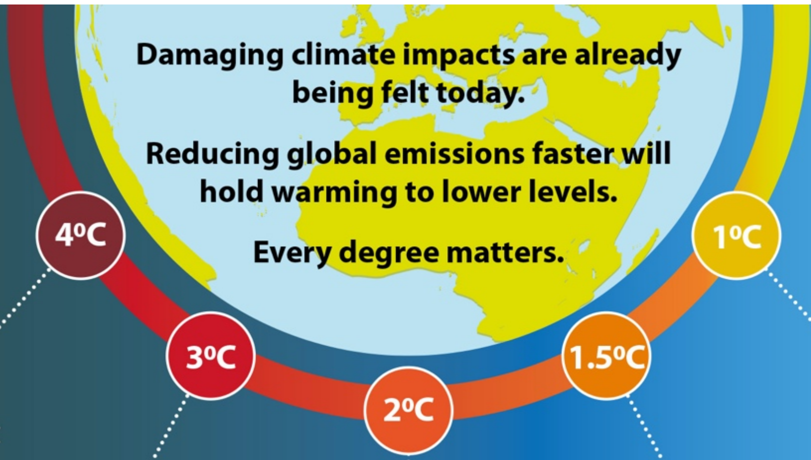
The Road to Net Zero

Committee on Climate Change

"A net-zero GHG target for 2050 will deliver on the commitment that the UK made by signing the Paris Agreement. It is achievable with known technologies, alongside improvements in people's lives, and within the expected economic cost that Parliament accepted when it legislated the existing 2050 target for an 80% reduction from 1990. However, this is only possible if clear, stable and well-designed policies to reduce emissions further are introduced across the economy without delay."

The World Green Building Council has recognised that, in most cases, net zero energy buildings are not feasible. Rather than generating all energy needs on-site, a combination of on-site and off-site energy generation combined with other energy-efficient measures is more achievable on a mass-scale. Already, the move to renewable energy has significantly reduced the carbon intensity of the UK grid, from around 560 g of CO_2 e per kWh in 2012 to 256 g of CO_2 e per kWh now and forecast of that reducing further. Electrification of the heat used for heating buildings and hot water, with that heat deriving from low-carbon, non-fossil-fuel, renewable sources allows us to make significant progress on the road to Net Zero.

Committee on Climate Change



Unchecked emissions growth would lead to very severe and widespread climate change at 4°C or more by 2100.

The world is moving towards a low-carbon future, reducing some risks. We are currently on track for around 3°C of warming by 2100.

The world has committed to reduce emissions faster to keep warming 'well-below' 2°C. This would help limit the most damaging effects of climate change.

Keeping below 1.5°C would limit many important risks further, helping to protect key ecosystems and reducing impacts on poorer people around the world.

Damaging climate impacts are already being felt today at 1°C of warming.

Climate change is here today:

- The frequency of heatwaves has increased around the world. Many extreme events are being made more likely due to climate change.
- Sensitive ecosystems, such as coral reefs, are being damaged due to extreme heat.
- Animals on the land and the ocean are shifting their territories in response to climate change.

UK action to address climate change can have an international impact

The UK can and should act as a leader in the global response to climate change - UK emissions contributed to causing it, and its leadership can have an international impact.

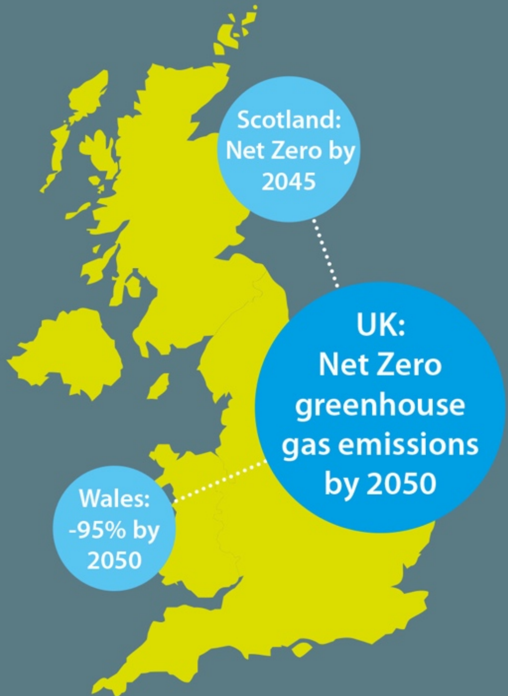
The UK has been a leader on climate change action. The UK has the opportunity to continue its leadership and join other countries already pursuing net-zero emissions targets.

The UK has committed to act by signing the Paris Agreement. This provides many options for countries to collaborate to reduce their emissions and prepare for the impacts of climate change.

Annual costs of achieving net-zero emissions are between 1-2% of GDP in 2050, comparable to those estimated in 2008 for achieving an 80% target.

80% reductions in emissions relative to 1990 levels estimated 2008	**100% reduction in emissions in 2050** estimated today

- Innovation has driven down the costs of key technologies, such as offshore wind & battery storage.
- Some costs to consumers, such as increased heating bills, can be offset by cheaper transport costs (thanks to a widespread shift to electric vehicles) and cheaper electricity bills (thanks to low cost renewable electricity).



There are many benefits of phasing out harmful emissions

For the economy

New green industries with new jobs and export opportunities for the UK.

For the individual

Quieter streets, cleaner air, less congestion.

Smarter cities and more comfortable homes.

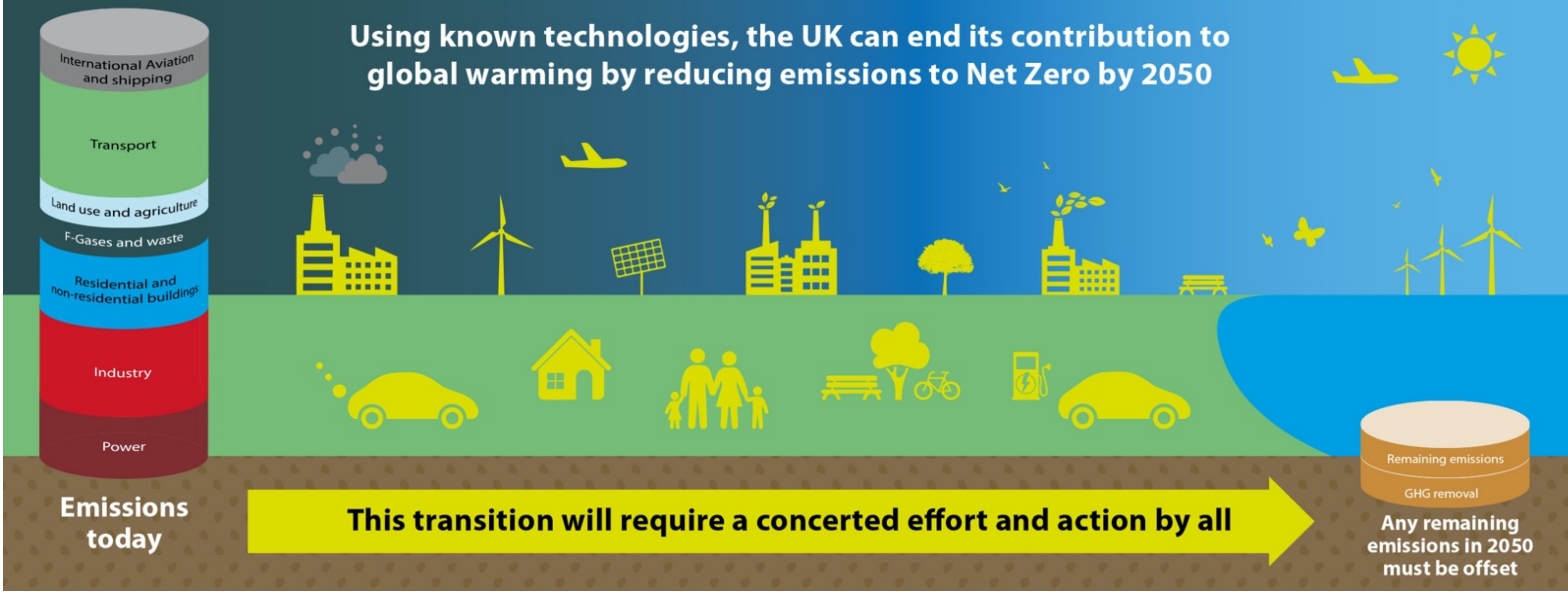
Healthier lifestyles, with more active travel and healthier diets.

For the country

More biodiversity, cleaner water, more green space to enjoy.

Reduced global warming, avoiding climate damages like flooding.

Using known technologies, the UK can end its contribution to global warming by reducing emissions to Net Zero by 2050



Borders College Project

To expand on an existing carbon reduction programme, the management team at Borders College considered options to reduce dependence on gas for heating. The college occupies three buildings of differing styles within a single campus at Galashiels, with heat supplied from five plant rooms.

The three buildings have quite different challenges in terms of heating:

Main Building:

A modern building extended and redeveloped in 2007. It houses college catering, corporate office accommodation, the college library, lecture halls and educational facilities.

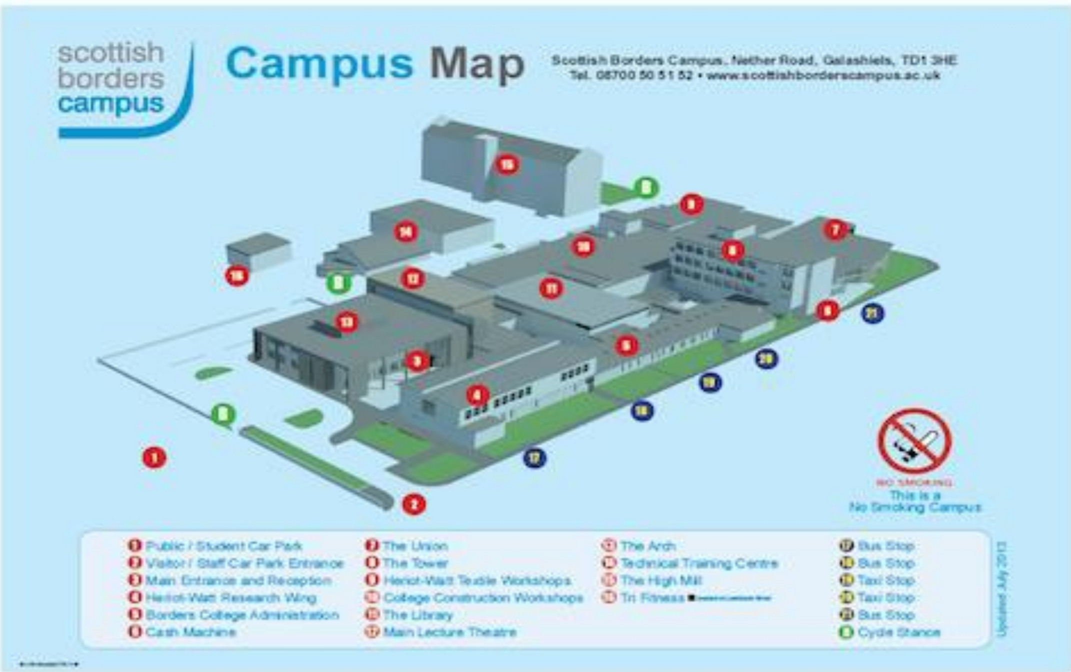
TTC:

A modern building housing technical training for vehicle mechanics and engineering students. It has a large open workshop and office accommodation space.

High Mill:

A Victorian mill and home to the textile department of the university, jointly run with Herriot Watt University. A listed building that retains the old cast iron heat distribution infrastructure.

The five plant rooms serving the campus comprise three around the Main Building and one each in High Mill and TTC. They housed gas boilers in various stages of repair and life expectancy.



The Challenge

The Management team's objective was to upgrade the existing plant room infrastructure to accommodate renewable heat technology without affecting the building side heat emitters, with the key objective of reducing dependency on natural gas.

Various options were considered. Biomass boilers were rejected on the basis of lack of storage space for fuel, together with the relative inaccessibility of the campus by road and the requirement to increase vehicle movements to deliver fuel to site. Connection to the local district heating network was also considered, but the complexity of the project placed severe delays on the delivery timetable.

Heat pumps were therefore identified as the preferred option, a technique that takes low-grade thermal energy and converts it into high grade usable heat through heat exchange and compressor technology.

Heat pump installation at Borders College

Choice of thermal energy source

Using heat pumps to convert low-grade thermal energy obtained, typically, from the environment or from heat that would otherwise go to waste, is a well-established approach to achieving energy efficiency in the provision of space heating and hot water.

Key to successful deployment of a heat pump is the choice of thermal energy source. In essence, the warmer the heat source, the more efficiently the heat pump can operate.

Ground source, air source and river source (open water) were all considered before wastewater (sewage) heat recovery was selected. Worldwide, many millions of litres of wastewater are washed down the drain, with a typical temperature at discharge of around 20ºC, representing a massive heat recovery opportunity.

Wastewater heat recovery was a new concept being introduced to the UK, chosen here because of the relative ease of access to the sewer line running past the back of the college, the consistency of wastewater flow and the relatively warm water available.

Project implementation

The team at Hillside Environmental were engaged to help develop a central energy centre to distribute heat to the existing plant rooms through buried heat distribution pipework. The existing boilers were maintained as backup, if required.

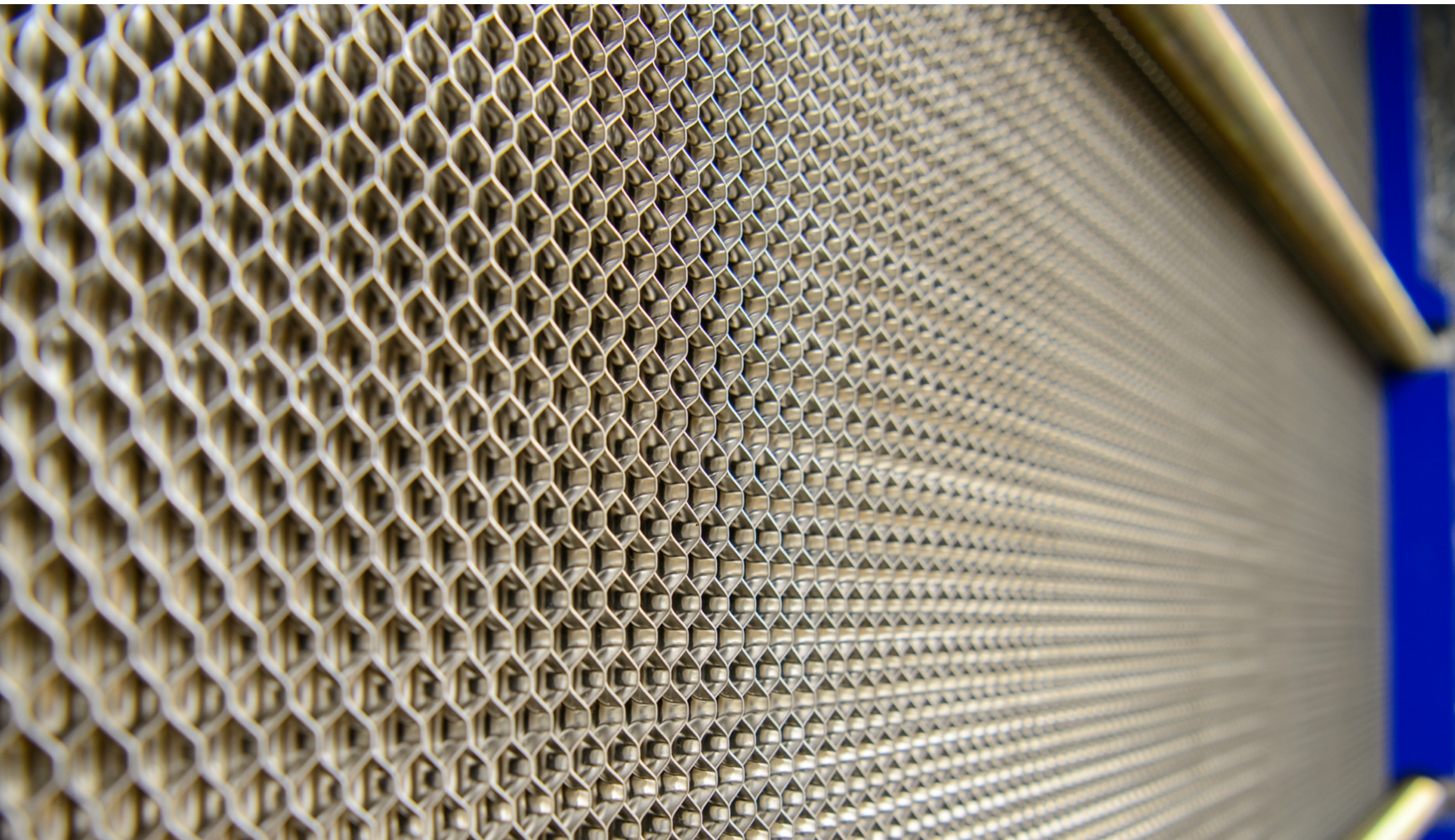
Throughout the Design and pre-construction process the team at **Hillside** provided advice and support to the various stakeholders to move the project to delivery.

- Energy Analysis and Benchmark of heat supply, including analysing the BMS data and producing thermal load calculations.

- Technical design for installation and operation of heat pump and buried infrastructure, including the Energy Centre design and heat network routing with heat loss calculations to enable the centralised distribution.

- Established the connection arrangements & system integration to the five college plant rooms serving the buildings’ heating system.

- Established an access agreement with the local water company and developed the sewer interface



Pioneering approach

The Borders College project presented a number of new technology/new technique opportunities to demonstrate how heat pump and distributed heat solutions can be deployed to benefit multiple building Net Zero strategies.

New technology deployment

This was the first heat from sewage project to be deployed in the UK

Heat pump retrofit

The retrofit solution displaced gas supply to the campus buildings

Fourth Generation DHN

Operating as a hybrid approach, with retained boiler infrastructure

Funded installation

CAPEX was recovered through a heat purchase agreement and energy savings

The project was established as an R&D opportunity to prove the wastewater heat recovery concept. As a proof of concept, a low-risk financial solution that covered construction, operation and heat supply was established.

Funding the project

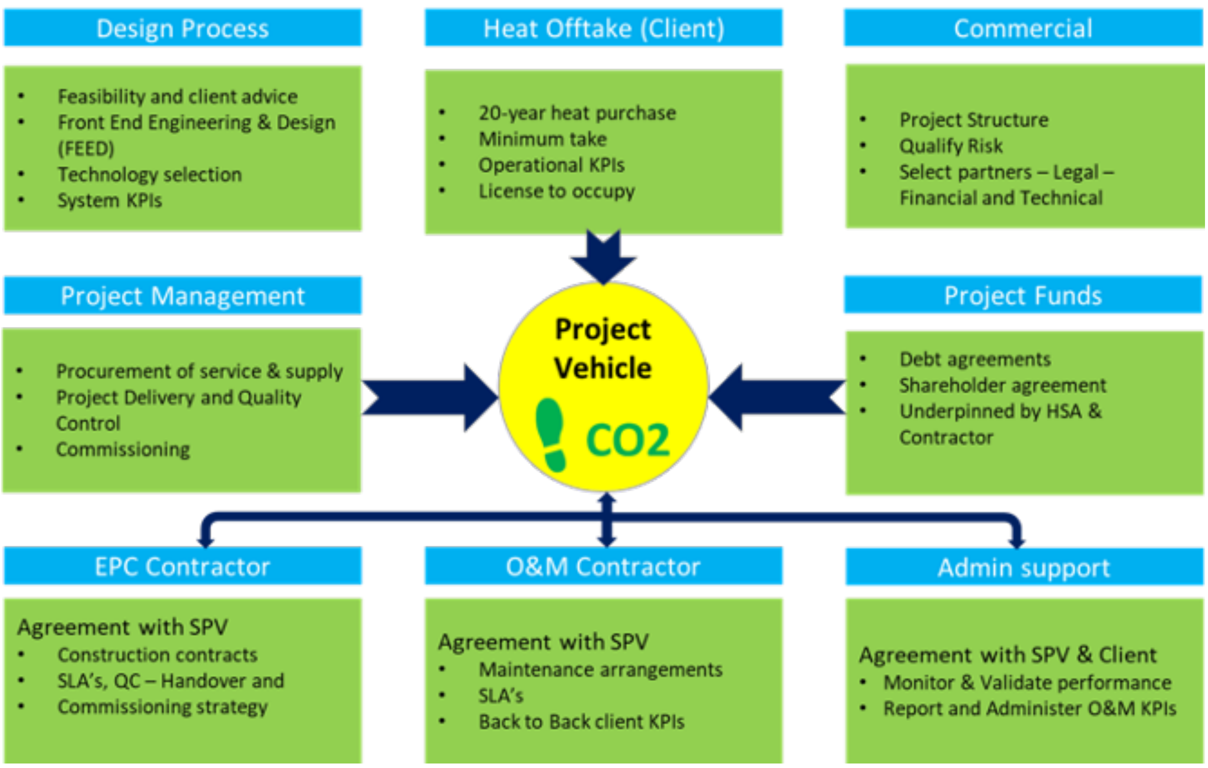
The use of heat supply contracts and commercial finance was adopted as the business model to support the project delivery, and Hillside corporate finance expertise was instrumental in delivering a successful financial approach.

The establishment of a Special Project Vehicle (SPV) was used to allow funders to invest as equity stakeholders with primary risk on the technology providers and main contractors, with limited financial risk to the college.

All stakeholders were involved in the development of contractual and commercial arrangements required to deliver the construction and post commissioning operational services.

- College as Heat off-takers
- SHARC (wastewater heat recovery supplier) as Design, Build and Operate contractors
- Private equity funders

The commercial risk is taken by the technology provider and funding partners, allowing the college to support a pioneering approach. The college continues to reduce carbon emissions over time by paying for heat supply at a rate competitive with their gas service.



Heat pump retrofit

A really key objective of the project, regardless of the source of thermal energy, was to prove the feasibility of retrofitting a heat-pump energy centre into the campus environment. That way, for future projects in other settings, alternative heat sources can be deployed into the heat pump model depending on availability.

During the design process the capacity of the existing heating system was evaluated, and it was shown:

- That it would be possible to maintain comfort levels at lower flow temperatures
- Boilers and heat distribution plant were found to be oversized
- Installed plant in boiler rooms at various stages of life expectancy but operational
- Installed BMS accepted as functional, with some adjustments required for flow temperatures and handshake between systems

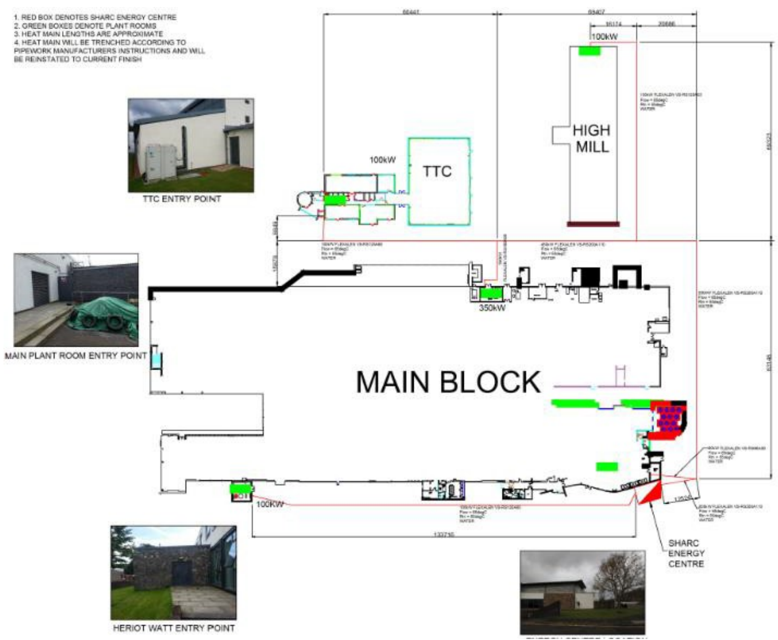
It was felt that High Mill, a Grade 2 listed Victorian mill, would present the greatest challenge in terms of meeting thermal comfort levels. A contingency was therefore established to reactivate the gas boilers if required.

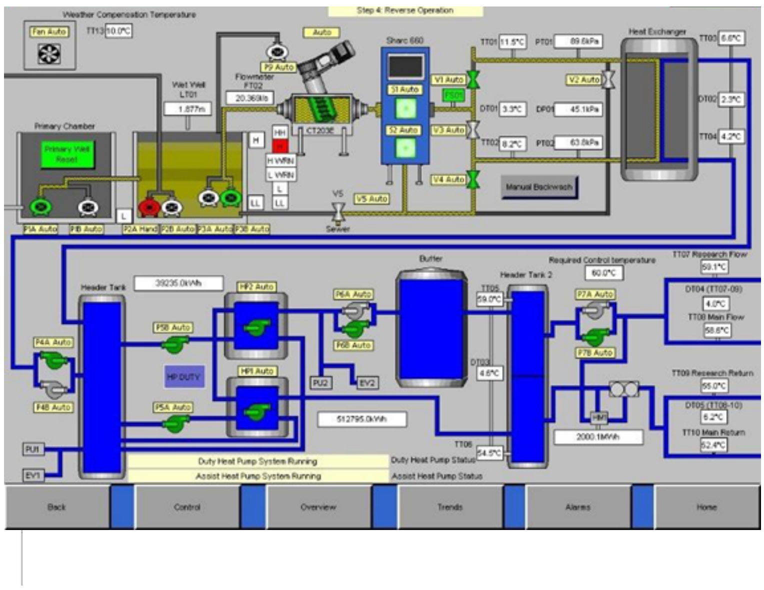
High Mill

Construction was carried out during summer/autumn 2015

Fourth Generation DHN – 60ºC/40ºC feed/return

Heat produced in the energy centre is distributed to the five plant rooms through a buried heat network consisting of 1km of pre-insulated flow and return plastic pipework. Connection is to each building's low loss header with valve control and screening devices at each point of connection. A cloud-based management system with HMI monitors and controls the process through an on-site PLC, including switching to gas generated heat if required to maintain comfort levels.





Project launch and subsequent reception

The system was launched in December 2015, to an audience of over 200 Scottish engineers and local authority stakeholders by Fergus Ewing, then Scottish Energy Minister.

Since then, the College has been happy to share their experience as a pioneer in this area, and in the first three years of operation have been host to an amazing three hundred plus visits from the UK and beyond.

Clockwise –

- Pete Smith College VP speaking at the launch
- Guests enjoying the launch event –
- Fergus Ewing, just returned from attending the Paris 2015 COP to sign the accord unveiling the launch plaque –
- A delegation from Enterprise Ireland on a hosted fact-finding trip to the college. Centre is Donald MacBrayne of Scottish Water Horizons alongside Borders College Head of FM Rob Hewitt.
- The attending dignitaries at the launch event visiting the energy centre

Project recognition

During Autumn 2017, the system was recognised for its pioneering achievements, winning two prestigious awards:

EAUC Green Gown Awards – Newcomer of the Year

Scottish Green Energy Awards – Best Innovation

Technical Challenges

As a new technology being deployed in the UK for the first time, the implementation was relatively smooth, but there were some technical challenges that have required modification to resolve.

Sewer content and diversity

The sewer presented several challenges that have been resolved through modifications to equipment and operation.

1. Density of Fibrous material content of sewer resource

The density of solid content, particularly baby wipes, was more challenging than experienced elsewhere. Differences between UK (EU) and north America in water consumption and the way UK sewer systems are used for inappropriate waste disposal was identified as cause.

This did create the need for a series of modifications to stabilise performance.

- Adoption of primary wastewater pre-screening
- Increased capacity of secondary fine screening devices

2. Low Flow

Particularly during the summer period, sewer flow dropped, creating system availability challenges - however, as the low flow periods coincide with higher sewer temperatures, a valve control arrangement was created to facilitate multiple water passes when more energy is available for extraction from the warmer water.

3. Low Temperature

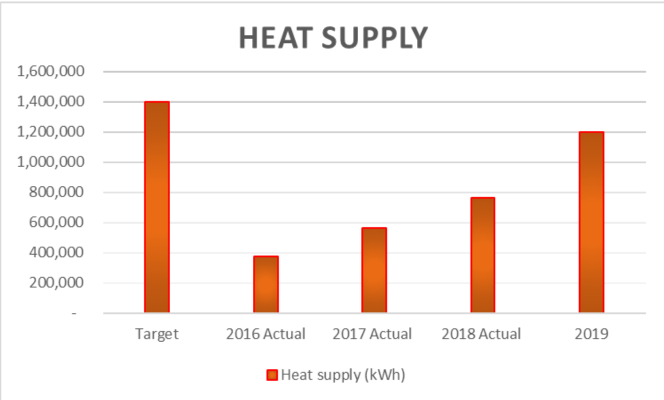
The sewer resource remains productive down to 10^{o}C, but at periods below this the frost protection on the heat pumps begins to trip the units. These are rare events but coincide with periods of high demand, particularly overnight / early morning in preparing for occupation. In order to resolve the challenge, the team carried out several modifications

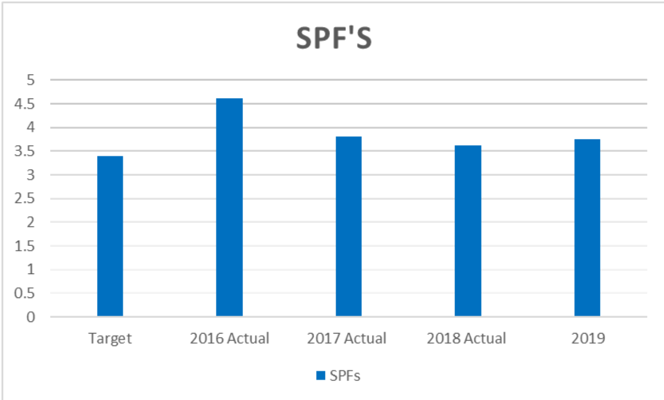
- Adopted modulation between heat pump and Gas boiler back up.
- Developed the controls regime to further automation response to low temperature events
- Increased differential flow rates on PHX

System Productivity

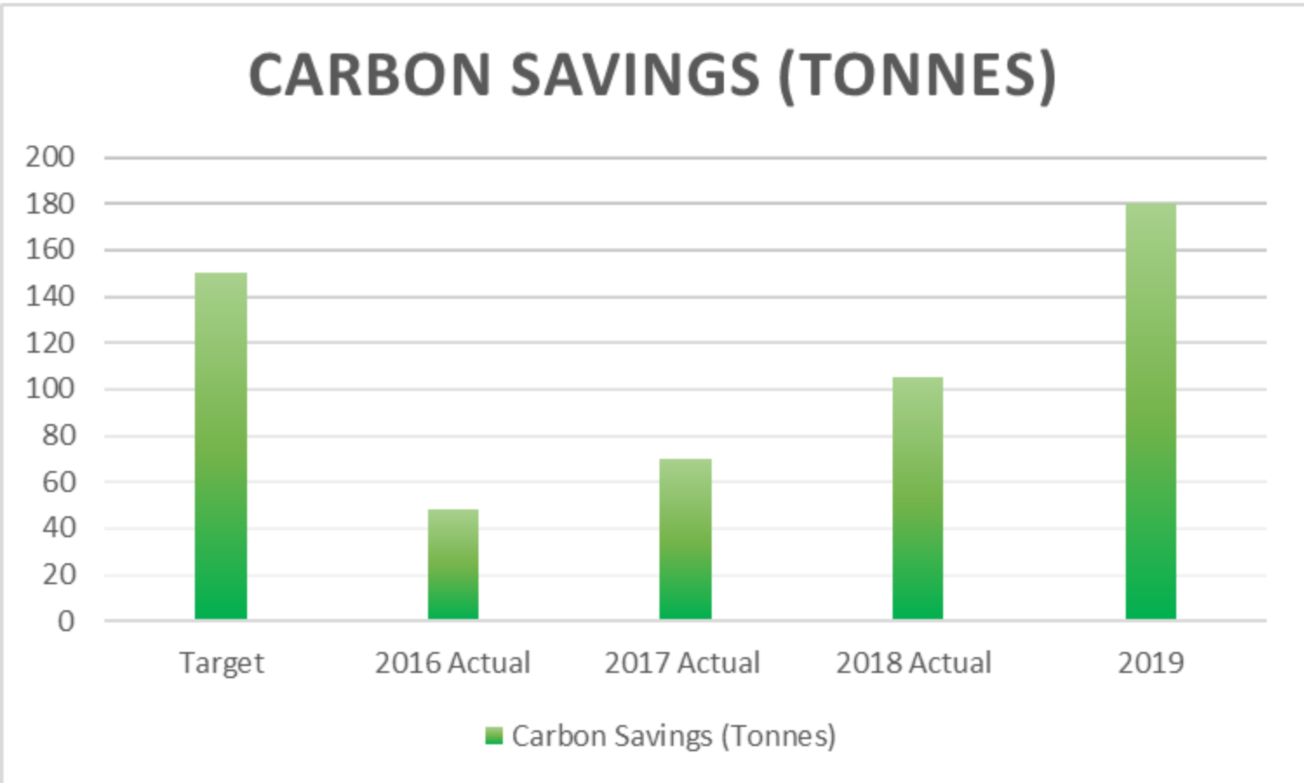
The heat supplied by the system has significantly increased as the modification programme resolved availability issues. The system has delivered high quality renewable heat – around 1GW of production per annum – displacing significant amounts of gas consumption from the college's energy mix.

The heat pumps are performing extremely well, with consistent efficiency being achieved.





With an energy grid that is decarbonising at pace, the college's carbon savings will continue to improve over the life of the installation.



Next Steps

The system is performing well, and the college has ambitions to harvest further energy efficiency from the operation:

Renewable power technology

Solar generation and battery storage technology to mitigate grid electricity costs and improve carbon reduction.

Boiler plant centralisation

Integration of the boiler plant with the 4th Generation DHN service to improve the hybrid efficiency and decommission the five satellite plant rooms, reducing service and maintenance costs and releasing the building space for other uses.

Further steps on the Road to Net Zero

For more information, and to take the next steps on your own Road to Net Zero, contact Hillside Environmental for a free, no-obligation discussion.

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