CASE STUDY (Design)

Queens Quay Heat Network

DESIGNING THE UK'S LARGEST WATER SOURCE HEAT PUMP

OVERVIEW

The Queens Quay development in Clydebank will transform the former John Brown Shipyard from an industrial landscape to a vibrant, diverse and architecturally engaging community. The plans for the 23 hectare site will create 1,000 private homes, 200 rented homes and the associated infrastructure to support them such as a health centre, care home and commercial facilities.

The site already included 4 existing buildings; Titan Enterprise Business Centre, Aurora House council offices, Clyde Bank College and the Clydebank Leisure Centre and these will be integrated into the new community.

The project is ground-breaking in many ways, but one of the truly exciting aspects is that it will feature Scotland's first major Water Source Heat Pump, taking heat from the nearby River Clyde and pumping it to customers through a system of buried district heating network.

The project received £6m in funding from the Low Carbon Infrastructure Transition Project.

THE SOLUTION

The developers and the council had ambitions of making this Scotland's "greenest town" and stated three core ambitions for the energy infrastructure:

- Lower bills for residents offering a reduced tariff and no costs for servicing or repairs
- Reducing carbon emissions through the use of an innovative water source heat pump. The eventual savings after build out will be equal to the total carbon footprint of over 1,240 local residents.
- Increased security of supply ensuring a minimum of down time and constant access to heat for all customers.

By the bid stage, the client and their consultants, Ramboll had created a RIBA stage 3 design based on their heating demand estimates and specified two x 2MW water source heat pumps as well as additional boilers and ancillary equipment.

To make the scheme financially viable, the clients entered into an Invitation to Negotiate, in which interested contractors could explore options for reducing the CAPEX needed to bring the project to market. Whilst we always apply the

PROJECT SUMMARY:

CLIENT
West Dunbaronshire Council

PROJECT
Water Source Heat Pump, District Heating

TIMESCALE:
Ongoing

CONTRACT VALUE:
Not Applicable

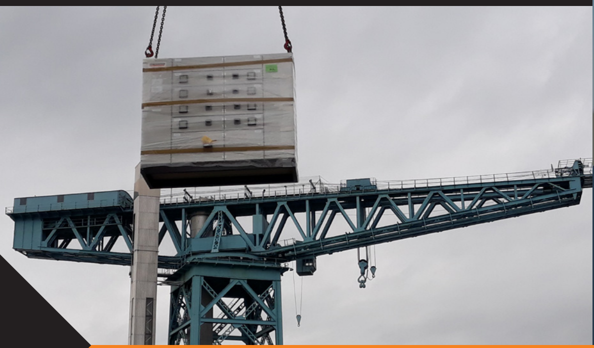
THE BENEFITS:

> Initial CO_2 reduction of 409 tonnes per annum raising to 1,903 tonnes at full build out and 5,705 tonnes by 2040 due to decarbonisation of the grid. (This latter figure is in excess of driving a car around the world 1,138 times!)

> Seasonal COP of 250% with peak COP of 300%+

> Reduced heating costs for residents.

Our designers were given a specific building footprint and created a solution which would work optimally within this space.



The people of Clydebank will see the benefits of this pioneering project for generations to come. It will also make a major contribution towards the Council's climate change targets to reduce CO2 emissions.

COUNCILLOR MARIE MCNAIR, VICE CONVENER OF INFRASTRUCTURE, REGENERATION AND ECONOMIC DEVELOPMENT

principals of value engineering to reduce the cost of a project, in this instance we were also able to make a significant financial contribution towards the cost of the project.

Evolving the Design in Partnership with the Client

Once we were chosen we were responsible for progressing the design to RIBA Stage 4, where the Technical Design has been finalised. To do this we worked in consultation with the client and their professional team to progress the design and this began by combining CIBSE benchmarks with our database of high resolution, real-life heating data to predict the heat demands. By introducing our database of historical heating data we were able to create more accurate profiles for the new build sections of the development. For the existing buildings we were able to take the gas usage data to model future energy needs.

We then diversified the data to give us a clear picture of average usage across the site which allowed our designers to begin sizing the major plant. During this process our designers had to make some important decisions about the sizing of the heat pumps and we worked closely with Star Renewables who were designing and building the heat pumps.

Whilst the peak demand will be approximately 20MWs this level would only be needed for a very small percentage of the year, with our estimates showing the peak demand would only account for 25 hours out of an average year. The challenge faced by us was to design a system which would maximise the use of the Water Source Heat Pumps (WSHP), which are eligible for RHI and are extremely efficient in reducing carbon emissions. This was made possible, in part by utilising a thermal store which could take any excess heat the WSHPs generated and then release it when it was needed.

Our solution specified two 2.65MW WSHPs which could run as close to maximum output as possible to deliver the majority of the annual heat demand. This configuration means that in the summer months, when demand is low, we can take one heat pump offline at a time to perform scheduled maintenance, with the other still providing heat. The scheme also has added resilience due to the gas boilers installed in the energy centre which, when used, are capable of delivering another 15MW to meet the peak demand. These boilers will only be used during peak demand times or as a backup option, so for the larger amount of the time the system will produce no local carbon or NOx emissions.

This low-carbon hot water is pumped through a pre-insulated district heating pipework which is buried in the ground. This network distributes water to larger buildings, where it connects to a plate heat exchanger and also to homes, where it connects to a heat interface unit.

An important factor for consideration is that WSHPs rely on electricity, but have a high coefficient of performance, meaning for every MW of electricity used, the heat pumps produce multiple MW of heat. Whilst the scheme is already effective at reducing carbon emissions, as the grid decarbonises in the future, the system will become more environmentally friendly.

Because of the increase of renewable electricity generation contributing to the grid it is expected that the grid carbon factor is predicted to decrease by over 87% between the years 2018 and 2044, with the heat pumps carbon emissions decreasing by a similar amount over that period.

Understanding the River & Ecosystem and its Influence on Design

To design water source heat pumps, it is essential to fully understand the water source and for the Queen's Quay project this is a tidal, saltwater river which is under the protection of the Scottish Environment Protection Agency and has a range of both plant and aquatic life. This meant we had to fully acquaint ourselves with the information for area aspect including:

- Average water temperature
- Seasonal water temperature
- Flow rates
- Wildlife and ecostructure

We began by building a comprehensive picture of the river and how that would affect our

Water is taken from the River Clyde and pumped up to the energy centre where latent heat can be extracted.

'The District Heating Network will have a hugely positive impact on Queens Quay and Clydebank as a whole and we are delighted to welcome Vital Energi on board to help us deliver it. Once completed, the network will provide heating and hot water to existing buildings including Clydebank Leisure Centre and the Council office campus as well as serving the new homes.'

COUNCILLOR IAIN MCLAREN, CONVENER OF INFRASTRUCTURE, REGENERATION AND ECONOMIC DEVELOPMENT

THE SOLUTION

design. The initial stages involved desktop research to map the river's temperatures throughout the year, establishing that it generally ranges from between 6-12 degrees Celsius.

Another key consideration depended on the average flow rate of the river, as this determined the distance between the abstraction pipework (where water is taken from the river) and the injection point (where the water is returned to the river). It is essential that this distance is adequate as, should the distance be too short, the system could find itself taking the cooler water which had already been through the system.

It was important that the calculations and the filtration system were effective as each of the two heat pumps uses up to 125l of water per second and we, the client and SEPA were all firmly committed to ensuring the system would not damage the river's ecology.

Designing a 21st Century Heating System & Updating Existing Buildings

One of the main hurdles facing our designers was that the heat network would be made up of a mixture of new-build premises and older existing buildings. The older buildings had been designed for historic heating systems which favour a higher 82°C flow and 71°C degree return and whilst the ammonia based heat pumps are capable of delivering that, the new building's heating systems are designed specifically for efficient district heating and are based around a 75°C flow and 45°C return.

During the delivery phase of the project our team will begin retrofitting the heating systems inside the existing buildings so that they can work with the lower flow and return temperatures. This work will mainly involve modifying the heating controls, with the possibility of some larger heat emitters, such as radiators. By doing this and enabling a site-wide uniform flow and return temperature the heat pumps will have a higher coefficient of performance, making the overall system more efficient.

Working With the Clients to Deliver an Optimised Energy Centre

To create the energy centre we worked with the building contractor to deliver the optimum layout. One issue was that the building had received planning permission, so we were working with a set building footprint. Our designers then set out with these restrictions to, not only to create an efficient layout, but also one in which operation and maintenance could be delivered in a safe and efficient manner.

To achieve this we created a mezzanine solution which allowed us to optimise the space available to us. We then designed the standard energy ventilation to ensure this met all essential legislation, but due to the fact that the heat pump process uses ammonia as a refrigerant we also needed to create an emergency ventilation scheme to ensure it would not harm anyone in the energy centre or further afield. To do this we created a box which housed the heat exchangers and a ventilation system which led to a 30m flue.

While designing large-scale energy projects we always ensure that we understand the client's long-term masterplan and can include future phases and planned expansion into our designs. By future proofing our designs in this way it can save the clients thousands of pounds by creating easily expandable district heating networks and ensuring the potential for extra capacity has been catered for. In this instance we were able to leave space in the energy centre for a third and fourth heat pump which can now be easily installed as the build out progresses.