electricity north west
Bringing energy to your door

NIA ENWL017

Electricity & Heat

Closedown report

31 July 2019

VERSION HISTORY

Version	Date	Author	Status	Comments
V1.0	10/07/2019	P Turner	Final	

REVIEW

Name	Role	Date
L Eyquem	Innovation PMO Manager	31.07.19
G Paterson	Innovation Engineer	31.07.19

APPROVAL

Name	Role	Date
Steve Cox	Engineering & Technical Director	31.07.19

CONTENTS

1 EXECUTIVE SUMMARY

1.1 Aims

The aim of the project was to trial a new technology that would be able to capture environmental and waste heat and store this energy to enable demand to be reduced at times of maximum demand.

1.2 Methodology

FutureBay carried out some initial studies of the components of the system and the proposed installation. The technology was then designed, budgeted for and built to enable the system to be demonstrated. The system underwent a series of tests and conclusions made.

1.3 Outcomes and Key Learning

The tests showed that the system could use waste energy from air conditioning systems and store it to enable the energy to be reduced at peak periods of the day. The project highlighted the benefit of the NIA to enable a smaller scale, higher risk project to be investigated as opposed to running a larger scale NIC project.

1.4 Conclusions

The FutureBay hybrid Energy Storage and HVAC system has the potential to make a significant contribution to helping manage these two major issues. FutureBay stores energy and reduces air conditioning energy consumption by up to 50%. It can shift AC and heating loads from periods of peak demand to off peak demand, and also deliver electricity on demand. Effectively it has the potential to reduce demand on the network by up to 150% of an air conditioning systems load.

2 PROJECT FUNDAMENTALS

Title	Electricity and Heat
Project Reference	NIA_ENWL017
Funding Licensee(s)	Electricity North West Limited
Project Start Date	July 2016
Project Duration	2 years
Nominated Project Contact(s)	Cara Blockley(cara.blockley@enwl.co.uk)

3 PROJECT BACKGROUND

Electricity demand will increase and change both through the adoption of low carbon technologies and general load growth; including the increased deployment of air conditioning. As traditional reinforcement to accommodate this load could be costly and disruptive, new and innovative solutions are being sought. Air conditioning systems tend to release a significant amount of heat as a by-product which is currently a wasted resource.

This project investigated the feasibility of utilising the heat currently wasted to improve overall energy efficiency (reducing electrical demand) and allowing the electrical demand to be managed.

The project will be a mixture of research and development and will investigate how an innovative way of managing energy holistically can derive benefit for a Distribution Network Operator and their customers.

The project was split into the following phases:

Phase 1. Feasibility study that identifies and undertakes a detailed review of a trial site producing waste heat to investigate how the heat could be used to reduce and shift the overall energy requirements of the site. This phase included the broad outline concept design, costing and potential benefits.

Phase 2. Design and budget for installation of one unit at the trial site.

Phase 3. Build, install, monitor and analyse the system operation at the trial site.

Phase 4. Dissemination of learning.

4 PROJECT SCOPE

The project will be conducted at a single location and help understand how benefits for a Distribution Network Operator and their customers can be derived from improved energy management. The scope of this project includes the adaption design work required to implement technology from other sectors in a trial site.

5 OBJECTIVES

The project has 4 primary objectives.

1. A trial installation to assess impact and opportunities for a GB DNO.
2. To determine the capability of the technology to assist in overall energy management.
3. To quantify the impact on metered energy consumption at the trial site.
4. To investigate the impact on timing of energy consumption at the trial site.

Achieving these objectives will support network operators in releasing network capacity for use by customers, particularly in areas of high and increasing demand.

6 SUCCESS CRITERIA

This project will be considered a success upon

1. A trial site being identified.
2. The trial site being adapted such that sufficient monitoring and data is available to quantify potential costs and benefits
3. Production and publication of a report to disseminate the findings.

7 PERFORMANCE COMPARED TO THE ORIGINAL PROJECT AIMS, OBJECTIVES AND SUCCESS CRITERIA

7.1 Summary of Performance for Smarter Networks Portal

The project has successfully delivered against its original aims, objectives and success criteria. The following section summarises the methodology used to meet the objectives specified in Section 5, the outcome of the research and how the associated success criteria stated in Section 6 were met.

7.2 Project Phases

This project was established to demonstrate that the FutureBay technology could:

- Shift the timing of demand for a data centre, or similar commercial or industrial process, cooling from periods of peak demand to periods of off peak demand and hence reduce electrical loads on the network
- To utilise waste heat from providing the cooling duty to create electricity during periods of peak demand, hence further reducing the loads on the network
- To demonstrate the potential to reduce the overall net electrical consumption from providing cooling duty compared to traditional cooling technologies

All Phases of the project have been completed.

Phase 1

Project partner, Futurebay, carried out intensive monitoring of temperatures, fan speeds and power consumption of an air conditioning system at the trial site. The analysis of the data collected showed that around 60kWt of waste heat was being discharged from the data centre cooling system that could be utilised by the Futurebay system, with temperatures of 40°C. It was identified that the FutureBay system could capture this waste heat and converts it into usable electricity, dispatching this electricity at periods of high demand. Figure 1 shows a simplified overview of the system.

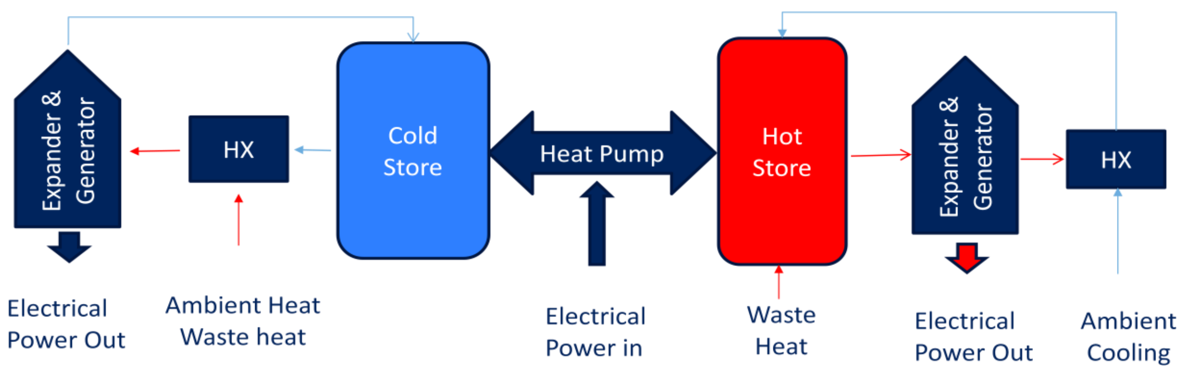

Figure 1 Simplified Overview

The FutureBay technology contains three major subsystems that dominate the electrical load of the installation:

Heat Pump

The heat pump is operated off peak using lower cost electricity to move heat from one storage tank to a second tank. As it operates it cools the first vessel and heats the second. The unit includes a soft-start module to minimise current draw on start up. Figure 2 shows the picture of the heat pump.

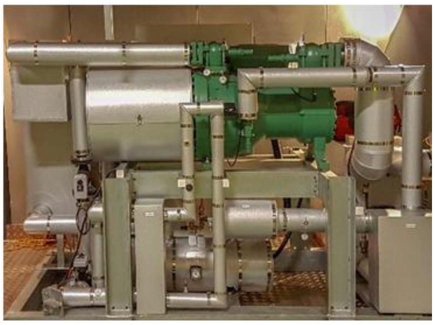

Figure 2: Heat pump

10LT Organic Rankine Cycle

The 10LT unit generates power continually using the data centre as a heat source. It extracts heat from the data centre at various points to evaporate the working fluid within it to drive a turbine. The cooling stored within the cold storage tank is used to condense this working fluid before it is pumped back around the cycle.

Figure 3: Cold ORC

20LT Organic Rankine Cycle

Two 20LT units generate power during periods of peak electricity generation using the hot storage tank as a heat source. They extract heat from the hot store to evaporate the working fluid within them to drive turbines. Ambient air is used to condense this working fluid before it is pumped back around the cycles. See figure 4.

Figure 4: Hot ORC

Phase 2

Due to planning permission constraints in the timeframe of the NIA the installation could not take place at the original proposed trial site. An alternative site was proposed and a replica load to represent the temperatures and demand of the trial site Data Centre was developed.

The specification and design of the system was completed

Phase 3

FutureBay built a full-scale prototype of their system as a technology demonstrator.

To determine if the key parameters of time shifting energy consumption from periods of peak demand to periods of low demand, and to demonstrate the FutureBay capability of producing electricity from waste heat on demand, the following tests were undertaken:

- Can two thermal stores of 70°C and 0°C be delivered by the subsystems using off peak electricity?
- Could the hot store be stratified enabling a constant temperature feed to the hot ORCs?
- Could the hot side ORC produce electricity and deliver heating at peak times?
- Could the cold side ORC produce electricity and cooling at peak times?

Delivering this enabled the team to demonstrate that the FutureBay technology is a viable and effective way of time shifting energy from one period to another, demonstrating effective energy management. And additionally generating electricity from waste heat at peak times which would lower the overall operating costs of the system and reduce the overall amount of CO2 produced in delivering the cooling duty.

7.3 Conclusions

The image in figure 5 shows a thermal image of the hot store during a mid charge which highlights the increase in temperature of the water store. Figure 6 & 7 show the energy production from the hot store and the fact that it can simultaneously deliver heating, raising cold air from 9.3°C to a maximum of 26.1°C.

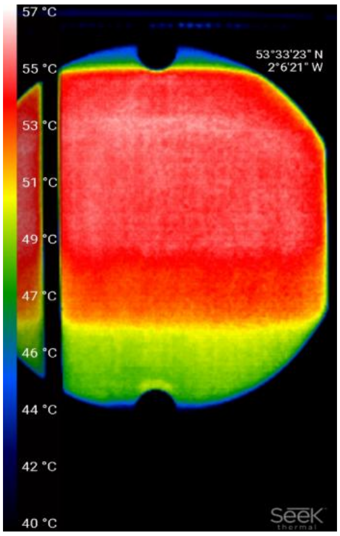

Figure 5: Thermal image of Hot Store

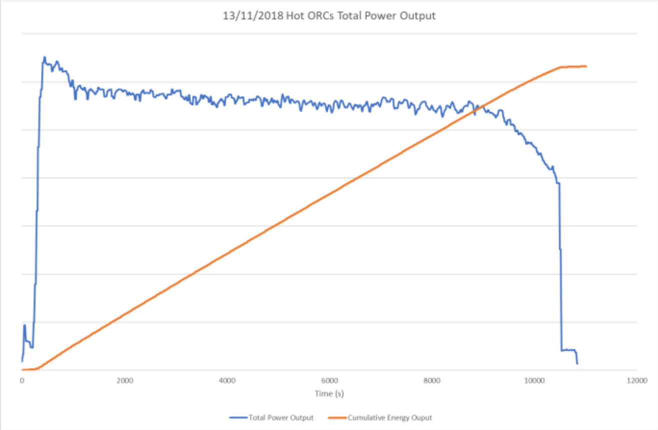

Figure 6: Energy production from hot ORC

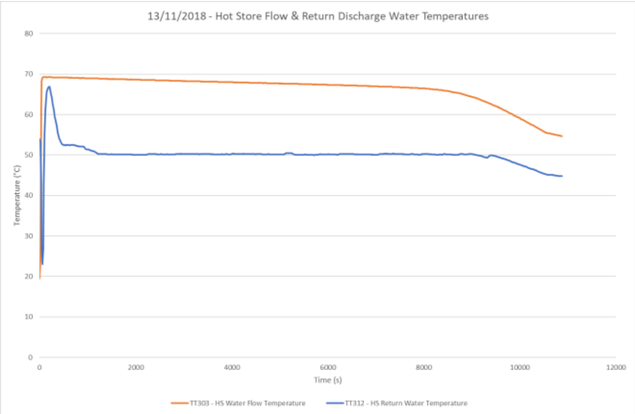

Figure 7: Simultaneous energy production and Hot store heating.

Figure 8 below shows that the FutureBay cold ORC was capable of producing electricity by running between a waste heat source and the cold store.

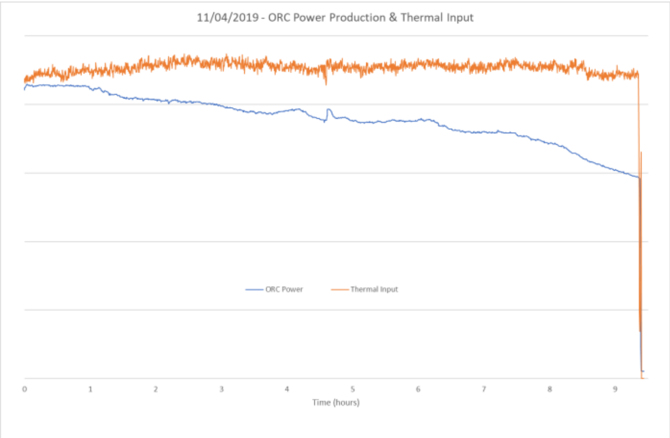

Figure 8: Cold ORC power production and thermal input

The system was designed to cool a data room in conjunction with CRAC units. Figure 9 below shows that simultaneous with the production of electricity the FutureBay system was capable of delivering the necessary cooling.

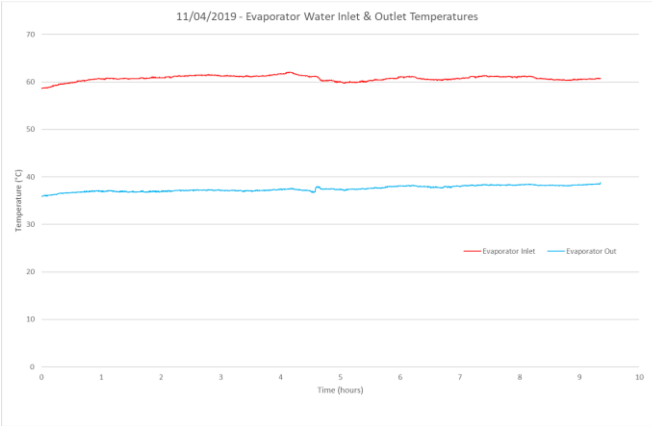

Figure 9: Evaporator inlet and outlet temperatures.

8 THE OUTCOME OF THE PROJECT

The International Energy Authority report on *The Future of Cooling* highlights that –

- Air conditioning consumes around 10% of global electricity production - producing c.1.25 million US tons of CO2 pa
- The global stock of air conditioners in buildings will grow to 5.6 billion by 2050, up from 1.6 billion today – which amounts to 10 new ACs sold every second for the next 30 years requiring new electricity capacity the equivalent to the combined electricity capacity of the United States, the EU and Japan today

In addition there is a growing need for energy storage to help electricity grids deal with increasing contributions from intermittent renewable energy sources and the growing network demands. It is already noted that in some regions PV installations are starting to stall due to lack of energy storage, and the Edison Electric Institute, estimates that seven million zero emissions vehicles will be on US roads by 2025. One electric vehicle is equivalent to adding three houses to the power system.

The FutureBay hybrid Energy Storage and HVAC system has the potential to make a significant contribution to helping manage these two major issues. FutureBay stores energy **and** reduces air conditioning energy consumption by up to 50%. It can shift AC and heating loads from periods of peak demand to off peak demand, and also deliver electricity on demand. Effectively it has the potential to reduce demand on the network by up to 150% of an air conditioning systems load.

The proof of concept technology demonstrator constructed and tested as part of this project, was built to demonstrate that the system can deliver two thermal stores, one hot one cold, that the hot store can be stratified enabling a constant temperature feed to the hot ORCs and that both the hot and cold sides can produce electricity whilst delivering heating and cooling respectively. The test report concluded that all these key processes were delivered by FutureBay's revolutionary Hybrid Energy Storage and HVAC System and that the system performance supported the thermodynamic modelling previously produced. Futurebay is now using this platform to optimise it's technology and produce market ready product.

FutureBay has in parallel with the build and test program undertaken a review of potential early applications. The flexible nature of the FutureBay system, in that it can store and deliver on demand electrical energy, deliver space heating and domestic hot water (DHW), and can deliver cooling, whilst also able to capture low grade waste heat and add this to the energy store, creates a very wide range of potential opportunities. Currently applications requiring air conditioning where there are sources of waste heat are seen as the favoured early markets. In particular supermarkets. In addition hotels are also being considered where they required DHW and air conditioning.

A key aspect of the FutureBay system is that it can be a direct AC replacement, either in a new build or AC replacement scenario.

8.1 Summary of outcome - for Smarter Networks Portal

Once the system had been built and commissioned a number of runs were carried out charging the system which identified that 8.25 hours of off-peak running would deliver a hot tank at 68.5^{o}C and a cold tank at -5^{o}C.The tests demonstrated that the hot tank could be stratified with the top 85% (above the distributor) all within 2K of the average (67.7^{o}C) and the bottom 15% (below the distributor) ranging from 45.7^{o}C to 66.2^{o}C. This stratification makes it eminently suitable for driving a constant temperature ORC engine.

FutureBay were able to drive the Hot ORC and deliver 31.6kWh of electricity and 1,133kWh of space heating. As the focus of the system was to provide cooling this heat was despatched to ambient when electricity prices were at their highest, in other applications it could be used for space heating and/or providing hot water, further offsetting energy consumption, costs and CO_2 emissions

To dispatch the cold store it was necessary to simulate the waste heat that would have been available from the data centre and FutureBay were able to demonstrate that the system could provide a runtime duration of 22 hours and 53 minutes, generating at least 43.5kWhe and providing 1.2MWht of cooling to the simulated data centre.

In conclusion the FutureBay Technology demonstrator delivered all the key test parameters.

It has shown that the technology can shift energy demand from one time period to another making it a viable method for energy management, can deliver the stored heat and cold on demand, delivering valuable services such as space heating and air conditioning. The flexibility of operation of the system has enabled the system to deliver electricity on demand to allow for maximum value of the stored energy to be delivered, namely at those periods of peak demand and cost. The demonstrator therefore shows that the FutureBay technology can reduce net electrical consumption as it produces electricity from heat that would be wasted, reduces CO2 emissions by the net reduction in electricity consumption and shifting electrical loads to lower CO2 night time electricity, and reduces peak demands on the network by shifting electrical loads to off peak periods and by producing electricity on demand during peak times.

9 REQUIRED MODIFICATIONS TO THE PLANNED APPROACH DURING THE COURSE OF THE PROJECT

9.1 Summary for Smarter Networks Portal

The project has been completed

The initial assessment of the installation had not identified a requirement for planning permission. After the initial design was completed it was recognised that the installation would be larger than expected and planning permission would be required at the proposed location. The installation at the proposed location would also have resulted in a significant reduced of car parking spaces required for office personnel. For these reasons an alternative site was proposed and a replica load to represent the temperatures and demand of the trial site data centre was developed. The change in location had no effect on the project outcomes.

10 PROJECT COSTS

Item	Category	Estimated Costs £k	Final Costs £k rounded	Variance
1	Futurebay Project Consultancy	990	990	0

11 LESSONS LEARNT FOR FUTURE PROJECTS

This project has highlighted the benefit of being able to register an NIA project as opposed to a larger scale NIC project to develop projects that are classed at a higher risk.

12 PLANNED IMPLEMENTATION

Due to the current size of the installation it is not planned to implement his system but a close working relationship with FutureBay will continue should this position change. FutureBay are continuing to develop this system.

13 DATA ACCESS

Electricity North West's innovation data sharing policy can be found on our website.

14 FOREGROUND IPR

The project has trialled technology designed by Futurebay and the IPR belongs to them. The technology will be made available via Futurebay for others to replicate the project if required.

15 FACILITATE REPLICATION

This project was a research project which produced a proof of concept and associated functional specification. There is no replication but network operators may wish to use the functional specification and apply it to their network management systems.