Appendix 5:

Feasibility Study:

The Utilisation of Surplus Heat at: Durham Crematorium

Project number: 1227036

Durham County Council
Technical Services
County Hall,
Durham
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1. Executive Summary

This feasibility study report recommends the installation new heat recovery measures at Durham Crematorium. These measures would make use of waste heat produced by the recently installed cremators which is presently discharged to atmosphere. The primary purpose of the project is to utilise this waste heat energy for the operation of the Crematorium, with any excess being exported off site.

The waste heat would be classified as low grade and would typically be at around 90°C. A number of possible uses for the waste heat have been identified, although three specific proposals are recommended by this report:

- To provide an alternative source of heating to two residential bungalows, which are located on the crematorium site;
- To provide de-icing and frost control to the drive and pathways in the immediate vicinity of the crematorium building main entrance and exit, by means of underground heating;
- To provide electricity generation by means of a turbine generator, which runs on the *organic Rankine-cycle* principle.

Each of the three proposals is considered in detail within the main body of this report.

A further option to provide district heating to neighbouring properties was considered but discounted as it would be less practical and could prove to detract from the more favourable proposals mentioned above.

Each of the proposals would involve some disruption to the normal operation of the Crematorium. With careful consideration and planning, however, it should not prevent the Crematorium from being used. Disruptive work would need to be carried out outside of normal crematorium hours. Heating to the bungalow would involve crossing the main site access road with a pipe trench and could require the crematorium heating to be isolated for a time. Work to the drive and pathways around the main building entrance and exits would be the cause of significant disruption, however the management of the facility have suggested temporary closure of one of the entrances could be accommodated whilst work could be undertaken. The power generation proposal would involve installation of a containerised packaged plant facility, which would need to be accommodated within a screened or walled area at the rear of the main building. The proposed container would need to be craned over the building at installation and additionally, it would require an access road for service vehicles.

Planning Approval would need to be sought for the proposals.

The estimated budget cost for the proposals are as follows:

- Heating to bungalows £71,600
- Heating to driveways/paths £100,000
- Power generation plant £ TBA

All costs include professional fees.

A programme for the works is yet to be agreed however work on the power generation plant alone is expected to take around eighteen months for the design, installation delivery and setting to work. The bungalow heating and roadway/pathway heating could be worked into this programme, to ensure that these works are co-ordinated fully to the benefit of the Crematorium.

A European Union grant is being sought to fund part of the cost of the power generation plant. This however requires partnering from similar facilities in two other European Union countries. Whilst two possible partners have been identified at the time of writing this report, the application had not been submitted so it is not clear whether this funding would be available. It is unlikely that the power generation element of the work would proceed without this grant.

2. Introduction

DCC Technical Services (Mechanical and Electrical Section) have been commissioned by Alan José of Durham Crematorium to provide a Feasibility Study into the utilisation of the surplus heat produced by the crematorium in its day to day operation.

Three new cremators were installed in 2011-12 as part of a major redevelopment of the crematorium, to bring the facility into line with new emission legislation. The new cremators each produce a significant amount of waste heat; some of which is utilised for building heating, however the majority of which is currently discharged to atmosphere.

The committee who own and operate the crematorium wish to explore the possibility of utilising more of the waste heat for the following purposes:

- To generate electricity specifically for the crematorium but with the possibility of exporting surplus to the grid;
- To heat the two bungalows located near the main entrance to the site;
- To heat the roadway and paths in the area immediately around the entrance and exist to the crematorium building for the purpose of eliminating frost, snow and ice;
- To consider exporting heat further afield to Durham University buildings to the north of the site or Mount Oswald to the west of the site.

The report is based on the information provided in the commission document, together with a full review of record documentation and a site visit by Alasdair Cameron of DCC M&E Section in February and March 2013.

3. Project Details

Project Sponsor

Alan José FICCM, Superintendant and Registrar, Durham Crematorium, South Road, Durham, DH1 3TQ.

Project Title

Feasibility Study: The Utilisation of Surplus Heat at Durham Crematorium.

Project Budget

It is recommended that a works budget of £XXX,XXX be made available to carry out this project in its entirety.

The individual estimated budget cost for the proposals are as follows:

- Heating to bungalows £71,600
- Heating to driveways/paths £100,000
- Power peneration plant £ TBA

Depending upon which option is preferred. Building Control fees and Planning fees would be applicable to the project.

The above figures include professional fees at around 12.5%.

Design Team – Project Directory

Project Manager	Richard Fenwick (03000 268 120)
Lead Consultant & Mechanical Design Engineer	A. G. Cameron (03000 260 965)
Electrical Engineer	Alan Davies (03000 260 971)
Quantity Surveyor	Gordon Tabor (03000 268 127)
CDM Co-ordinator	B. Freear (0191 383 4023)

Consultees

DCC Asbestos Management Unit, Sean Durran (03000 261 217).
DCC Energy Management & Carbon Reduction Unit: Keith Slater (03000 265 546)
IFZW Cremator manufacturer & Installer: Danny Heinrich (+49 375 27767);
UAS Specialist power generation manufacturers: (+49 9942 9486)

Construction (Design and Management) Regulations 2007

The CDM Regulations will apply to the proposed works detailed within this document. The project will require notification to the Health & Safety Executive.

Principal client duties under the regulations are:-

All construction projects (Part 2 of the Regulations)	Additional duties for notifiable projects (Part 3 of the Regulations)
• Check competence and resources of all appointees (designers, CDM co-ordinators, contractors, specialists etc.). • Ensure there are suitable management arrangements for the project welfare facilities. • Allow sufficient time and resources for all stages (including adequate mobilisation time between appointment of contractor and start of work). • Provide pre-construction information to designers and contractors (details of location of services, asbestos information, access restrictions, ground conditions, drawings etc.)	• Appoint CDM co-ordinator.* • Appoint principal contractor.* • Make sure that the construction phase does not start unless there are suitable welfare facilities and a construction phase plan is in place. • Provide information relating to the health and safety file to the CDM co-ordinator. • Retain and provide access to the health and safety file. • The client must sign the F10 declaration form to confirm awareness of their duties under CDM 2007. **(* There must be a CDM co-ordinator and principal contractor until the end of the construction phase)**

4. Client Requirements

Brief

Refer to commissioning document, included in this report under Appendix A.

Additional Requirements

Durham County Council is committed to reducing its CO_2 emissions to 40% of its 2010 level by 2015. When installing any new plant therefore, consideration must be given to utilising plant which uses energy from renewable sources, where these prove to be financially viable.

Design Guidance/Regulations

- Chartered Institution of Building Services Engineers (CIBSE) *Guides A, B, C & H*, London CIBSE 2001-2005.
- HM Government, *The Building Regulations Approved document L (Conservation of Fuel & Power)* HMSO London 2010.

5. Site Investigations

Site survey

A detailed survey of the existing mechanical installation has been undertaken, within the main plant room of the crematorium, together with a full review of relevant record information held at the Crematorium and at County Hall. A brief visual survey of the Crematorium and the general site area was also carried out to ascertain the extent of any external pipework.

Restrictive Covenants

Not applicable.

Site Investigation Report

Not applicable.

Site Services

No alterations to existing site services have been identified, although additional underground heating pipework would be required as part of the proposal. A detailed survey and scan will be required at design stage to ascertain the position of existing external services, prior to any work being undertaken on site. The extent of external services is however expected to be well recorded, given the recent nature of work undertaken on site.

6. Statutory Approvals

Planning Permission

The preferred proposal is to locate new electricity generating equipment within a shipping container, located behind the main crematory building at the south east of the site. This would however necessitate that a suitable building treatment be provided to screen the container to ensure the final construction is sympathetic to the surrounding environment. Planning approval will need to be sought for such a building, should the Authority commit to design and implementation of the proposed scheme.

Design work relating to any necessary building work and alterations to the landscaping to cater for such a structure would be carried out by one of the DCC Architectural team members. The Architects Section would also be responsible for preparing and submitting Planning applications.

Building Regulations

It will be necessary to apply for Building Regulations approval as part of the design and implementation of the scheme. Liaison/communication with *Building Control* will be headed by the DCC Architects Section.

7. Programme

Critical Path

Given that the existing crematorium has recently undergone a major plant refurbishment, the purpose of this project is essentially improvement and enhancement of the existing estate. The programme given below is therefore set out on the basis that the proposals are not required to meet any particular timescale or completion date. Notwithstanding this, a suggested programme is included which would allow for procurement of the proposed generating plant during 2014 with delivery/installation during mid 2015. The roadway heating and bungalow heating could be designed and procured from late 2013/early 2014 and could incorporate an enabling works contract to construct an external screened area for the accommodation of the proposed containerised electrical generating plant. It would be necessary to complete the ground works before installation of the power generation equipment could commence.

The bungalow heating element of the project could be installed without affecting the operation of the crematorium, although connections into the heating system would need to be made outside of normal working hours. For the roadway heating, this would require temporary closure of each of the two public entrances to the building, although this has been approved in principle by the Crematorium. The Crematorium would be able to operate with limited disruption providing the management are given sufficient notice as to the proposed dates of construction and that the work is indeed completed within the agreed timescales.

For the power generation part of the project, this could also be installed without affecting the operation of the crematorium, although it would need to be commissioned and set to work outside of normal working hours. The ground works and external work required for the plant container could be carried out without affecting the operation of the crematorium, however due consideration must be taken to avoid noisy plant operations during ceremonies.

8. Architectural Design Report

By Architect

9. Structural Engineer's Report

Not Applicable to project.

10. Mechanical Engineer's Report

Heat Recovery: Bungalow heating

Two bungalows are located at the north west of the Crematorium site which are owned by the Crematorium but are rented to tenants under long term lease agreements. Each of these buildings is presently heated by a single gas fired condensing combination boiler. It would be possible to utilise waste heat from the Crematorium to provide heating and domestic hot water to each of these buildings.

This could be facilitated by installing a second pumped heating circuit which would run from the existing plantroom, located to the south of the main crematory room, to the bungalows on the western boundary of the site. The circuit would be connected to the existing 2500 litre accumulator vessel at the plantroom end and would circulate water from this point via a new set of dedicated heating pumps. Within the plantroom, the new steel pipework would connect to a pre-insulated plastic piping system before dropping below ground level and leaving the building. The pipework would then run externally, within a trench to the west of the main drive way in a northerly direction to the bungalows. The trench could be located within soft ground for almost its entire length, although it would need to cross the drive near the main gate (see sketch 1 in Appendix 2). The pipework would split in order to serve each of the two bungalows. It is suggested that the proposed heating circuit be connected to the existing bungalow heating systems adjacent to the existing boiler plant in each premises, where it would connect to a proprietary heat exchanger/metering unit.

The type of heat exchanger to be considered for heating each of the two bungalows would be able to provide domestic hot water in addition to central heating. This heat exchanger unit is similar to the type used on multi-tenant building which rely on a single primary heating system, although the water would be hydraulically separated by plate heat exchangers. The metering unit suggested would be able to quantify the energy consumed within each of the buildings to allow the tenants to be charged per kWh of heat used. It is intended that the existing combination boilers for each building be retained however as the waste heat would not be available when the crematorium is not in operation. Consideration will be given to locating the heat exchanger unit adjacent to the existing boiler plant within each building. The existing boiler for "Links View" is located within the garage and the existing boiler plant for "The Bungalow" is located east of the front door within a utility room.

The existing 2500 litre accumulator vessel would be of sufficient capacity to be able to provide a the full heating load imposed by the bungalows alone, however its energy capacity could be significantly depleted, by use of other waste heat systems (such as the crematorium building or driveway heating). Additionally, as the heat produced by the cremators reduces after a day's operation, the waste heat available is likely to drop off.

The existing heating control panel would require additional controls for the pumps at the plantroom end of the circuit. At the bungalow end, additional heating controls would be required to permit the heat exchanger units to work in conjunction with the existing combination boilers.

Heat Recovery: De-Icing of driveway/paths at entrance to Crematorium building

The Crematorium management have expressed a request for frost control of the drive and pathways to be considered for the external area, immediately adjacent to the crematorium entrance and exit (see sketch 2 in Appendix 2 which shows the approximate area of coverage). This type of system could be implemented and would again make use of waste heat produced by the crematorium.

The system would use a water/ethylene glycol mix which would be heated and circulated within a pipework grid located beneath the surface of the drive and the adjacent pathway. Such a system would incorporate thermal-insulation base upon which pipework would be laid, to prevent heat loss into the ground. The insulation compressive strength would need to be carefully considered to support vehicular traffic of the type commonly in use at the crematorium.

The system would consist of a third pumped heating circuit dedicated to driveway heating which would run from the existing plantroom, located to the south of the main crematory room, to the main public entrance and exit drop off points at the crematorium. The circuit would be connected to the existing 2500 litre accumulator vessel at the plantroom end and would circulate water from this point via a new set of dedicated heating pumps. Within the plantroom, a plate heat exchanger would be required to hydraulically separate the water within the 2500 litre accumulator vessel from the water/glycol mix which would need to be circulated through external pipework and could be subject to freezing. After the plate heat exchanger, the new steel pipework would connect to a pre-insulated plastic piping system before dropping below ground level and leaving the building. The pipework would then run externally, within a trench to the rear (east) of the main building, in a northerly direction to main entrance loop/drop off area. The trench could be located within soft ground for the majority of its length before connecting to the heating grid. Consideration would be given to installing a remote mixing manifold, which would be located externally, in the vicinity of the underground heating grid. This would be housed within a GRP box and would consist of pumps, controls and valves which operate to control the temperature of the ground in order to prevent frost and ice forming on the road and adjacent paved areas.

The existing 2500 litre accumulator vessel would be of sufficient capacity to be able to provide a the full heating load imposed by the driveway heating alone, however its energy capacity could be significantly depleted, by use of other waste heat systems (such as the crematorium building or bungalow heating). Additionally, as the heat produced by the cremators reduces after a day's operation, the waste heat available is likely to drop off significantly.

The existing heating control panel would require additional controls for the pumps at the plantroom end of the circuit, in addition to thermostats and manifold pump controls located near the main building entrance.

Heat Recovery: Off-site Heating

Consideration has been given to using heat waste heat generated by the crematorium, for heating neighbouring properties. Durham University has a number of buildings to the north of the site at its Ustinov and xxx Colleges. To the west of the site across the A177 road is the main historic building at Mount Oswald, although it has recently been announced that planning approval has been granted for the development of housing on the site of the Mount Oswald golf course.

These sites have been considered as potential users of waste heat, however it is unlikely that this would be a feasible proposal for the following reasons:

- There would be insufficient residual heat from Cremators 1 and 3, should the power generation proposal be adopted (which is a preferred proposal);
- There would be insufficient residual heat from Cremator 2, should either the bungalow or the driveway heat recovery proposals be adopted;
- Both sites are really too distant to be economically viable: Mount Oswald is at a distance of some 400m. Although the University buildings are as near as 280m however the ground levels are such that it would be impractical to install external buried pipework between the two sites.

It should be noted that formal enquiries have not yet been made with the owners of these buildings regarding the use of waste heat.

Heat Recovery: Power generation

Management of the Crematorium have expressed their interest in exploring the possibility of utilising waste heat from one or two of the recently installed cremators for the purpose of generating electricity for the crematorium.

Due to the highly specialised nature of this technology, it has been necessary to employ the skills of a team of specialists to consider this proposal. The team includes representatives from the recently installed cremator manufacturers, IFZW, from Germany and an engineering company (UAS) who specialise in the manufacture of turbine generator sets which utilise the Organic Rankine Cycle. This equipment enables the use of low grade heat for power generation by the use of a refrigerant which in is gaseous condition is able to power a turbine generator. Further details of the proposed plant are provided within Appendix C of this report.

Consideration has been given to locating this plant within garden equipment store, in the recently constructed building extension. This would however necessitate the construction of alternative accommodation for the garden equipment.

A more practical option would be to house the proposed electricity generating plant within a standard 20-foot shipping container. This would enable the plant to be accommodated on site within construction of a new building. Additionally, the plant could be fully assembled and tested at the manufacturer's own premises and delivered to site in full working order, within the container. A possible location has been identified at the rear of the existing crematory building, to the south east of the main crematorium. Consideration will be given to constructing appropriate screening for the container to ensure the final installation is sympathetic to the existing building and the surrounding environment in addition to meeting any Planning requirements.

This could take the form of a walled compound with gates, constructed to match the existing building.

A new access road would be required to permit service vehicles (i.e. light vans etc.) to access the container; this could be constructed around the southern perimeter of the existing crematorium. Delivery of the container would have to be by a suitable wagon however a crane would be required to lift the container over the existing cremator building and set it down at the rear. A contract lift should be considered for this operation.

It is acknowledged that the system has a high capital cost however it may be possible for the Crematorium Committee to obtain a grant from the European Union for part of the funds required. This grant is dependent upon the applicant forming a partnership with two other applicants for the same technology within two separate EU countries. Two possible partners have been identified in Belgium and Germany and an application is in the process of being prepared.
Keith Slater of the DCC Energy Management and Carbon Reduction Team has been tasked with compiling the application on behalf of the Crematorium Committee. Details of this application do not fall within the remit of this report.

Asbestos

The proposals covered within this report are confined to recently constructed areas of the main Crematorium building (completed in early 2012) which do not contain or make use of any asbestos containing materials. Alterations to plant and equipment would not extend into older areas of the existing building where asbestos materials could be present.

Minor alterations to the existing bungalows are proposed, however the asbestos management plan for the site does not indicate that these buildings contain asbestos materials in the areas where work is proposed. Notwithstanding this, it is still recommended that a *Refurbishment* type survey is undertaken prior to any works taking place within the bungalows. The main cost plan and risk register cover the cost of this survey and any necessary costs for remedial action, should asbestos be discovered within these buildings.

Ecology

To be added.

11. Electrical Engineer's Report

Electrical Distribution

Details to be added by Electrical Engineer

12. Cost Analysis

Estimated Costs

Based on recent similar projects, we would estimate the costs of the work to be as follows:

Proposal 1: Bungalow Heating

Building & trenching works	£10,000
Mechanical installation	£43,120
Electrical Installation	£3,000
Asbestos removal	£Nil
Preliminaries	£2,500
Contingency	£5,000
Design Fees	£7,953
Total Construction Cost	£71,573

Proposal 2: Roadway/Pathway Heating

Building, civil & trenching works	£36,000
Mechanical installation	£43,000
Electrical Installation	£2,500
Asbestos removal	£Nil
Preliminaries	£2,500
Contingency	£5,000
Design Fees	£11,125
Total Construction Cost	£100,125

Proposal 3: Power Generation

Building enabling works	£TBA
Containerised plant	£TBA
Electrical Installation for above	£TBA
External services/utility costs	£TBA
Preliminaries	£TBA
Contingency	£TBA
Design fees	£TBA
Total construction cost	£TBA

Exclusions

Feasibility study fees.

Procurement Strategy

The provision of heating to the bungalows and to the driveway/pathways at building entrance, could be procured through Durham County Council Direct Services. Bungalow heating could be procured separately through a mechanical services contractor if required. Procurement of the containerised power generation plant however is of a highly specialised nature and would have to be procured through the crematory installers IFZW and their specialist partner, UAS. To enable this, it would be necessary to obtain permission from a DCC Head of Service/Crematorium Committee, to carry out the procurement exercise as a *variation to contract procedure rules*.

Professional Fees

Professional fees of 12.5% of the total construction cost have been allowed within the cost plan.

Feasibility fees expended to date: (to be advised separately by Business Support Unit).

Historical Analysis

Not applicable.

13. CDM Co-ordinator

The following risks have been identified with the project to date:

Risk	Precautions
Working in an occupied area	Liase closely with management and staff on site. Maintain access and compound away from public areas. Erect fencing around construction area and provide clear directions of alternative routes.
Asbestos	Type 3 survey to be undertaken and 14 days notice to HSE prior to any works to asbestos containing materials. Works to be undertaken in accordance with HSE guidelines.
Craneage of containerised plant	Use contract lift. Obtain method statements prior to work being carried out.
Installation of new plant & heavy equipment	Break sections down & use lifting equipment
Hot work	Implement hot work permit system
Working in at high level	Use appropriate access platforms, ensure lighting is adequate.
Excavation works	Check record drawings, carry out Cat scan, utilise safe digging techniques. Ensure barriers around excavation work.

14. Risk Register

Item No.	Description of Risk	Probability	Impact	Action/ Mitigation	Action Owner	Cost
1.	Undiscovered asbestos	Low	Low	Type 3 survey	S. Durran	£1500
2.	Poor condition of existing distribution pipework	Low	Low	Disconnect pipes to check	Contractor	£1500
3.	Problems relating to ground works for containerised plantroom	Low	High	Full survey and detailed design	Contractor	£5000
4.	Unforeseen external services	Low	Medium	Carry out CAT scan before work commences	Contractor	£5000
5.	Unforeseen electrical work	Low	High	Carry out load check during design	Client	£5000
6.	Unforeseen works relating to power generation installation	High	High	Allow contingency	Client/ designer	£10,000

A contingency sum of £20,000 has been allocated within the cost report to cover all risk items associated with the proposals.

15. Conclusion and Recommendations

Summary

The proposals within section 10 complies fully with the requirements of the brief for the project.

Option Appraisals

Four option proposals are included within this report, as follows:
Heating to Bungalows
De-Icing of road/pathways at entrance and exit to Crematorium;
Off-site heating
Power generation

Each option is discussed in detail within Section 10 of the report.

Recommendations

It is recommended that the proposals for heating to the bungalows, de-icing of the road/pathways around the crematorium entrance/exit and power generation be adopted. See Section 10 for details.

Clients Action

Consider cost of project and commission DCC Technical Services, to design and implement the scheme as proposed.