Boiler House Refurbishment and Ventilation Controls Upgrade with Energy Performance Related Payments at Dublin Port Headquarters

Energy Performance Related Payments (EPRPs) are used in energy retrofit projects to provide a guarantee to the client that the anticipated energy savings will materialise. Two energy efficiency upgrade projects completed last year by Dublin Port Company employed EPRPs to incentivise the consultant and contractors to maximise the energy savings. Cian O'Riordan describes the projects and outlines the innovative payment approach employed.

Crane lifts new boilers and microCHP to rooftop boiler house

Introduction

When Dublin Port's Maintenance and Services Manager, Ciarán Callan, watched two more leaking boiler tubes being plugged in the 30 year old oil-fired combi-boilers at the Port Centre offices in October 2011 he knew it was time for an upgrade. Oil prices were now almost twice that of gas and the existing installation was likely to be operating at less than 60% seasonal efficiency. Ciarán was aware that efficiencies in excess of 85% could be achieved with a modern condensing boiler installation and precisely engineered controls.

A solution for the control of the building's Variable Air Volume (VAV) boxes, which regulate airflow from the Main Air Handling Unit (AHU) to the various office zones in the building, was also required. The VAV boxes were pneumatically controlled, but not regulating space temperatures satisfactorily and Ciarán was convinced they were highly inefficient.

Despite the challenging budgetary climate, if he could make a convincing case that the energy savings would pay for the works within a reasonable period of time, he would be in a position to secure the required capital funding. Ciarán contacted energy consultants PowerTherm Solutions and asked them to carry out a feasibility study.

PowerTherm concluded that electricity savings of at least 7% and fossil fuel savings of 20-25% could be achieved. The potential savings were valued at €39,000, and the reduction in CO_2 greenhouse gas emissions would be 114 tonnes per annum. PowerTherm Solutions carried out a detailed energy efficiency retrofit design and the Sustainable Energy Authority of Ireland co-funded the project under their Better Energy Workplaces 2012 scheme, providing 35% of the overall project costs.

Boiler House Refurbishment

The Boiler House Refurbishment project consisted of removing the two existing oil fired combination boilers, the Low Temperature Hot Water (LTHW) circulation pumps, associated pipework, the Motor Control Centre (MCC), controls panel and associated pneumatic controls.

The new installation consisted of two new fully modulating and condensing gas-fired boilers (286kW each) plus a micro CHP (4.5kW electrical, 12.5kW thermal output) with a condenser module. A vertical low loss header with integral air and dirt separator was installed to prevent hydronic imbalances and protect the new installation from any particles returning from the existing LTHW system. New LTHW pumps, pipework, valves and commissioning sets were installed and lagged. To replace the hot water element of the original combi-boilers a new Domestic Hot Water (DHW) calorifier, heated from the LTHW system, with a backup electric immersion was also installed. As there was previously no gas on site, a new gas supply was required. The boiler house is located on the roof of the building so it was necessary to run the new gas line up the side of the building, hidden from view behind a structural column. Insulated flues and condensate drains were also required for the new boilers. The new MCC and Building Management System (BMS) controls panel is electronic and so all pneumatically controlled devices were replaced with motorised actuators.

Despite the small size of the CHP (which allows it to run during the summer to accommodate domestic hot water requirements only), its operation would be normally restricted to office hours and hence day rate electricity tariff (i.e. 8am to 6pm, Monday to Friday; as an office building there is no load at night time). In order to increase the useful operating hours of the CHP two thermal storage "buffer" vessels were installed and connected in series to effectively operate as one vessel (space restrictions in the plant room meant one vessel would not physically fit). When heating is no longer required at the end of the working day, the CHP is switched over to charge the buffer vessels. The following morning, before daytime electricity tariff, the controls switch over to discharge the stored heat from the buffer vessels into the heating system. This arrangement has allowed the CHP operation to be extended by up to 4 hours per day, significantly improving its return on investment.

A number of key design features were implemented to maximise the efficient operation of the boilers in condensing mode, such as widening the flow-return temperature difference, and weather compensating the system flow water temperature. These were engineered in technically specific ways to maximise system efficiency and avoid any operation issues.

Measurement and verification (M&V) of the improvement in the LTHW system efficiencies and quantification of the associated energy savings was a key element of the project. To facilitate this, a comprehensive metering and monitoring system was installed. Individual gas meters were installed on the boilers and the CHP, and heat meters were installed on the output side. An electricity meter was installed on the MCC panel, as was a dedicated meter for the CHP electricity output, and water meters were installed on the LTHW and DHW cold feeds. All meters were connected to the BMS and usage is logged at 15-minute intervals.

Considerable effort was required from the project team over a number of months to fine tune the control and maximise the performance of this relatively complex installation.

New condensing gas boilers and pipe work

Ventilation Controls Upgrade

The ventilation controls upgrade involved removing the existing pneumatic controls of the VAV boxes throughout the building and installing new BMS control units, damper mounted electro actuators and room temperature sensors. The more accurate control hardware coupled with the ability to now control each zone and VAV from the BMS, allows the system to be tuned to local requirements. The vast majority of VAVs have no local reheat batteries or cooling coils, so the supply air temperature of the Main AHU has been weather compensated and a "free cooling" dead-band created between heating and cooling modes. Improved regulation of individual zone ventilation has resulted in lower overall air volume requirements and reduced AHU fan speed (controlled dynamically in association with the VAVs air flow requirements).

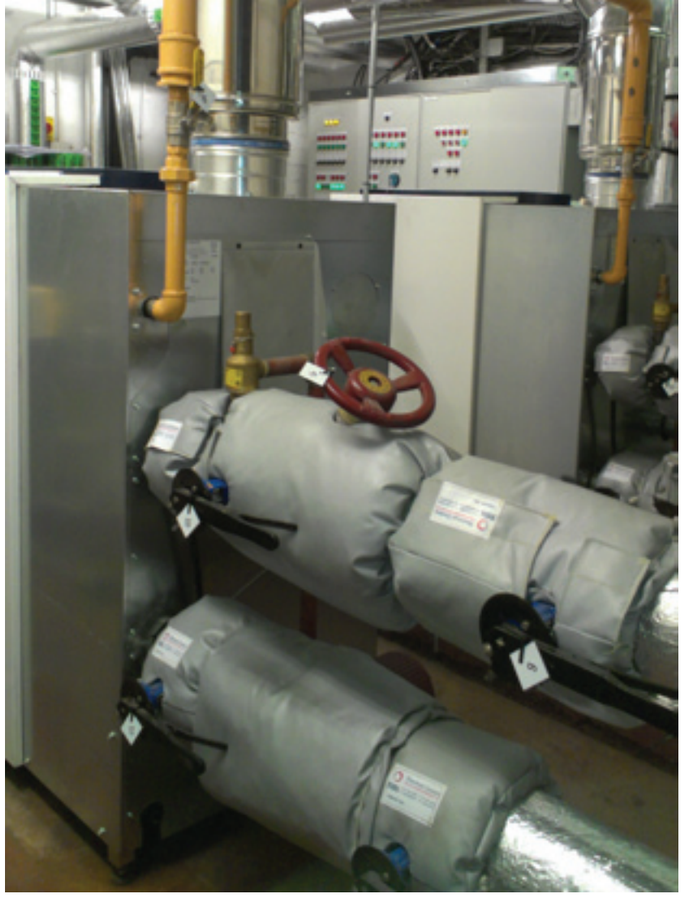
Energy Performance Related Payments

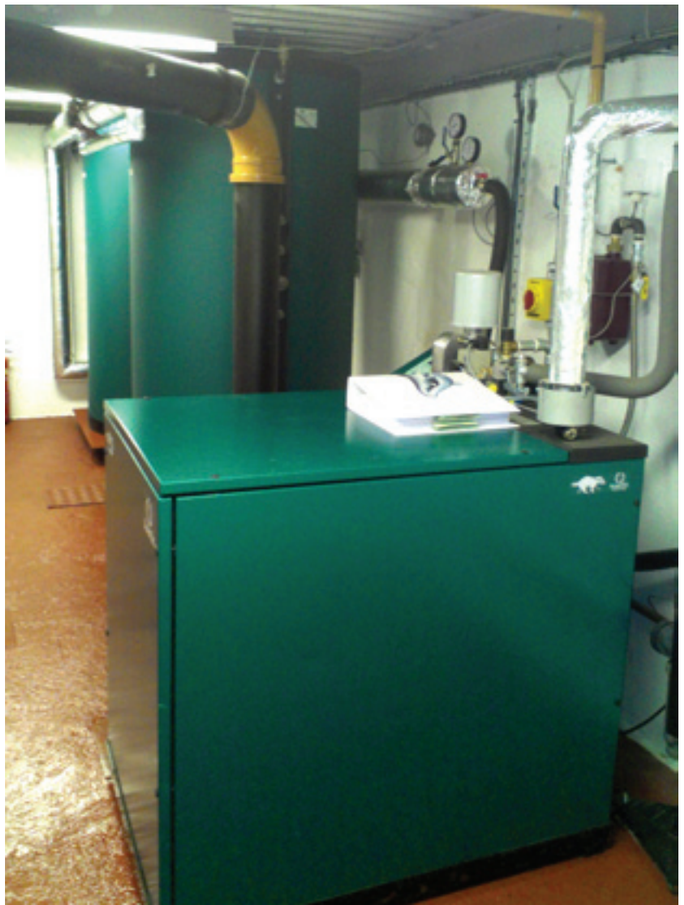
As the Maintenance and Services Manager had justified the projects as energy efficiency capital investments with a payback, he was anxious to secure a guarantee that the energy savings would be achieved. A meaningful guarantee would incentivise the consultant and the contractors to remain involved with the project until savings were realised, thereby reducing the risk to Dublin Port Company.

For the Boiler House Retrofit the consultant (PowerTherm Solutions) and the main contractor (T. Bourke & Co.) each guaranteed separately to the client that the project would achieve a minimum 15% energy efficiency improvement in fossil fuel use. If this guarantee was not achieved, each would lose 7.5% of their respective contract values.

So, in addition to the standard Works Retention of 5%, an Energy Performance Guarantee Retention of 7.5% was included. The standard NEC3 Engineering & Construction Contract was used, but with a short additional clause detailing the terms of this energy guarantee retention.

Where project savings are to be accurately quantified for contractual purposes a Measurement and Verification Plan is required, which must include baseline energy data. PowerTherm Solutions, whose consultants are Certified Measurement and Verification Professionals (by the Association of Energy Engineers), prepared the M&V plan, which was signed off and agreed with the client prior to any works taking place.





A slightly different arrangement was implemented for the Ventilation Controls Project, as it was concluded that tuning and optimising the system would be critical to realising the savings. As such, a Pain/Gain Share Arrangement was put in place for PowerTherm and the controls contractor (Standard Controls Systems). If 100% of the target electrical kWh savings are achieved, the parties would receive 100% of their respective fees. For each 1% of additional savings, they would receive a bonus of 0.5% of their fee, up to a maximum of 5%. For each 1% savings fall short of target, they incur a penalty of 0.5% of their fee, up to a maximum of 5%.

It was noted that the Ventilation Controls Project would achieve indirect heating and cooling-related savings, but that these would be very difficult to accurately quantify. So a proportionate approach to these savings was adopted; performance was measured by evaluating the direct electrical savings recorded by the Main AHU variable speed drives. If these savings could be verified, Dublin Port could be confident that the indirect savings would follow. A separate Measurement and Verification Plan, including the relevant baseline data, was also prepared for the Ventilation Controls Project.

For both projects the performance related payment elements of the contract were outlined in detail in the Tender documentation, so all involved were aware of the requirements from the outset.

Actual Performance

The M&V plan outlined twelve months as the term for the measurement and verification of savings, which continues at the time of writing. The year to date savings, to the end of July, have been quantified however; electricity savings are currently 12% (55,000kWh), while the (non weather corrected) fossil fuel savings are currently 18% (93,000kWh). At current rates both the electrical and fossil fuel savings will exceed targets, which will result in the contracting parties receiving the total fee for the boiler house project and a bonus payment for the Ventilation Control project.

Conclusions

The projects are summed up by Project Manager David Browne as having many of the more 'traditional' retrofit project challenges, as well as the energy efficient element challenges at design, installation and commissioning stages, which brings a whole host of additional complexities.

"Both projects brought their own intricacies and challenges. The Boiler House project for example had many levels of difficulty which had to be overcome, none more so than the fact that the plant room is located on the roof of a five storey building with only a small passenger lift and stairwell access. The logistic issues around removing the old plant, locating the new plant and installing a gas pipeline to roof level were considerable. Similarly with the Ventilation Controls project; a lot of the VAV retrofits were in occupied office areas, above suspended ceilings, so we had come up with some innovative work approaches to minimise the impact to the building's occupants.

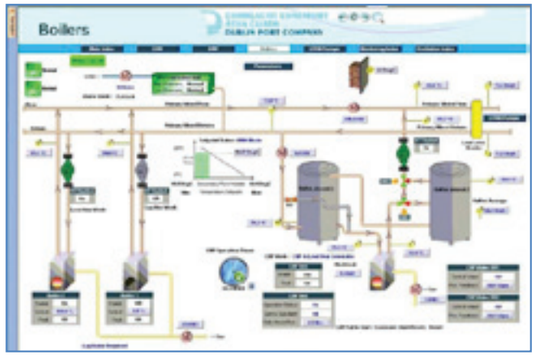
The mechanical and control elements of the design were paramount to achieving the targeted savings, and this added a high degree of technical complexity to the installation. Control valves, sensor pockets, secondary pipework tie ins etc. all had to be installed specifically as per design in order for the system efficiency to be maximised. We were working

within an existing boiler house of limited space, and this constraint meant that all aspects of the installation had to be extremely precise. We were lucky to have assembled an excellent project team; from a knowledgeable, helpful and understanding client team to the contractors and sub contractors that really devoted themselves to the projects, maintained a positive 'can do' attitude throughout and took pride in their very high standard of workmanship. The net result is two original, very rewarding and successful projects; from an operational and an energy efficiency point of view."

At a technical level, the boiler house project demonstrates that considerably more energy savings can be achieved by refurbishing a boiler house and using customised controls than by simply replacing an inefficient boiler with a high efficiency unit.

At a contractual level, both projects demonstrate the advantage of including an incentive based payment element into the project. Dublin Port Company will not only see target savings achieved, but exceeded. A straight forward example of this is the implementation of the complex control strategies that were integral to the upgraded systems operating as efficiently as possible, without compromising on occupancy comfort. These control strategies require considerable time and effort to commission and fine tune, and as such can easily be left incomplete and ineffective. In this case consultant and contractor alike worked tirelessly to fine tune all control based operations.

All too often complex energy projects fail to realise the savings outlined in the original design and specification. There are often varying reasons for this, but the primary ones can usually be traced back to the fact that, financially at least, only the client stands to gain from any savings achieved. By incorporating an EPRP element into the contract, all members of the project team (client, consultant, and contractor) are invested in maximising the energy savings and the success of the project. Using a pain/gain arrangement is likely to provide an even greater incentive to tune the system than a fixed minimum threshold target.



Controls graphic illustrates the new installation and control

Selected Project Details

Client – Dublin Port Company

Site – Dublin Port Centre Building

Energy Consultancy, Design & Project Management - PowerTherm Solutions

Mechanical Contractor - T. Bourke & Co.

Controls Contractor – Standard Control Systems

Boiler Plant – Rendamax R600 units supplied by Eurogas, 2 x 286 kW

CHP Plant - Senertec micro condensing unit & buffer tanks supplied by Kinviro, 4.5kWe/12.5kWth

Cian O'Riordan is Managing Director of PowerTherm Solutions. He acts as consultant to organisations wishing to develop, procure and implement Energy Performance Contracts (EPCs). He has undertaken extensive work for SEAI in the area of EPCs and EPRPs.