

Eccup No.1 WTW - Hydroelectric Scheme

hydroelectric installation fully integrated with the previously existing operation to generate up to 700MWh of electricity per annum

by Zoe Kevanhu BEng (Hons)

Eccup No. 1 Water Treatment Works (WTW) is situated within the Eccup Complex approximately 6 miles to the north of Leeds adjacent to Eccup impounding reservoir. The WTW was originally commissioned in 1965 to treat water from the Washburn Valley Reservoirs and provide potable water for many distribution areas within Leeds and Harrogate. The current operating range of the WTW is around 32,000m³ - 64,000m³ per day. The inlet works at Eccup No.1 WTW is connected to the lowest of the Washburn Valley Reservoirs, Swinsty Reservoir, some 18.5km to the north west of the WTW, via the Washburn Valley Mains; one 42" and four 30" cast iron mains.



Turbine installation - Courtesy of JN Bentley

Background

Yorkshire Water's vision is 'taking responsibility for the water environment for good', with one of their strategic objectives to achieve this vision being the use of sustainable resources - to get the most out of them and reduce emissions and waste in line with their Corporate Challenge.

This was a key driver for the Eccup Hydroelectric scheme, supporting YWS's drive towards ascertaining new and sustainable means of utilising natural resources, with the aim of achieving their target of generating 14% of their own electricity needs through renewable means by 2015.

In 2008 YWS commissioned a feasibility study and a report was produced into the potential commercial viability for renewable energy installations within the YWS clean water network. The report identified the inlet mains at Eccup No.1 WTW as a potentially viable location for a hydroelectric generation facility. At this point energy was being lost as the inlet water stilled within the inlet channel of the works which could be recovered by such an installation.

Reinforced by the introduction of more generous 'Feed-in Tariffs' for the installation of renewable energy sources by the UK government in 2010, in September 2010 YWS contracted MMB (a joint venture between Mott MacDonald and JN Bentley) to carry out Early Contractor Involvement (ECI) in the form of an Investigation Contract under the AMP5 Framework model for 'Other Installations'. An ECI report was produced evaluating the commercial viability of a hydroelectric generation installation at Eccup No 1 WTW.

Through interrogation of flow and pressure data from historic records and site trials by MMB, turbine selection with Gilkes & Gordon Limited (Gilkes) and development of a detailed hydraulic model and surge analysis trials with sub-consultants Hydraulic Analysis Limited (HAL), value engineering evaluations were undertaken. Such evaluations facilitated the specification of several key plant items. These included:

- The type and size of hydroturbine to offer the greatest potential for generation over the widest range of works operating flows and mains pressures.

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- The type and stroke times of isolation valves to reduce surge effects on operation.
- Inlet water screening requirements with a view to limiting head loss.

Evaluations of all options were developed on the basis of balancing the greatest potential for energy generation while limiting the potential surge effects on the inlet works and upstream system.

The MMB commercial team were able to prepare outline cost estimates based on the specifications developed in the production of the ECI report and conclude that, based on several options presented for further consideration and detailed development, the installation would have an estimated payback period of around 6-8 years. The information contained within the report facilitated the client in securing the required expenditure from within the business for the scheme to proceed to delivery.

MMB were contracted in July 2011 under the AMP5 Framework model for 'Other Installations' for delivery of the hydroelectric generation scheme. Working in partnership with surge analysis experts Hydraulic Analysis Limited, hydropower sub-contractor Gilbert Gilkes & Gordon Limited, control specialist CEMA Limited along with other valued supply chain members, MMB developed, installed and commissioned a horizontally mounted Francis turbine with asynchronous generator in a new hydroturbine building immediately upstream of Eccup No.1 WTW inlet works.

Key design challenges

Dynamics and Surge: A constraint within the contract was to not adversely affect the current operation of the Washburn Mains, as a result of surge pressures from operation of the hydroturbine. Through the development of a detailed hydraulic model and carrying out surge analysis trials, in association with HAL, it was possible to select items of equipment and develop an operating philosophy which minimised the generation and magnitude of any surge.

The dynamic effects of the hydroturbine necessitated the installation being founded on a monolithically cast slab. The shuttering details for such a slab, incorporating several pits and raised plinth areas was challenging, as well as the co-ordination for concrete deliveries to ensure they were on time as waiting between batches would not have been acceptable.

Pipework arrangements: Existing pipework arrangements at the inlet works were such that the installation of our pipework was directly adjacent to the concrete structure of the inlet works. In addition, the bypass main, which was to maintain the flows to the

works until the turbine was commissioned, shared a thrust block with the main into which we were connecting. Stitch drilling was undertaken to free the pipe for connection. It was imperative that the works remain operational throughout the construction and as such co-ordination, planning and accuracy were key to ensure the inlet flow was not compromised.

Due to programme constraints to meet the clients key date requirements, coupled with extended lead times on plant items as a result of market conditions at the time, it was necessary to install large diameter pipework prior to the installation of the hydroturbine plant items themselves. As the pipework needed to be cast into thrust blocks at several locations as it was installed, removing any flexibility in the pipework, a bespoke rig was constructed to the dimensions of the final equipment connection points to ensure accuracy.

Through design development with our sub-consultant Gilkes; it was possible to develop a horizontal draft tube section as an alternative to the usual vertical, which would free discharge into a chamber. This enabled us to optimise the pipework arrangement to suit the spatial constraints as described above. The alternative draft tube also removed the need for an additional reinforced concrete structure, providing capital efficiency for the client.

Hydroturbine House: Capital efficiencies were also found in the development of a removable section to the roof of the hydroturbine building. Should the need arise, this will allow removal of the hydroturbine and generator, through the roof as part of a planned removal activity. Due to the relative infrequency of this activity, this option was developed with the client as a suitable and cost efficient alternative to the inclusion of a large permanent lifting arrangement and a larger building to suit this.

The size of the building which houses the installation was a key issue as the Eccup Complex is within the green belt and was subject to planning permission requirements. Close liaison with Leeds City Council Planning Department, including site visit, telephone conversations and responses to requests for additional information resulted in full planning permission being granted for the scheme.

The housing is a brick building with a flat roof. This is fitting with the existing surrounding buildings on the Eccup complex and as a result was satisfactory to the Planning Department. From a cost point of view, MMB carried out a cost comparison of a traditional building versus a secure GRP/steel kiosk type structure which demonstrated that, for the size of structure, a traditional build could be completed for less cost as a result of the utilisation of MMB employed labour, thus providing best value for the client.



Installation of hydrogeneration plant items - Courtesy of JN Bentley



Construction of the hydrogenation facility in close proximity to existing structures - Courtesy of JN Bentley

Supply chain interaction

JN Bentley have an extensive skills base within their employed staff and at times the ability to resource tasks at short notice from within this pool, and the flexibility this offers, has proved invaluable to the success of the project in both cost and programme. However, JN Bentley also maintain strong relationships with many sub-contractors offering better value for the client when this is an option. For this project in particular, reinforced concrete sub-contractors, pipework suppliers and roofing detailers and fitters were of particular benefit due to the complexity of some of these items.

Through development of positive working relationships with the sub-consultants involved at the Investigation stage it was possible for MMB to work with these parties during the delivery of the project to develop innovative design details leading to cost efficiencies and programme savings for the client as previously identified.

Programme

The hydroturbine was installed to achieve the client's key date of 31 March 2012. Due to unforeseen restrictions within the Yorkshire Water raw and clean water networks the facility was required to operate on reduced capacity initially. Alterations within the network have subsequently taken place enabling commissioning checks at full capacity to take place during December 2012, allowing the facility to now generate to the design capacity.

Conclusion

Through thorough data gathering, innovative design development and successful planning and co-ordination, it has been possible to deliver a 700MWhpa facility to supply electricity to help power the treatment processes of Eccup No.1 WTW.

By value engineering and searching for the most efficient solutions throughout the scheme we have been able to provide capital efficiencies and best value overall for the client.

MMB have worked collaboratively with all parties involved, client, sub-consultant, sub-contractors and third parties, at all stages of the scheme, and this has been key to achieving the desired outcomes of the scheme successfully.

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Completed hydroturbine building - Courtesy of JN Bentley