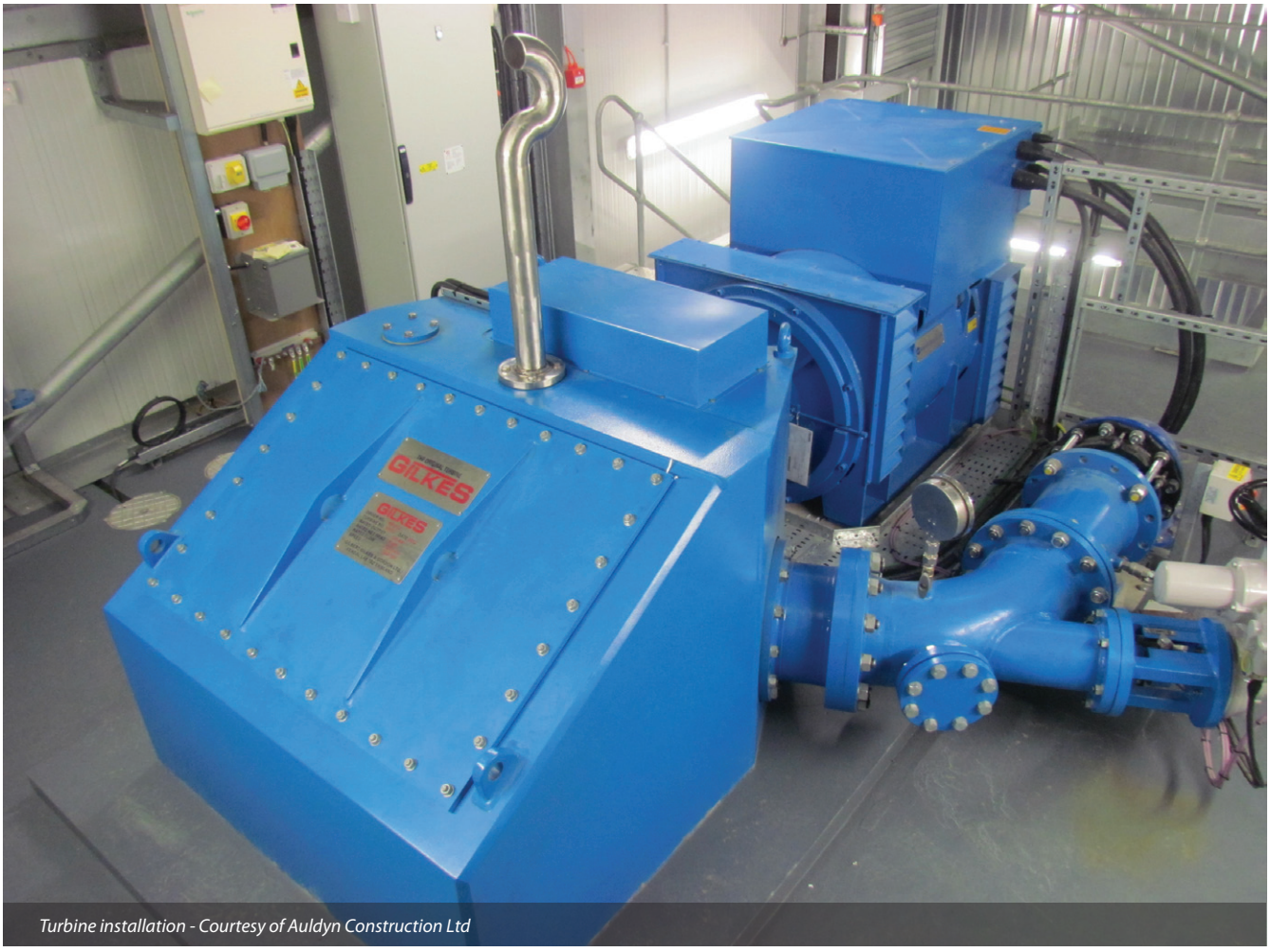
Sulby WTW Energy Recovery Scheme

hydroelectric scheme generates power from incoming raw water on the Isle of Man

by Tim Woakes MEng CEng MICE

The Isle of Man Water & Sewerage Authority has recognised that due to increasing energy costs and local and global initiatives to reduce carbon emissions they have an obligation to investigate the viability of and pursue sources of green energy. As such they have undertaken an ambitious project to convert the potential energy stored in the Sulby Impounding Reservoir into electricity to power Sulby Water Treatment Works (WTW) by passing the raw water through a turbine prior to the treatment process.



Turbine installation - Courtesy of Auldyn Construction Ltd

Background

The Isle of Man is a self governing Crown dependency which, through its ancient parliament Tynwald, enjoys a high degree of domestic legislative and political autonomy. The Isle of Man Water & Sewerage Authority is a statutory board, charged with ensuring the economic, efficient and effective provision of the services and infrastructure necessary to meet the Island's needs in terms of a wholesome supply of drinking water and the treatment and disposal of sewage.

Sulby WTW, sited on the bank of the Sulby River and completed in September 2005, is one of two modern treatment works on the Isle of Man. Sulby WTW supplies drinking water to approximately 30% of the Island's population mainly in the North and West. The treatment works is fed from Sulby Impounding Reservoir which has a capacity of 4.8 million cubic meters of water when full and a direct catchment area of 16 square kilometres.

The top water level when full is 185m AOD, and the top 4m of water is available for use by the Manx Electricity Authority (MEA) who have a connection to the scour pipe leading to a 1MW hydroelectric power station in Sulby Valley, which discharges directly into the Sulby River. Once the water level is drawn down to 181m AOD the MEA no longer generate electricity, as the storage within the reservoir below this level is solely required for drinking water.

A 300mm ductile iron (DI) pipe connects to three draw offs within the reservoir, the use of which depends on the water level and the seasonal variation of water quality. Approximately 2km down Sulby Valley the main splits into two.

The 300mm DI pipe continues 3km down to the WTW, and is duplicated by a newer 400mm DI pipe. Both mains enter the basement of the works downstream of a swab receiving facility on the opposite side of the Sulby River.

The WTW site is at approximately 35m AOD, with the water level within the inlet blending chamber some 7m above ground level. The excess pressure is destroyed by the flow control valves on the two inlets to the works to prevent over topping of the inlet blending chamber. The works currently processes an average of 10-12MLD, with a capacity of 21MLD for future demand increase.

The Isle of Man Water & Sewerage Authority recognised that due to increasing energy costs, combined with local and global initiatives to reduce carbon emissions that they have an obligation to give due consideration to 'sources' of green energy. Given the consistent flows and a static head of up to 150m at the inlet, Sulby WTW was identified as an ideal location to recover energy using a hydroelectric turbine.

The scheme

The objective of the scheme was to construct a hydroelectric turbine at Sulby WTW to give the shortest payback period with least impact on the existing treatment process. Various studies were undertaken to determine the options available. The conclusions were that the following permutations of the concept should be considered further:

- A machine on top of the WTW inlet blending chamber.
- A machine in its own new turbine house outside, but close to the WTW. This option then required water to be pumped to the WTW's inlet blending chamber.
- A machine in its own new turbine house attached to the WTW building. The turbine would be at a level such that water flowed under gravity into the WTW's inlet blending chamber.

A review of the technical feasibility of each scheme was then undertaken. It was determined that a machine placed on top of the blending chamber would only be feasible if the roof height was increased in its immediate vicinity. Discussions with the Planning Department ascertained that planning permission was unlikely to be granted for this and therefore this option was discounted.

The Planning Department confirmed that the construction of an annex adjacent to the existing WTW would be acceptable on the proviso that it matched the existing works aesthetically and its roof level was not greater than that of the existing WTW.

A whole life costing exercise was undertaken to ascertain which of the two remaining solutions gave the highest return over a 20 year design life. It was determined that a machine at a level such that no interstage pumping was required was the preferred option, to be installed in a new annex immediately adjacent to the existing works.

Investigations were subsequently undertaken into the type of turbine which would be most suitable for this flow/head scenario. This activity resulted in a recommendation that the following types of turbine could be utilised at Sulby WTW:

- Pelton Turbine.
- Turgo Turbine.
- Crossflow turbine.

A design and build team, comprising Isle of Man contractor Auldyn Construction Ltd and Northern Ireland based designer Atkins, was appointed to progress the scheme. The team approached turbine suppliers Gilbert Gilkes & Gordon Ltd of Kendal, Cumbria to assist with the design and ultimately supply the turbine.

A single Turgo Impulse turbine was chosen as the most efficient turbine for this combination of flow and head. The turbine and associated pipework was designed to operate up to 16MLD, flows above which would utilise the second stream into the works.

Annex steel frame - Courtesy of Isle of Man Water & Sewerage Authority

Internal pipework and supports - Courtesy of Auldyn Construction Ltd

Swab launcher at Sulby Dam
Courtesy of Isle of Man Water & Sewerage Authority

Completed annex
Courtesy of Isle of Man Water & Sewerage Authority

The design and build team supported by the Authority's cost consultants EC Harris completed a design, gained planning approval and built up a target cost for the scheme. The target cost was subsequently audited by EC Harris and accepted by the Authority. An NEC3 Option C Contract was awarded for the construction phase of the scheme in February 2012, and work commenced on site that month.

Maximising return

The pipes connecting the water treatment works and the impounding reservoir were known to suffer from high headloss. Pressures exhibited at the works suggested that the pipes had a C value of around 90 to 100 and were in urgent need of cleaning.

The high level of manganese deposition within the first stage filter nozzles suggested that the pipes were likely to be coated with a significant build up of manganese and silts. It was therefore decided that a swabbing exercise should be undertaken prior to the completion of the turbine scheme.

A purpose built swab launcher existed on the newer 400mm pipe but only a removable hatch was present on the older 300mm main. A swab receiver adjacent to the treatment works, but on the opposite side of the river catered for both mains but no realistic environmentally acceptable method of disposing of the dirty water was in place, and hence the mains had not been swabbed effectively for many years.

The first phase of the swabbing exercise was to undertake enabling works. A new swab launcher was installed at the head of the 300mm main at the base of the dam. In order to manage the dirty water which would accompany the swab down the main an old settling tank with a capacity of 300m^3 was connected with 225mm HPPE pipe to the swab receiver, utilising old redundant pipework to cross the river.

These enabling works allowed the swabbing exercise to take place. The dirty water was allowed to settle in the old tank before being decanted into the adjacent river.

Following the swabbing exercise the pressures at the water treatment works increased substantially, with the C values increasing to over 120, corresponding to an increase in 10m head at 10MLD and over 25m head at 16MLD. This has almost doubled the power predicted to be produced by the turbine over the next 20 years.

An additional function to maximise return was included by way of a dump to river facility. This allows flow over and above that to be treated by the works to be passed through the turbine and dumped to the river. This will only be utilised when the impounding reservoir is spilling.

Construction

Construction commenced on the 11 June 2012 with the breaking out of concrete hardstanding in readiness for the piling work which would form the foundation for the steel frame of the annex. A total of 13 (No.) 220mm diameter steel piles were installed and a ground beam constructed above. The steel frame was then installed and the concrete floor of the turbine level cast. This was designed to reduce vibration within the annex.

The annex was subsequently clad with a combination of green oak and Manx stone to match the existing treatment works building and adhere to planning requirements.

The internal ductile iron pipework and galvanised steel supports were installed following the commissioning of the roof level crane. This was also utilised to lift the turbine into place. One of the two inlet pipes was intercepted and diverted out into the turbine annex before re entering the existing building and back into the inlet blending chamber.

Within the existing treatment works building various modifications were undertaken to connect the turbine pipework into the existing. A number of planned works shut downs were utilised to undertake these connections in a safe and controlled manner. 'Spectacle' blanking plates were used to keep the existing pipework and the new pipework separate, until the turbine was suitably commissioned utilising the dump to river facility 'off-line'.

Tycon Automation Ltd and Saftronics Ltd provided significant software support during the scheme. New software was written and installed to seamlessly incorporate the turbine into the control philosophy of the existing works. A vast array of new cabling was installed to connect the new turbine panel in the annex with an existing panel in the main MCC room.

Once all parties were content with the operation of the turbine the spectacle plates were removed and the turbine fully commissioned running water into the treatment works. The turbine began generating electricity on the 1 February 2013.

The turbine currently generates around 90-100kW, approximately 40% of the electricity required to treat water at Sulby WTW. The £950,000 scheme is expected to have a payback period of approximately 9 years.

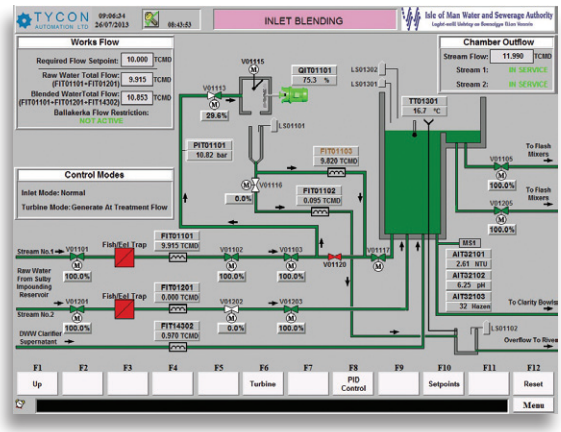
Future schemes

The Authority is now undertaking feasibility studies to ascertain the viability of installing energy recovery turbines at other sites across the Isle of Man.

The Editor & Publishers would like to thank Tim Woakes, Project Delivery Manager with Isle of Man Water and Sewerage Authority, for providing the above article for publication.

New turbine panel within annex - Courtesy of Auldyn Construction Ltd

Connection to existing blending chamber - IOMWASA



Sulby WTW inlet SCADA showing turbine - Courtesy of IOMWASA