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## Modern plant

New equipment at the Blue Lake Expansion Project

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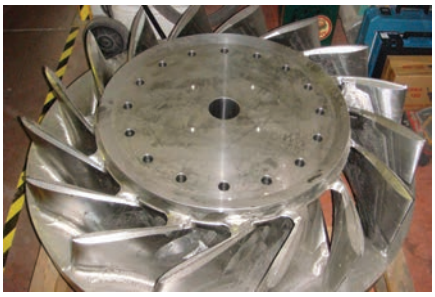
# One-of-a-kind modernisation

When Gilkes was awarded the equipment contract for the Blue Lake Expansion Project in 2010, its engineers were excited for the challenge and relished the opportunity to be involved in such a complex mechanical and civil, one-of-a-kind plant modernisation project.

Established in 1853, Gilbert Gilkes & Gordon Ltd (Gilkes) exports small hydropower solutions to over 80 countries from its main manufacturing facility on the edge of the Cumbrian Lake District, in England. Drawing on the vast experience it has gained from designing, manufacturing, installing and commissioning hydro projects, Gilkes prides itself on its plant modernisation. The Blue Lake Expansion Project was a fantastic opportunity to demonstrate these skills, particularly due to the scale of the project and location of the site.

The City of Sitka is situated on the west side of Baranof Island in the southeast panhandle of Alaska. In an average year, Sitka receives almost three times more rain than Seattle; this water is used in two hydroelectric power plants that supplies 100% of the required electricity to the town. In recent years, Sitka had experienced load growth due to two major factors: oil prices and seafood processing. With oil prices rising considerably between 2002 and 2008 many businesses and residents converted to electric heating systems which were more cost effective, but placed an increased load demand on the grid. An additional seafood processing plant also came online in the same time frame, increasing the load demand further still.

The two original Blue Lake hydro turbines which



were installed in 1959 were struggling to supply enough power to the city, and additional power sources were explored. Initially it was envisaged that refurbishment of the existing units plus the addition of a further single unit at Blue Lake would be sufficient. However it was soon clear that to satisfy the already increased load and any future power requirements of the city, a new, larger hydro project would be needed with a full modernisation and replacement of the existing two turbines.

Dean Orbison, Blue Lake Project Manager, commented: "A detailed turbine and control specification was developed for the Blue Lake Expansion project by the City of Sitka. The equipment was advertised for competitive bids and Gilkes was selected, based on a best value evaluation of the bids received."

Primarily the plant modernisation arrangement would be three new 7140kW Francis units at the upgraded Blue Lake powerhouse. A smaller 1625kW Francis unit, uprated due to the increased net head, was installed at the Fish Valve facility. This utilises the water that must be pumped from the Blue Lake Dam directly to the creek to conserve and promote salmon populations.

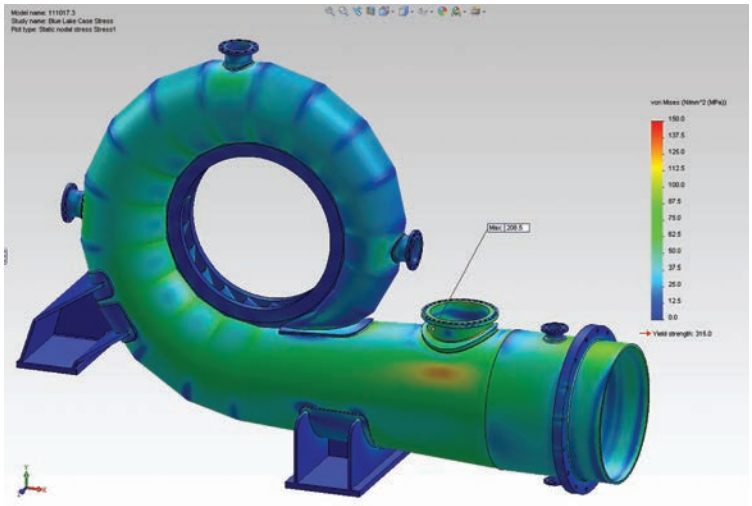
At the forefront of this project with Sitka being an islanded system, grid stability was a major consideration in the turbine design. The generation output had to be governed to the load requirement of the city, rather than feeding into a utility-type grid. With this in mind the Gilkes design and engineering departments commenced work.

### Gilkes Design

The design for the Blue Lake turbines was conducted using the latest CFD and FEA software. At over a metre runner diameter, a special high-efficiency hydraulic runner design was developed which also included custom design of most other components. Every aspect of the design was checked using FEA software to ensure allowable stress levels were not exceeded. To increase hydraulic efficiency, Gilkes designed the runner to be a fully CNC machined, two-piece, welded construction, as well as increasing the number of segments that made up the turbine case reducing the internal head loss.

A key feature of the project is that the turbines were also designed to operate in synchronous motor mode, with the generators acting as motors to spin the turbine units in air so as to provide power factor control to the grid. Operation in this manner is to provide additional rotating inertia, and thus stability to the electrical distribution system. The turbines are equipped with water injection specifically for this purpose. Cooling water is injected into the stationary wear rings at the runner crown and band sealing rings. Water injection and shaft seal cooling water are supplied from a cooling water system that takes water directly from the penstock upstream of the turbine inlet valves, and is then fed to each turbine via a cooling water and instrument panel

**Below, left: Original Blue Lake Turbines; Right: FEA analysis of turbine case; Above: CNC machining of two piece runner.**



custom designed for this application.

Gilkes also worked in close cooperation with a leading seal supplier that provided a sealing solution which caters for all the operating conditions from synchronous motor operation, to a high tail water condition (maximum flood level). Upon completion of the design, the various elements of the equipment supply were procured from specialist suppliers from around the globe. This included the UK, Italy, Canada, and the US which resulted in high quality equipment that met a very detailed contract specification.

**Installation and commissioning**

With the project situated in a remote location, and also being challenged with extremely limited storage facilities, Gilkes decided to manufacture much of the major equipment within a logistically-close geographical time zone to the site and owner. Benefits to this were that shipping costs could be reduced and client-witnessed factory acceptance tests were easily scheduled and executed. A selection of industry-leading companies were chosen and Gilkes' project engineers managed the interfaces between the client, manufacturers, and multiple time zones with competence. The equipment was manufactured, extensively shop tested, witnessed, and stripped down. It was then very carefully packaged for ocean transport before being transported to Sitka by barge from Seattle, Washington; where equipment from multiple countries had been marshalled.

Paul Carson, Chief Start-Up Engineer, commented: "The project benefited greatly from Gilkes' dogged efforts to coordinate the work of its subcontractors throughout the programme. Virtually all issues with fit-up, supply scope, instrumentation and software coordination were resolved in the design phase. This paid off tremendously at the job site. There were no delays in the equipment installation and testing caused by the goods and services as provided by Gilkes. In fact the turbine generator start-up progressed much faster than planned."

With the site in this remote location, transportation and installation was always going to be a challenge, however with Gilkes' past experience of delivering hydro projects to remote locations, such as the Grytviken project on a sub-Antarctic island, Gilkes was confident that this could be overcome. Its proven strategy of a dedicated team headed up by experienced project engineers, and a constant communication path between the client and Gilkes ensured the project was executed successfully.

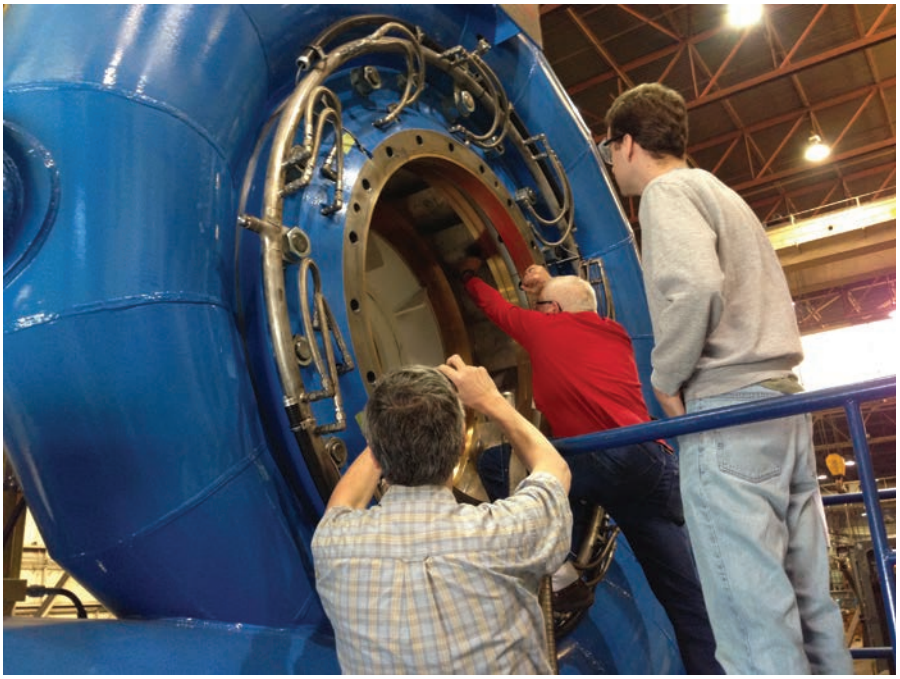
**Top: Installation of runner and testing of cooling water injection ports;**
**Middle, left to right: Custom designed shaft seal; custom designed cooling water panel;**
**Bottom: Shop assembly of the guide vanes and head covers.**

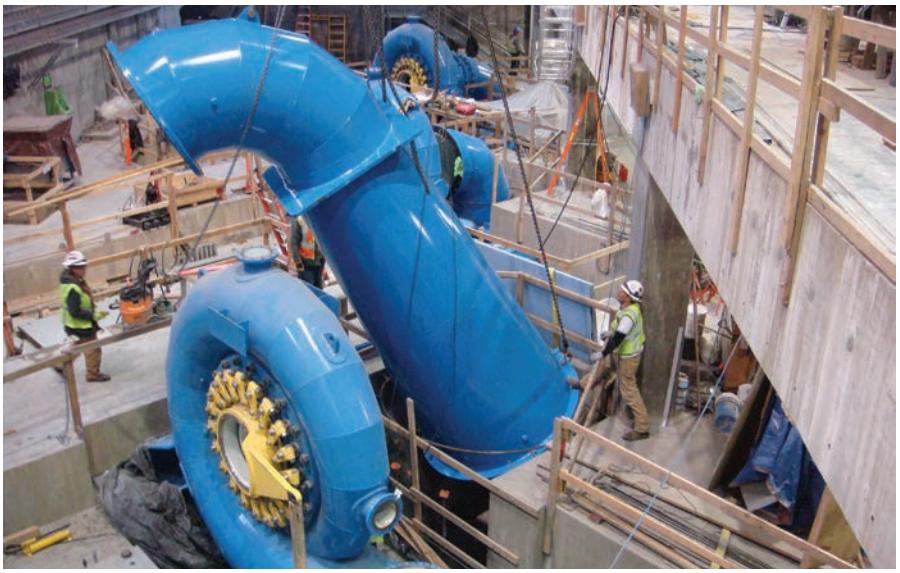
**Collaboration**

The installation of the turbines commenced in February 2014. During this installation process, the two original Blue Lake units continued to run to provide power for as long as possible into the installation/commissioning process.

Gilkes adopts a customer focused approach, working in close collaboration with the customer and contractors. For this project Gilkes insisted on having a presence on site throughout the entire installation, and ultimately had engineers at site for almost 12 months. This allowed the plant operators, mechanics, and supervisors to spend many hours working under the supervision and instruction of Gilkes installation and commissioning experts so that they had complete familiarity with the plant when it was handed over.

Commissioning, being led by Gilkes' technical director and one of their most experienced project engineers, was a phased approach and began in conjunction with the installation of the remaining units against an extremely tight deadline. This included a generation outage whereby the city





**Above, left: Client inspection of wicket gate clearances during factory acceptance test; Left: Site installation of unit #3 draft tube; Above: Commissioned and operational plant.**

residents were reliant on hydropower from the Green Lake plant, diesel generation and a modified drinking water supply. With only a short window between disconnecting the original Blue Lake powerhouse and connecting the new powerhouse to the grid, which also houses the new control centre for the entire Sitka electrical delivery system, every effort possible was given by all on site. The water supply to the existing turbines would be permanently cut off and the new penstock re-routed and upgraded. Other turbines and diesel generators would be utilised to compensate for the loss of generation, but would be limited by the draining lake level at the Green Lake hydro site and the high cost of diesel.

During commissioning, a full range of tests were run and every aspect of the turbine, control system, and relay protection system were performed and demonstrated to the owner. Additional to this were multiple load rejections whereby plant fail-safe systems are tested to ensure a number of things: the generators are not subjected to an overspeed condition, there is no discernible transient pressure rise in the penstock, and the plant shuts down efficiently and safely.

Following commissioning, performance tests were carried out using an ultrasonic flow meter. The results, combined with output measurements and index testing using the Winter-Kennedy method, were enough to demonstrate to the owner that the turbines had exceeded the performance guarantees as defined by the contract.

Commercial operation started in November 2014. "Blue Lake now operates as the lead power plant on an isolated electrical grid," said Paul Carson. "The project was transformed from a load-following plant to the lead frequency-controlling station by the combination of a new tunnel surge chamber and the Gilkes' equipment. The frequency control performance of the project is nothing short of spectacular. In my experience it was even more stunning that the final speed governor gain settings and frequency control performance exactly matched the values predicted in the Gilkes' design"

The turbines continue to exceed their guaranteed average efficiency value by over 4%. Another major success of the equipment's performance is how stable the grid system now is; so much so that the units have yet to even run in their synchronous condenser mode.

With the expansion of Blue Lake now complete and providing approximately 27% more electricity to the 10,000 residents of the island, Gilkes is extremely proud to have been involved in such a momentous project.

"Interactions with the Gilkes' staff were enjoyable at all levels during this four year project," Carson added. "From apprentice engineers and shop machinists to site technical representatives and project engineers, all of their staff were highly competent, courteous and dedicated to the success of the project. Gilkes provided for an owner's dream on this project- top quality equipment and field services from a competent, professional supply team."

Dean Orbison concluded: "The units were put in commercial operation two weeks ahead of schedule and have operated for one year now without a problem. I think that the success of this project was due to the fact that the companies and individuals who worked on the project were skilled at their work and took pride in producing an excellent product." ■

**For information visit www.gilkes.com**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