CASE STUDY

Glen Finglas, Scottish Highlands

HYDRO MODERNISATION

KEY INFORMATION

Customer:	Scottish Water
Turbine type:	Vertical Francis
Manufacturer:	Harland
Power (kW):	440 kW
Original Installation:	1965
Refurbishment:	2024

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SCOPE OF 2024 MODERNISATION SUPPLY

- Refurbished Runner
- Refurbished Generator
- New closed loop cooling system
- Redesigned guide vane mechanism and levers
- Replacement wear rings
- Refurbished shaft
- New flow monitoring for cooling circuit
- Flexible coupling buffers replaced
- All components refurbished
- All minor components replaced.

Glen Finglas dam and reservoir was constructed in in the early 1960's to provide water to the City of Glasgow through Loch Katrine. The dam contains a hydroelectric plant operated by Scottish Water.

The Hydroelectric facility was established in 1965 when a 460kW Harland Vertical Francis machine was installed.

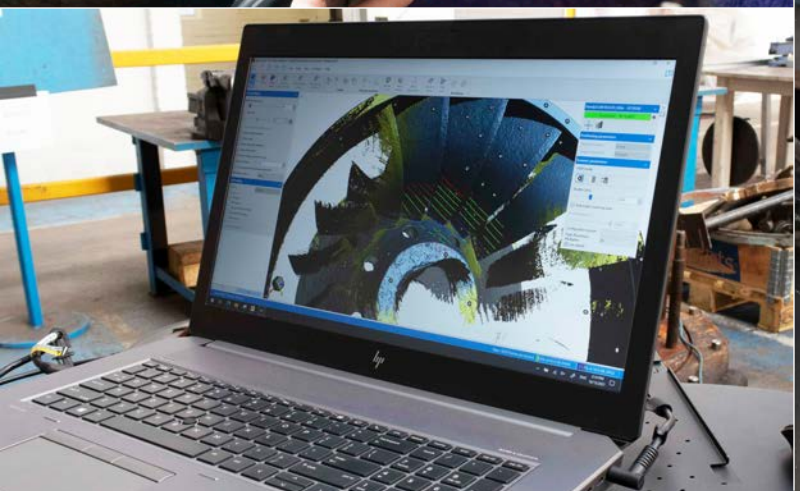
Previously refurbished around 20 years ago and regularly maintained by Gilkes service team for the last 10 years, the Glen Finglas Francis machine has now been adopted into a framework agreement with Scottish Water.

As part of the framework agreement, Gilkes Engineers conduct condition assessments on all the fourteen hydropower turbines covered by the agreement. The reports inform both Gilkes and Scottish Water of components that need maintenance, potential replacement, refurbishment, or upgrades to ensure that the assets can be suitably maintained. This proactive approach helps mitigate risks of failure and downtime while prolonging the plant's operational lifespan for sustained power generation into the future. Scottish Water carefully evaluates the condition assessment reports and subsequently provides project scopes to Gilkes as part of their project portfolio.

In 2019, the control and switchgear panel were replaced with a new PLC-based system. The manual start/stop intervention was eliminated, ACB synchronization became automatic, and dispersal valve opening during turbine trips was automated. The new panel was integrated into the telemetry system.

In 2021, additional tasks were completed:

- Swapping out the 415VAC dispersal valve actuators with a 110VDC version to ensure failsafe opening in the event of a grid failure.
- Substituting the outdated wooden battery cabinet containing Ni-Cad batteries showing signs of overcharging with an upgraded modern 110VDC battery unit.
- Incorporating battery condition monitoring into the control system.



2024 - REVERSE ENGINEERING

Following the most recent assessment of the turbine at Glen Finglas, a decision was made to proceed with a comprehensive overhaul of both the turbine and generator units.

Due to the lack of detailed drawings for the non-Gilkes designed and manufactured turbine, Gilkes faced challenges during the upgrade and modification process. Leveraging their expertise in reverse engineering, Gilkes engineers utilised 3D scanning technology to create accurate 3D CAD models of various components such as the runner, guide vanes, guide vane levers, and operating ring. Additionally, manual measurements were taken for other parts to gather sufficient data for redrawing the entire turbine assembly. This meticulous approach enabled Gilkes to overcome the limitations posed by the absence of original design documentation and ensure precise modifications and upgrades.

The process required the use of Creaforms HandyScan Black Elite 3D scanner which uses laser triangulation technology. The scanner produces a point cloud of the scanned surface, of which through software's such a VXmodel and Solidworks, can be used to produce solid CAD models suitable for further work and VXinspect which can be used to inspect and measure parts.
The scanner is particular useful for components with complex surfaces such as runners and guide vanes which traditional measurement methods cannot measure.

INITIAL SCOPE OF WORK

The initial scope of work involved refurbishing the generator, designing, and installing a new closed-loop cooling system for the upper bearing, and replacing wear rings. The need to replace the wear rings was discovered during previous maintenance in April '23 when the lower bearing and mechanical seal were replaced due to a leak.

A closed water-cooling skid was required to replace part of the existing cooling system. For the existing cooling system, the cooling water was taken from the spiral case and fed through the upper bearing, lower bearing, and mechanical seal. It was reported at times of low reservoir head that the upper bearing temperature was causing trips due to low cooling water flowrates. By installing a closed water-cooling system on the upper floor for the upper bearing, we could ensure that sufficient water was being fed to the upper bearing and at the same time allowing more flow to be used in the existing circuit for the mechanical seal and lower bearing.

The runner was refurbished by machining it to accommodate new wear rings, restoring design tolerances. Additionally, the bore and keyway were machined to fit the refurbished shaft. A scan of the refurbished runner was conducted for future reference in case a replacement is needed in the future.

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Guide Vane Mechanisms before refurbishment

Redesigned Guide Vanes

A MORE SIGNIFICANT REFURBISHMENT

Despite the extensive scope of work initially identified, upon dismantling the turbine, it was evident that a more extensive refurbishment was necessary.

An additional condition assessment report was conducted by the engineering team, leading to further recommendations for the scope of work. Scottish Water approved these additional tasks, which involved the following areas of work:

Redesigning the guide vane mechanism due to issues with proper closure caused by the original loose design. Modifications were made to enhance the vanes and levers, and ringfeder locking rings were introduced to securely fasten the guide vanes into place on the levers.

The shaft underwent metal spraying and machining due to severe damage caused by the runner's eccentric operation. The loose runner had worn down the shaft and key, necessitating repairs. Metal spraying was done on the shaft, followed by re-machining, and cutting a new keyway for proper alignment with the repaired runner.

Flow monitoring was added to the existing cooling circuit which still serves the lower bearing and mechanical seal to confirm a sufficient flow of water is being supplied.

The upper thrust and journal bearing was fully refurbished, and the lower wetted bearing and mechanical seal were replaced.

New guarding around the generator pedestal was made.

The flexible coupling buffers were replaced.

Components were shot blasted and repainted.

All fasteners, gaskets, seals, and bushes were replaced.

CHALLENGES

Access to turbines at older sites, particularly those on dams or in mills can often present challenges.

In this case, the machine is split over two floors with the generator mounted at ground level and the turbine located below ground with a 4.2m shaft connecting the two. This configuration meant the turbine assembly had to be lifted through a small hole in the floor to facilitate removal for refurbishment.

Because the turbine is housed below ground, we had to build up the turbine assembly in a jig and set the guide vane positions at the workshop in Kendal, then lower the whole assembly into position pre-assembled through the hole in the upper floor. This methodology proved to be successful and reduced the required assembly time on site.

An added complication of the project was the bats that nest on site, this required an ecological licence and an ecologist to be on site during the works to ensure the roosting bats were not disturbed as the construction work progressed.

Images show generator on upper floor and turbine on the floor below, presenting access challenges.

Powerhouse control panels and generator

IMPROVED PERFORMANCE

The turbine assembly is now much tighter. The clearances between the runner and wear rings have been restored to the correct tolerance and the guide vane mechanism is no longer slack, this all results in a more efficient machine.

The generator refurbishment will mean the generators life is extended and runs more efficiently.

The machine is power limited in the control software to 420kW. However, since the refurbishment, the guide vane opening to achieve this power is significantly less, providing scope to increase the output. Gilkes engineers have since returned to site and increased the power output of the machine to 440kW. The increased output will be monitored over a period of time to ensure the turbine and generator can successfully operate at this higher power. From a project perspective, the increased power will reduce the payback time of the project, increasing its financial benefits.

From an operational perspective the running temperatures of the upper bearing are lower and should be more consistent across the head range.

Additionally, the flow through the original cooling system is now being monitored to ensure enough flow is passing through the lower bearing and mechanical seal.

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