Turlough Hill Pumped Storage Scheme

Co. Wicklow Ireland

ELECTRICITY SUPPLY BOARD
BORD SOLÁTHAIR AN LEICTREACHAIS

Power from the Mountains

When the Electricity Supply Board moved on to the Turlough Hill site in 1968 and began its first work on a project which was to be the largest civil engineering operation ever undertaken in the country, it moved into an area not only of great scenic beauty but also one of great historical significance.
Turlough Hill stands in the Wicklow Gap four miles from Glendalough where the hermit St. Kevin founded a monastic city in the 6th century – a centre of learning and pilgrimage to which Irish Kings brought gifts of gold. The increase in importance of Glendalough as a centre of pilgrimage had its effect on the Wicklow Gap where the original tracks and trails were improved by the Leinster Monarchs and carefully paved with stone into a fair imitation of a Roman road -- now known as St. Kevin's Road. A portion of this road crosses the ESB site and is now excavated and open to view.
The pilgrimage to Glendalough survived from these early times down to the famine year of 1847.

Long before construction of the Turlough Hill scheme the Wicklow Gap was noted as a source of power. As long ago as 1800, large scale mining began in this area for copper, lead and zinc. These workings began on the Lough Nahanagan side of Camaderry Mountain and were called the Luganure Mines. Today ruins of miners' cottages and large tips of mine tailings can be seen in the Glendassan Valley on the approach to Turlough Hill from Glendalough. By 1837 the annual output of these mines was 11,000 tons of lead ore, then valued at slightly more than £1 a ton. The water of Lough Nahanagan was used to drive water-wheels which, in turn, operated pumps to drain excess water from the mines. It is interesting to think that today, long after the mines have ceased operation, the water of the same Lough Nahanagan is harnessed to drive the huge machines which act both as pumps and turbines in the ESB pumped-storage project.

Front Cover: Aerial view of scheme showing the upper reservoir and lower lake – Lough Nahanagan.

The upper reservoir under construction with an inset showing the intake structure.

The control room.

The 220kV switchyard.

The access tunnel leading to the main cavern.

The completed upper reservoir. Inset shows intake structure.

The Turlough Hill Scheme is the only one of its kind in Ireland although there are many such stations in operation in Europe and in the United States of America. There is one in Scotland and one in Wales. The design and construction-management of the pumped-storage project was carried out by ESB staff with the advice and assistance of the consulting engineers Lahmeyer International of West Germany. The project cost £22 million, £6 million of which was provided by way of a World Bank loan.
A pumped storage scheme like Turlough Hill enables the ESB to make the most economic and flexible use of its system. Electricity cannot be stored in large quantities and it is required in the home, office and factory the very moment the switch is pressed. The ESB must generate electricity to meet the varying demands of any one day and, of course, must have sufficient generating capacity to meet the highest point of demand in any 24 hour period.

As this daily peak period lasts for a relatively short time, it means that without a pumped-storage station such as the one at Turlough Hill, expensive generating plant would otherwise be out of operation for many hours. Another consideration is the time required to "warm-up" conventional oil or coal generating plant – this can take several hours. Pumped storage helps solve these problems and makes the total system both more economic and more flexible. Greater economy of operation is achieved because generating capacity from other stations can be used at periods of low demand to pump water from the lower lake to the upper reservoir where it is ready for use when demand increases. The most modern and efficient stations on the system can be used for this purpose. Greater flexibility is achieved because the generators in a pumped-storage scheme can be synchronised on to the system within seconds – providing power quickly to meet peak or sudden demand for electricity.

The Turlough Hill project is the largest civil engineering operation ever carried out in this country. It involved the construction of tunnels through the heart of the mountain. The largest of these provides access to the main cavern which houses the generating plant and the controls. This cavern is as large as a medium sized cathedral. The pressure tunnel, which carries water from the upper reservoir to the lower, has been drilled through the solid granite of the mountain.

Work in progress on the construction of the cavern.

The scheme's lower reservoir is the existing Lough Nahanagan. The upper reservoir, which has the capacity to hold 500 million gallons of water, is man-made. Its construction involved the removal of almost one million cubic yards of peat from the mountain top, the excavation of $2\frac{1}{2}$ million tons of rock, the construction of an embankment nearly a mile in length and up to 100 feet in height and the laying of 40 acres of waterproof lining. In December, 1973, the first of the station's four generating units went into operation and the station has been fully operational since the summer of 1974.

Technical Data

DATA FOR MECHANICAL AND ELECTRICAL EQUIPMENT

4 sets of vertical design, consisting of Pump Turbines, and Synchronous motor generators with pony motors.

Mean geodetic head		285.75 m.
Mean flow (turbining)	each	28.3 m3/sec.
Turbine output	each	73.0 MW
Mean flow (pumping)	each	22.1 m3/sec.
Pumping load	each	68.2 MW

DATA FOR WATER CONDUITS

PRESSURE SHAFT:

Length	584 m.
Internal Diameter	4.8 m.
Velocity at Nominal Turbine Output	6.25 m/sec.
Velocity at Nominal Pump Output	4.92 m/sec.

UPSTREAM MANIFOLD

Internal Diameters	2.4/3.4/4.15 m.

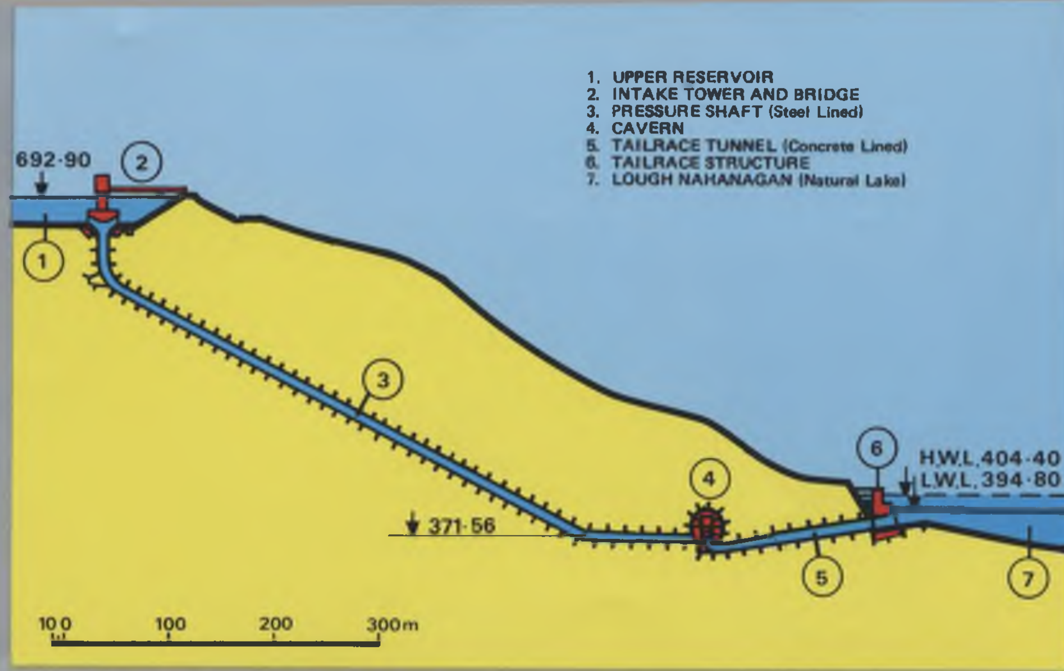
TAILRACE TUNNEL

Length	106 m.
Internal Diameter	7.2 m.
Velocity at Nominal Turbine Output	2.86 m/sec.
Velocity at Nominal Pump Output	2.10 m/sec.

DOWNSTREAM MANIFOLD

Internal Diameters	3.50/5.00/6.20 m.

The main plant is housed in an underground power station 82 metres long, 23 metres wide, with a height of 30 metres.
The operating floor level is 15 metres below low water level in the Lower Reservoir.
The main machines when rotated in different senses act as turbines or pumps and correspondingly give or take energy from the network. The power is nominally about 73 MW in each mode per machine with regulation down to lower loads in the turbine mode.
The machines can also operate as synchronous condensers in either direction.
Rotational speed of the machines is 500 r.p.m. with a max. temp. runaway speed of 780 r.p.m. based on an inertia per machine of 900 tm^2 and water hammer pressure rise under fault conditions of approximately 40% above normal.
The machine governors are electro/hydraulic with load control and joint control of all machines.



PRESSURE SHAFT AND TAIL RACE TUNNEL

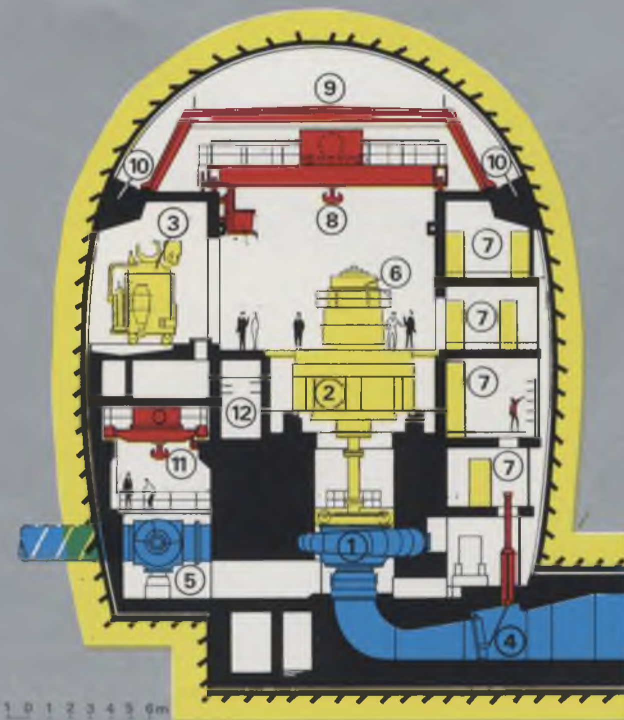
The reversible pump turbines, operating under a mean geodetic head of 285.75 m are fed through a single pressure shaft and single tail race tunnel both excavated in granite, the 4.8 m diameter pressure shaft being steel lined and the 7.2 m diameter tail race tunnel being concrete lined.

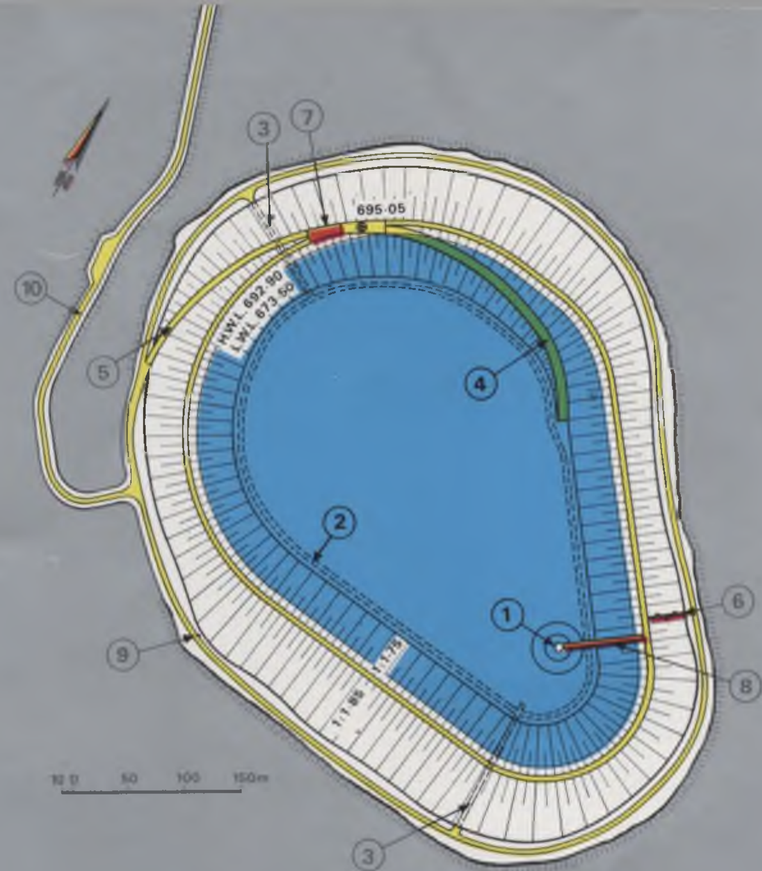
SECTION – CAVERN

1. Pump Turbine.
2. Motor/Generator.
3. Main Unit Transformer.
4. Flap Gate.
5. Turbine Inlet Valve.
6. Pony Motor/Generator.
7. 10 kV Switchgear, control Panels and Relays.
8. 2 x 70 ton Bridge Cranes.
9. False Roof with Soundproofing.
10. Haunch Beams.
11. 50 ton Bridge Crane.
12. Cable Gallery for 220 kV Cables.

CAVERN DIMENSIONS

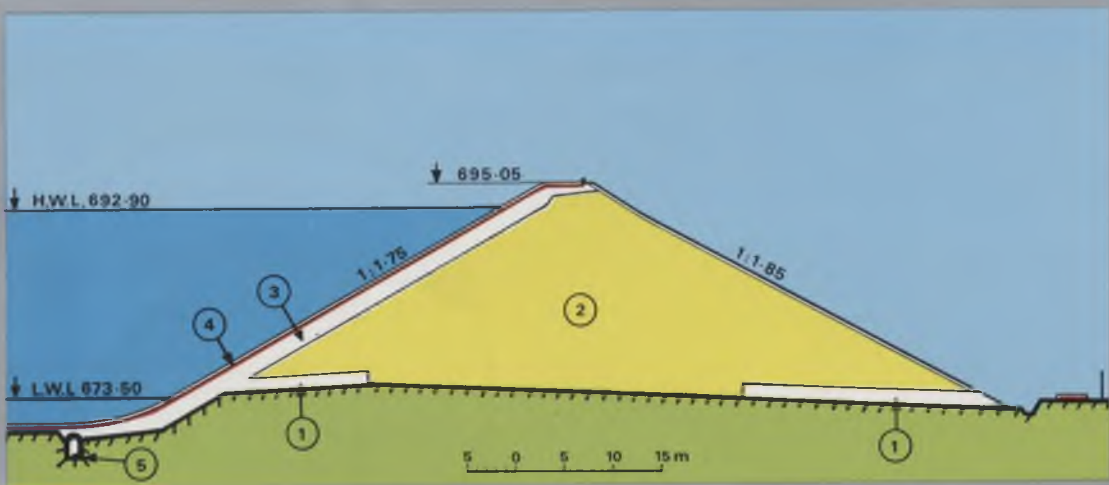
Length	82 m.
Breadth	23 m.
Height	28 m.





Technical Data

Because of the reversibility of the electrical machines, phase change-over links are provided on the machine busbars.
Access and availability problems necessitated the use of single phase transformers in the cavern, three per pair of main sets with 220 kV cables to the outdoor switchyard.
Start up in the pump direction is by a shaft mounted Pony motor of 5.5 MW. the water having been previously exhausted from the pumps by compressed air. Excitation of the main rotors is thyristor controlled. Starting in each mode and change of mode of operation is automatic following push button command. Standby auxiliary power is provided by both a house machine (1,000 KVA) and an outdoor diesel set.
Mechanical auxiliaries include two 70 ton cranes to handle transformers weighing 70 tons each and generator rotors weighing 130 tons each and a 50 ton crane for the spherical isolating valves. The entire plant is air conditioned.



UPPER RESERVOIR EMBANKMENT

1. Drainage Layer of crushed sound rock, graded from 150 mm to 10% passing 2 mm.
2. Rock filling.
3. Drainage layer of crushed sound rock graded from 200 mm to 10 mm, with blinding of crushed rock from 55 mm to 35 mm.
4. Asphaltic Lining –
   Spray coat of Cut Back Bitumen.
   Asphaltic Concrete binding and equalizing course 5 cm in thickness.
   Dense asphaltic concrete course 6 cm. in thickness.
   Mastic Sealing coat.
5. Ring Drainage Gallery.

UPPER RESERVOIR

1. Intake Structure.
2. Ring Drainage Gallery.
3. Access Gallery.
4. Inner Access Ramp.
5. Outer Access Ramp.
6. Access Steps.
7. Visitors' Platform.
8. Access Bridge.
9. Ring Road.
10. Access Road from Wicklow Gap.

The artificial upper reservoir has a capacity of 2.3 million cubic metres of water and a maximum operating depth of 19.4 metres.
It is formed partly by excavation and partly by the use of the excavated material in the construction of a ring shaped rock fill embankment.
An asphaltic concrete lining covers the floor, inner slopes, and crest.
A ring shaped under floor drainage gallery is provided at the foot of the inner slope of the embankment to collect and monitor any seepage through the asphaltic concrete lining.

Taking Care...

When the ESB decided to build a pumped-storage station at Turlough Hill it was determined to take great care to restore the areas which would inevitably be disturbed by the huge construction operation. With this in mind, one of the foremost firms of landscape architects in Europe, Sylvia Crowe and Associates, was employed to advise on the environmental aspects of the project. Miss Crowe's recommendations regarding the siting and finish of overground buildings and the seeding, planting, landscaping and restoration of the area, have been implemented.

It was part of the ESB's plan for the scheme that restoration work should go hand in hand with the development of the project. While work was still in progress on the construction of the upper reservoir and the generating hall inside the mountain, a new technique was being used to restore the growth of grass on the verges of the newly constructed two mile long road leading to the top of the mountain. A mixture of water, fertiliser, wood pulp, peat moss and grass seed was sprayed on to the road verges and the outer embankment of the upper reservoir. Now, the fresh grass has taken root and these roadside verges are favourite grazing spots for hill sheep.

The new road, built to carry machinery and equipment to the top of the mountain, is one of the highest usable roads in Ireland and provides one of the finest panoramic views of the Wicklow mountains. Crossing this new and modern roadway is the path taken by one of Wicklow's oldest roads – the ancient pilgrim route to the monastic city of Glendalough which was established by St. Kevin in the sixth century. St. Kevin's Road, as it is called, originally connected Valleymount and Glendalough, a distance of eleven miles, and was probably built between the 8th and 12th centuries – the peak period for the monastery at Glendalough. A section of this road crossing the Turlough Hill site was excavated by archaeologists from the National Museum at the request of the ESB. The excavated section is on permanent view to the public – large stone slabs which have been trodden by pilgrims many hundreds of years ago as they made their way to the shrine of St. Kevin.

The generating hall showing the four 73MW pump-turbines.

A visitor studies section of excavated St. Kevin's Road.

The administration building.

Reseeding to restore grass growth.

During the construction period, huge earth-moving plant created scars on the landscape and accommodation quarters and site offices for the work force dotted the hillside. With the completion of work on the site these buildings were removed and there is now little outward sign that such a major construction operation has taken place. The generating hall with its four pump-turbines, is hidden right inside the mountain while the transformer compound and offices are located so that they cannot be seen from the Wicklow Gap road. The administration building has been given a special 'rope' finish and blends neatly into the rock of the surrounding hillside.

The round tower and church, Glendalough.

Situated as it is in a beautiful and historic location, Turlough Hill has become a popular place for visitors. Throughout the year, but particularly during the summer months, many people, including organised groups, call to visit the station. Along with historic Glendalough and the natural beauty of the region, Turlough Hill has become an attraction in the Wicklow Gap for people from Ireland and abroad. The ESB has provided special facilities for visitors enabling them to tour the site in the company of a guide. And all the time this, Ireland's first pumped-storage station – a significant engineering achievement – continues to fulfil the purpose for which it was built – the economic production of electricity for social and industrial development.

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