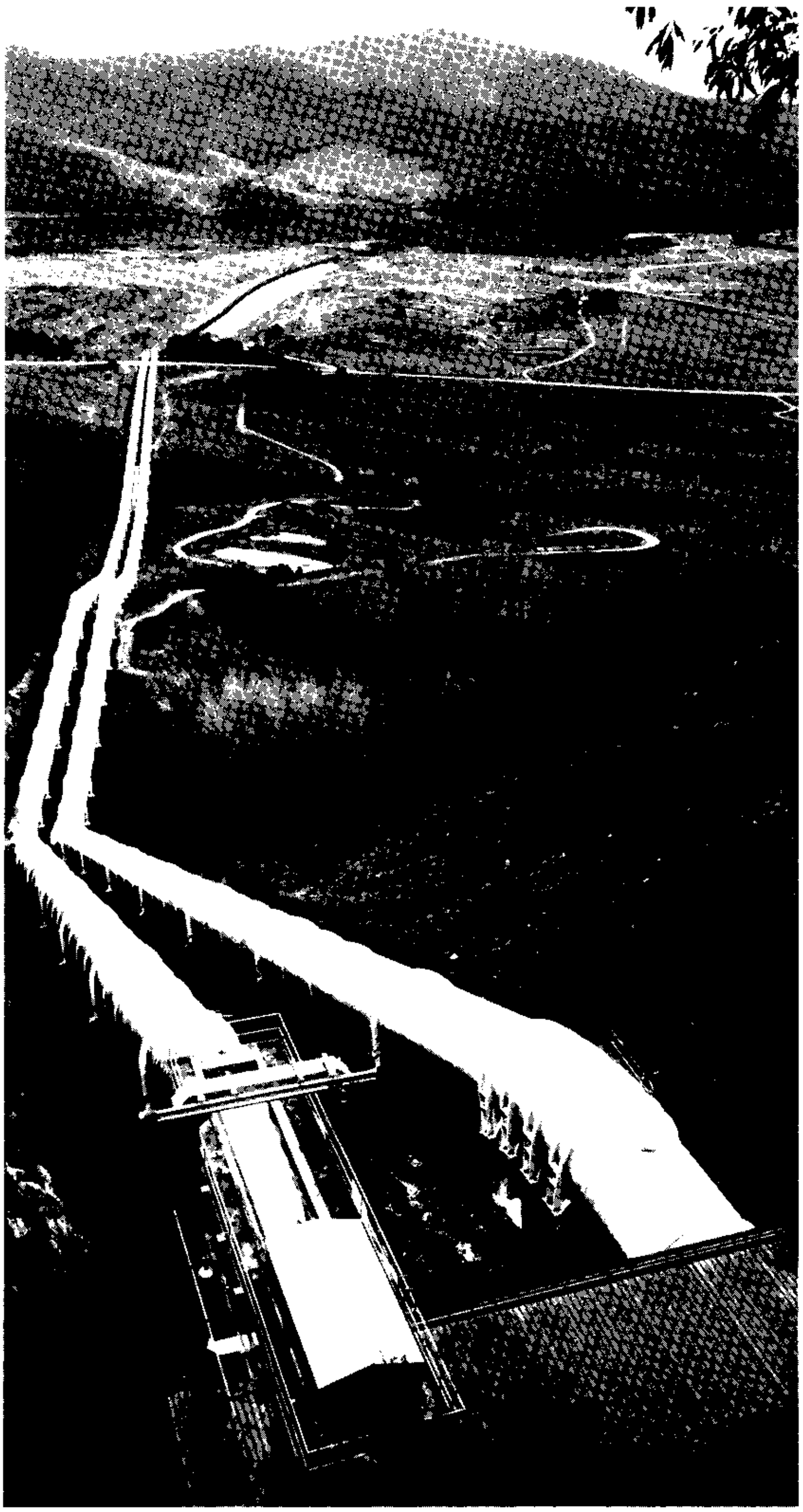
The Snowy Mountains Scheme – Australia

C O O M A N S W A U S T R A L I A



The Snowy Mountains Scheme is a hydro-electric and irrigation complex located in south-eastern Australia. It impounds the waters of the Snowy River and its tributary, the Eucumbene, at high elevations and diverts them inland by tunnels driven westwards through the Snowy Mountains to the Murray and Murrumbidgee Rivers.

In travelling through the trans-mountain tunnels and shafts, the diverted waters fall over 800 metres, generating large quantities of peak load electricity as they pass through the power stations to the irrigation storages west of the Snowy Mountains.

The Scheme's total generating capacity is 3 740 000 kilowatts.

Each year it provides an additional equivalent of 2 350 000 megalitres of water for irrigation in the Murray and Murrumbidgee Valleys.

Background

The earliest proposals for utilising the waters of the Snowy River to supplement the flows of the inland rivers for rural production date from the 1880s when heavy losses caused by drought suggested the western diversion of the waters from the Snowy Mountains. These proposals lost their urgency when the drought gave way to better seasons.

In 1908, the Snowy River was again examined, this time for its hydro-electric potential when the site for the federal capital was being considered. As a result, the State of New South Wales granted the Commonwealth the right to these waters as a source of power for the Australian Capital Territory.

S N O W Y M O U N T A I N S
H Y D R O - E L E C T R I C A U T H O R I T Y

Various proposals followed; some were based on the Snowy River's diversion for irrigation, others for its hydro-electric development and in 1944 the first large dual-purpose proposal was submitted. This was followed by other schemes until, in 1947, a joint Commonwealth-States Technical Committee was set up to investigate the question of the possible use of the Snowy River.

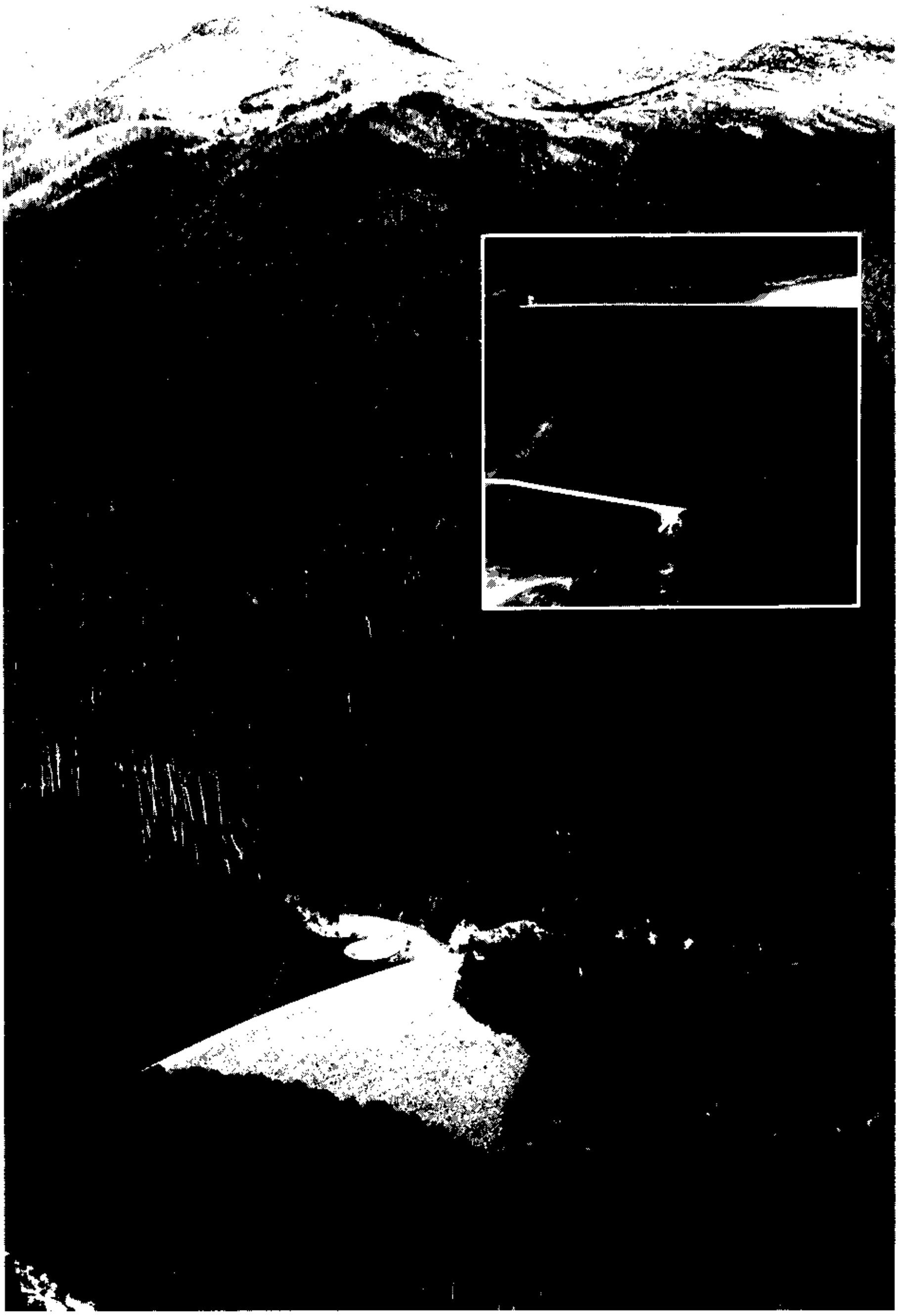
Acting upon recommendations presented by the Technical Committee, the Commonwealth Government in 1949 passed the Snowy Mountains Hydro-electric Power Act which established the Snowy Mountains Hydro-electric Authority with the responsibility for investigating, designing and constructing the Scheme.

Design and Construction

The early detailed investigations and office studies revealed ways in which the original proposals put forward by the Commonwealth-States Technical Committee could be improved. As a result, the original sixteen power stations were reduced to seven power stations but the installed capacity was lifted from 2 626 000 to 3 740 000 kilowatts. The 800 kilometres of open-channel aqueducts were reduced to 80 kilometres of buried pipelines and through the re-arrangement and the linking of storages, a sixty percent increase in active storage capacity was achieved.

The investigation and design of the works was carried out by the Authority's own staff with some assistance initially from the United States Bureau of Reclamation. The Authority's staff also performed some of the construction work including the building of aqueducts, erection of transmission lines, establishment of 10 regional townships and over 100 camps more than 1,600 kilometres of roads and tracks, and installation of the major electrical and mechanical plant.

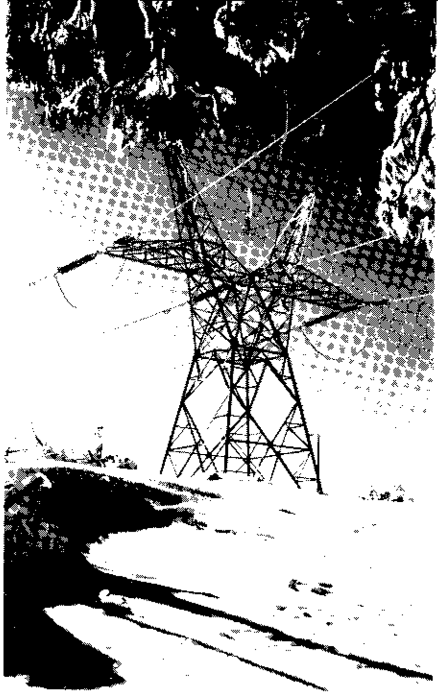
The major civil engineering works were constructed by contractors, both Australian and overseas, and the major electrical and mechanical plant items were supplied by overseas firms. Supervision of the contracts was carried out by the Authority's staff.



Geehi Dam with snow-capped peaks in the background

The cost of the Scheme was approximately $820 million and, as finally constructed, involved the investigation, design and construction of 16 large dams and many smaller diversion structures, some 80 kilometres of aqueducts, over 140 kilometres of tunnels, a pumping station, and seven power stations, two of which are underground.

Its total generating capacity is 3 740 000 kilowatts and, through diversion, regulation and control of the rivers, an additional annual equivalent of 2 350 000 ML of water is made available for irrigation purposes in the Murray and Murrumbidgee Valleys.



Power to the people!
Electricity from the Snowy Scheme is consumed in Victoria, New South Wales and the ACT.

Operation & Maintenance

The operation and maintenance of the completed works of the Scheme is directed and controlled by the Snowy Mountains Council, a body on which the Commonwealth, the Authority, and the States of New South Wales and Victoria are represented.

The Works Operations Centre in Cooma controls the operation of all the hydraulic and electrical works of the Scheme. It is linked with the Scheme's group control centres and with the systems control centres of the Electricity Commissions of New South Wales and Victoria.

The cost of constructing the Scheme was met by advances from the Commonwealth. These advances will be repaid over 70 years, with interest, out of charges to the Electricity Commissions of the Australian Capital Territory, New South Wales, and Victoria in proportion to the entitlements of each to energy from the Scheme. The whole cost of the works is met by charges for electricity and no charge is made to the States in respect of the additional water available for irrigation purposes.

The number of persons employed by the Authority and its contractors in the Snowy Mountains Area reached a peak of 7 300 in 1959. Today over 900 people are involved in the operation, maintenance and administration of the Scheme including employees of the Electricity Commission of New South Wales and Victoria engaged in the operation of the power stations.

Broadly, the Scheme falls into two sections — the northern Snowy-Tumut Development and the southern Snowy-Murray Development. Both developments are connected by tunnels to the Scheme's main regulation storage, Lake Eucumbene.

Snowy-Murray Development

The Snowy-Murray Development involves the diversion of the Snowy River by a trans-mountain tunnel system to the Geehi Reservoir and thence to the Swampy Plains River, a tributary of the Murray. In passing through the tunnel system the diverted waters fall some 820 metres, generating 1 500 000 kilowatts in Murray 1 and Murray 2 power stations.

Additional power is generated in Guthega Power Station which makes use of the rapidly falling water of the upper Snowy River on the east side of the Divide before it reaches the main tunnel system at Island Bend.

An essential part of this development is the two-way flow Eucumbene-Snowy Tunnel which connects the Snowy River with Lake Eucumbene. When the flows in the Snowy and Geehi Rivers exceed the needs of the Murray power stations, water from the Snowy River at Island Bend is diverted through this tunnel for storage in Lake Eucumbene.

Low flows in the Snowy and Geehi Rivers are supplemented by drawing the stored water from Lake Eucumbene back through the same tunnel and delivering it to the trans-

Hydrologists weigh snow samples to measure water content.

mountain tunnel system leading to the Murray power stations.

Additional water is supplied to the transmountain tunnel at Island Bend by the Jindabyne Project which pumps from Lake Jindabyne the runoff from the Snowy catchment downstream of Island Bend.

The Snowy-Murray Development provides 980 000 ML of additional water annually through the Hume Reservoir to the Murray River for irrigation in the Murray Valley. The total installed capacity of the Guthega, Murray 1, and Murray 2 power stations is 1 560 000 kilowatts.

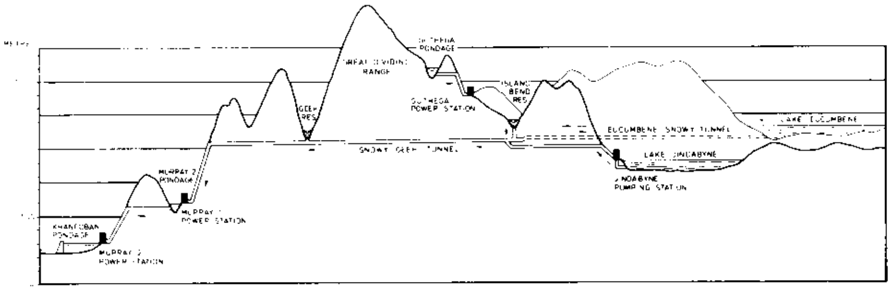
Snowy-Tumut Development

The Snowy-Tumut Development provides for the diversion of the Eucumbene, the upper Murrumbidgee and the Tooma Rivers to the Tumut River, and for the combined waters of these four rivers to generate electricity in four projects (Tumut 1, Tumut 2, Tumut 3 and Blowering) in their fall of 800 metres before release to the Tumut and thence to the Murrumbidgee. The Authority carried out the design and construction of Blowering Dam for the State of New South Wales which is responsible for the operation of Blowering Reservoir.

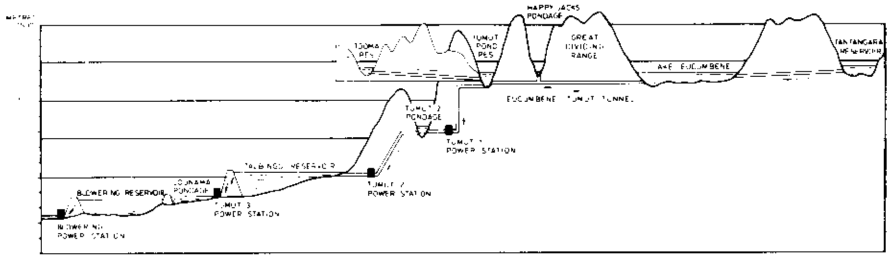
The transmountain tunnel system includes the Eucumbene-Tumut Tunnel connecting Lake Eucumbene with Tumut Pond Reservoir. The normal function of the tunnel is to divert water through the Great Dividing Range from Lake Eucumbene to the Tumut River but, during periods of high flow in the Tumut and Tooma Rivers, water in excess of that required for operating the power stations in the Tumut Valley is diverted in a reverse direction through the tunnel to Lake Eucumbene for storage.

The total installed capacity in Tumut 1, Tumut 2, Tumut 3 and Blowering power stations is 2 180 000 kilowatts. This section of the Scheme provides 1 380 000 ML of additional water annually to the Murrumbidgee River. Irrigation production has increased in new areas in the Murrumbidgee Valley through the operation of the Snowy Mountains Scheme.

Snowy-Murray Development



Snowy-Tumut Development



Vital Statistics

MAJOR DAMS	Height (metres)	Reservoir Capacity (megalitres)	In Service
Talbingo	162	920 550	1971
Eucumbene	116	4 799 100	1958
Blowering	112	1 632 400	1968
Geehi	91	21 106	1966
Tumut Pond	86	52 818	1958
Jindabyne	71	689 790	1967
Tooma	67	28 125	1961
Island Bend	49	3 013	1965
Tumut 2	46	2 600	1962
Tantangara	45	254 080	1960
Jounama	44	43 800	1968
Murray 2	43	2 283	1968
Guthega	33.5	1 548	1955

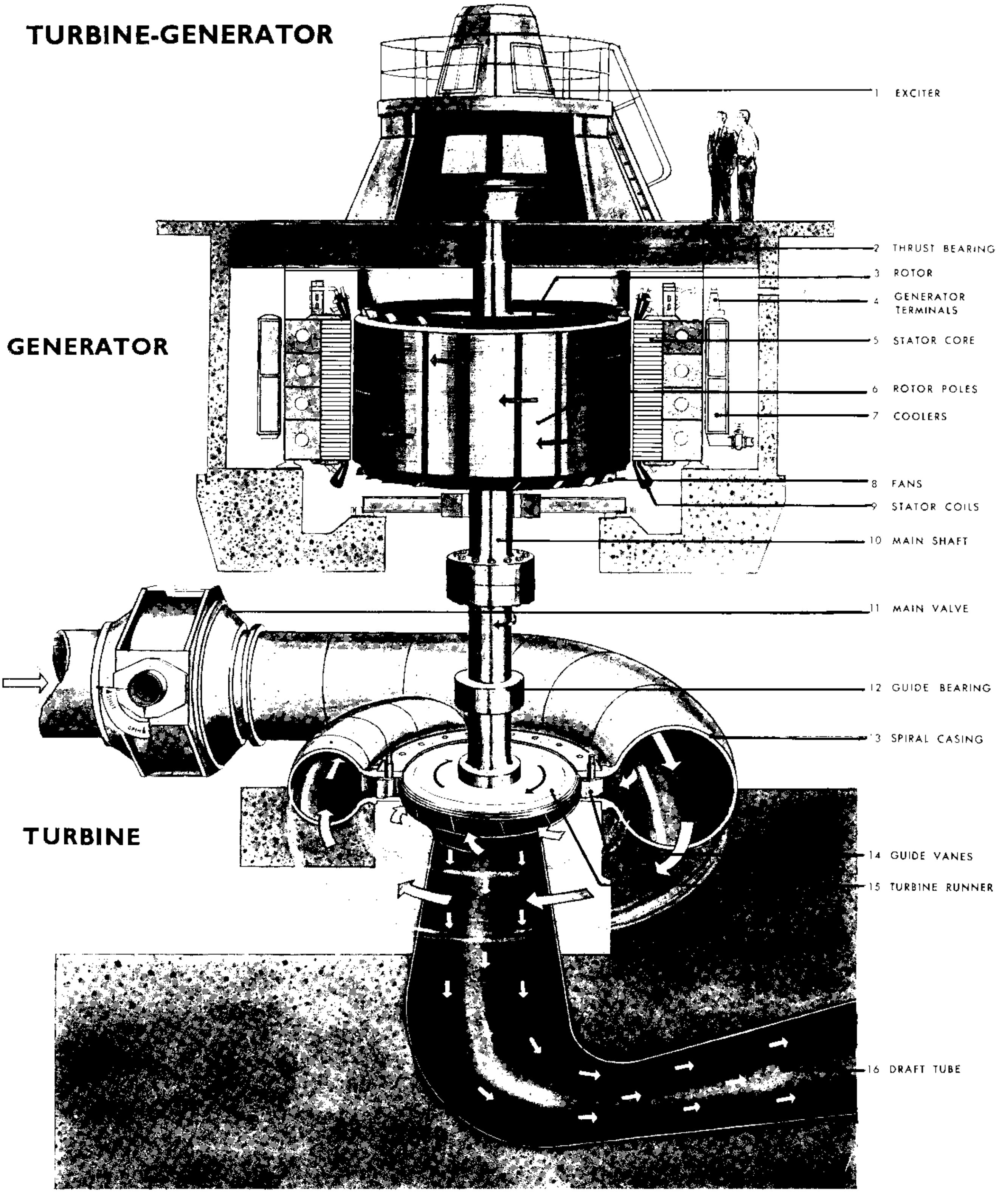
MAJOR TUNNELS	Length (km)	Excavated Diameter (metres)	In Service
Eucumbene-Snowy	23.52	6.35	1965
Eucumbene-Tumut	22.19	6.91	1959
Murrumbidgee-Eucumbene	16.64	3.35	1961
Snowy-Geehi	14.43	6.30	1965
Tooma-Tumut	14.30	3.71	1961
Jindabyne-Island Bend	9.86	3.95	1968

POWER STATIONS (Power)	Installed Capacity (kW)	Rated Head (metres)	In Service*
Tumut 3	1 500 000	150.9	1972
Murray 1	950 000	460.2	1966
Murray 2	550 000	264.3	1969
Tumut 1**	320 000	292.6	1959
Tumut 2**	280 000	262.1	1962
Blowering	80 000	86.6	1970
Guthega	60 000	246.9	1955

(Pumping)	Rated Capacity (cumecs)	Pumping Head (metres)	In Service*
Tumut 3	297.0	155.1	1973
Jindabyne	25.5	231.6	1968

*** Year of operation**
**** Underground station**

TURBINE-GENERATOR



Water under pressure passes through the main valve (11) into the turbine spiral casing (13). The guide vanes (14) direct the water into the turbine runner (15) along its periphery. The water is discharged from the bottom of the runner into the draft tube (16).

The water, in passing through the blades of the runner, causes it to rotate. The runner drives the generator rotor (3) through the main shaft (10). The weight of the rotating parts is supported by the thrust bearing (2). The main exciter (1) supplies direct current to windings on the rotor poles (6) setting up a magnetic field which rotates with the rotor.

The effect of this rotation of the magnetic field is to generate an alternating voltage in the stator coils (9) which are embedded in slots in the iron of this stator core (5).

Air is circulated through the generator, by fans (8) mounted on the rotor to remove the waste heat inside the machine. The air is cooled by passing it through water coolers (7).

The power output from the generator is adjusted by controlling, by means of the guide vanes, the amount of water flowing through the turbine.

JINDABYNE PUMPING STATION

Function: Jindabyne Pumping Station pumps water during off-peak periods from Lake Jindabyne through the Jindabyne-Island Bend Tunnel to the Snowy-Geehi Tunnel at Island Bend.

Type: Concrete surface station

Pumping Capacity: Two 12.7 m^3/s units pumping against head of 231.6 m

Machine Hall:

- Length: 57.91 m
- Width: 23.47 m
- Height: 15.54 m

Volume of Concrete:

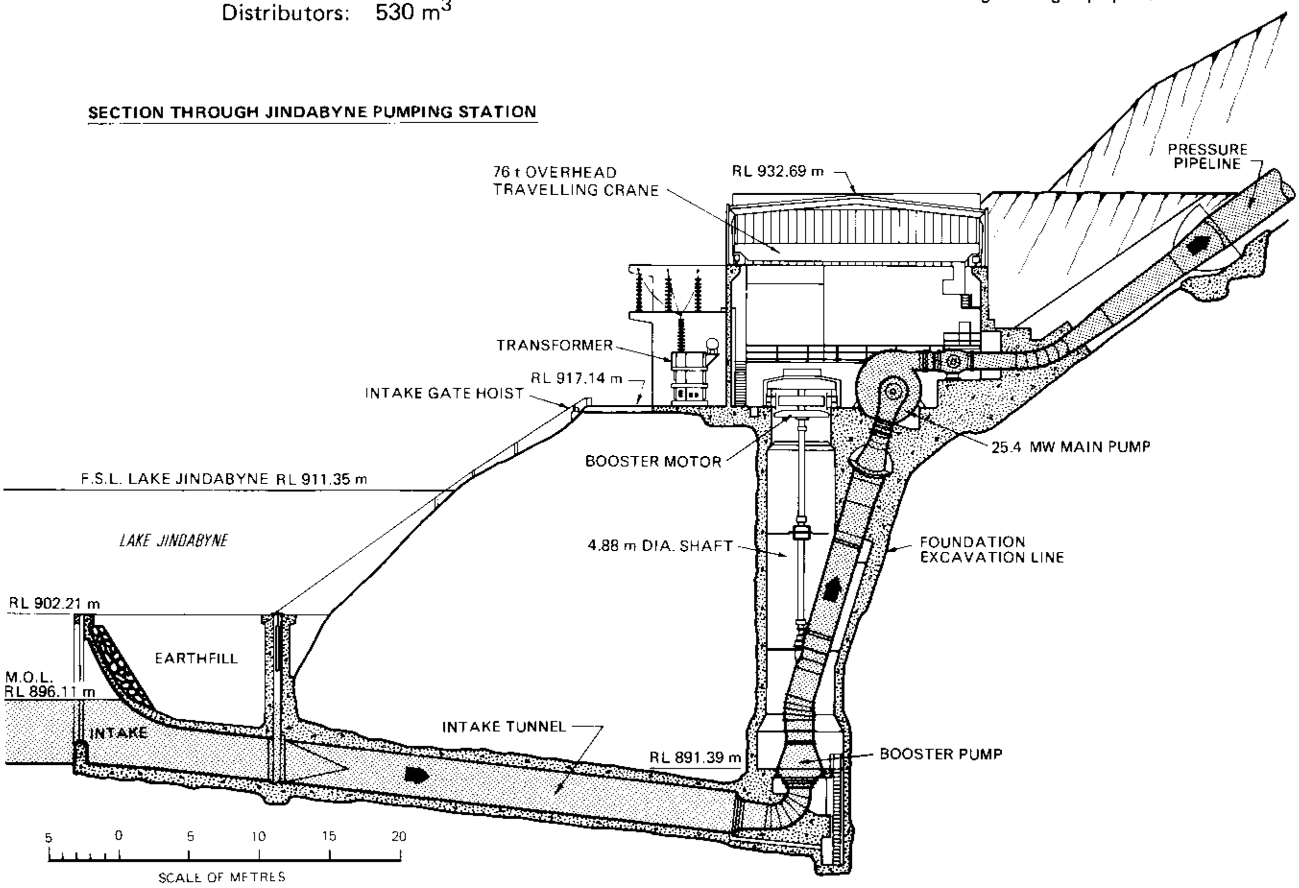
- Pumping Station: 2 740 m^3
- Intakes: 1 090 m^3
- Distributors: 530 m^3

Pumps:

- Main: Horizontal shaft, single stage, double suction, centrifugal. Rating: each 25.4 MW input for 12.7 m^3/s at 189.3 m head
- Booster: Each 6.7 MW input for 12.7 m^3/s at 48.8 m head

Supply Transformers: Two three-phase, oil-filled, water cooled, with off-circuit regulating equipment

SECTION THROUGH JINDABYNE PUMPING STATION



Motors:

- Main: Each 31.3 MW output, 11 kV, 0.9 power factor lagging 0.45 MW 50 Hz starting by Pelton turbine
- Booster: Each 7.5 MW output, 11 kV, 0.86 power factor lagging 330 r/min

Construction Period: March 1966 to February 1969

MURRAY 1 POWER STATION

Function: Murray 1 Power Station generates electricity from the waters diverted through the Murray 1 Pressure Tunnel from Geehi Reservoir.

Type: Concrete surface station

Generating Capacity: Ten 95 000 kW units – total 950 000 kW

Machine Hall:

Length: 158.50 m

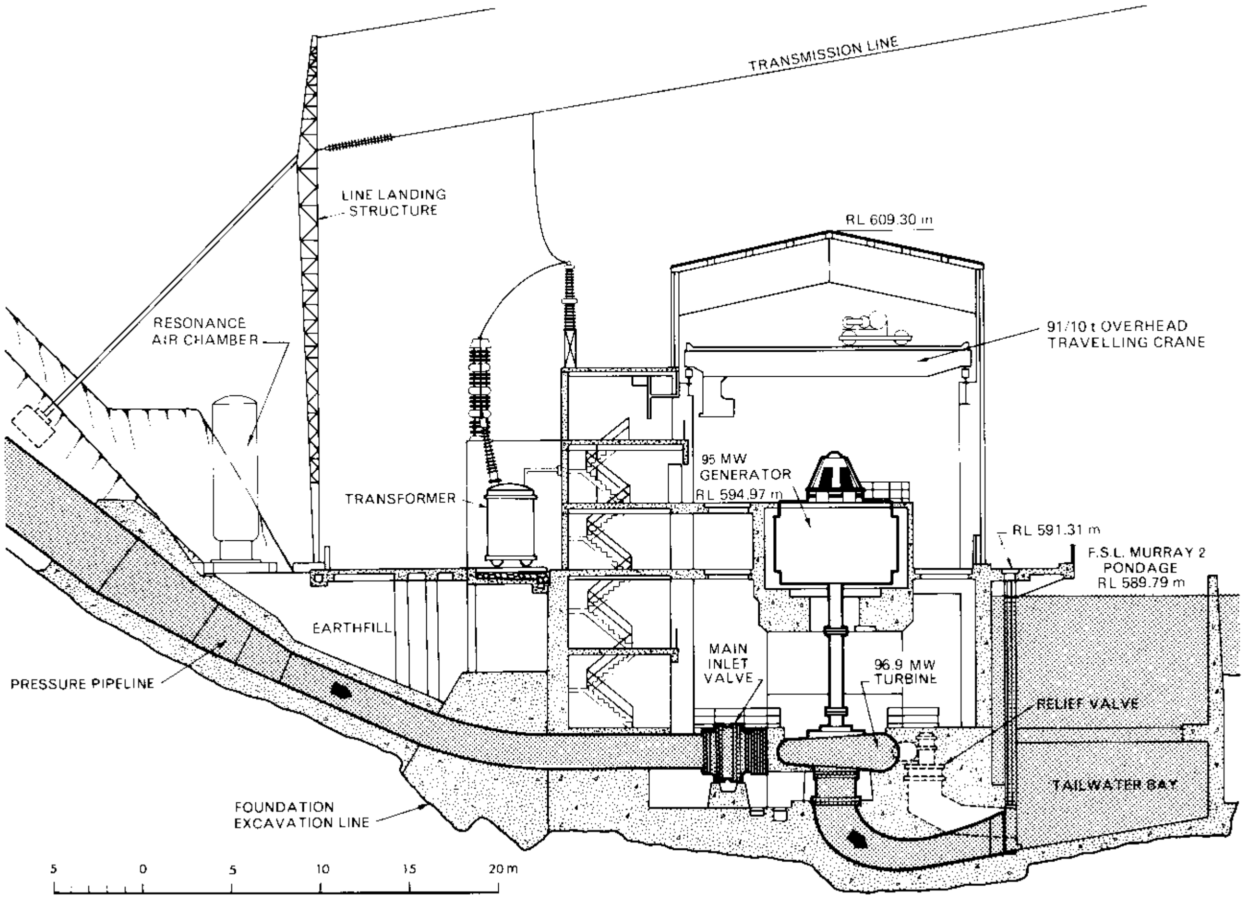
Width: 22.63 m

Height: 36.58 m

Turbines: Ten vertical shaft, Francis type, 96.9 MW at 500 r/min with rated head of 460 m. Total discharge capacity of 241 m^3/s.

Transformers: Sixteen single-phase oil-filled, water-cooled 68/34/34 MV.A, $\frac{346}{\sqrt{3}}/15/15$ kV

SECTION THROUGH MURRAY 1 POWER STATION



Volume of Concrete:

Power Station: 33 380 m^3

Distributors: 6 000 m^3

Tailwater Structure: 2 630 m^3

Generators: Ten vertical shaft salient pole, 15 kV 95 MW at 0.925 power factor lagging

Geology: Shales, siltstones and sandstone with overlying river gravel and slopewash

Other Features: Line landing structure outdoor at rear of station

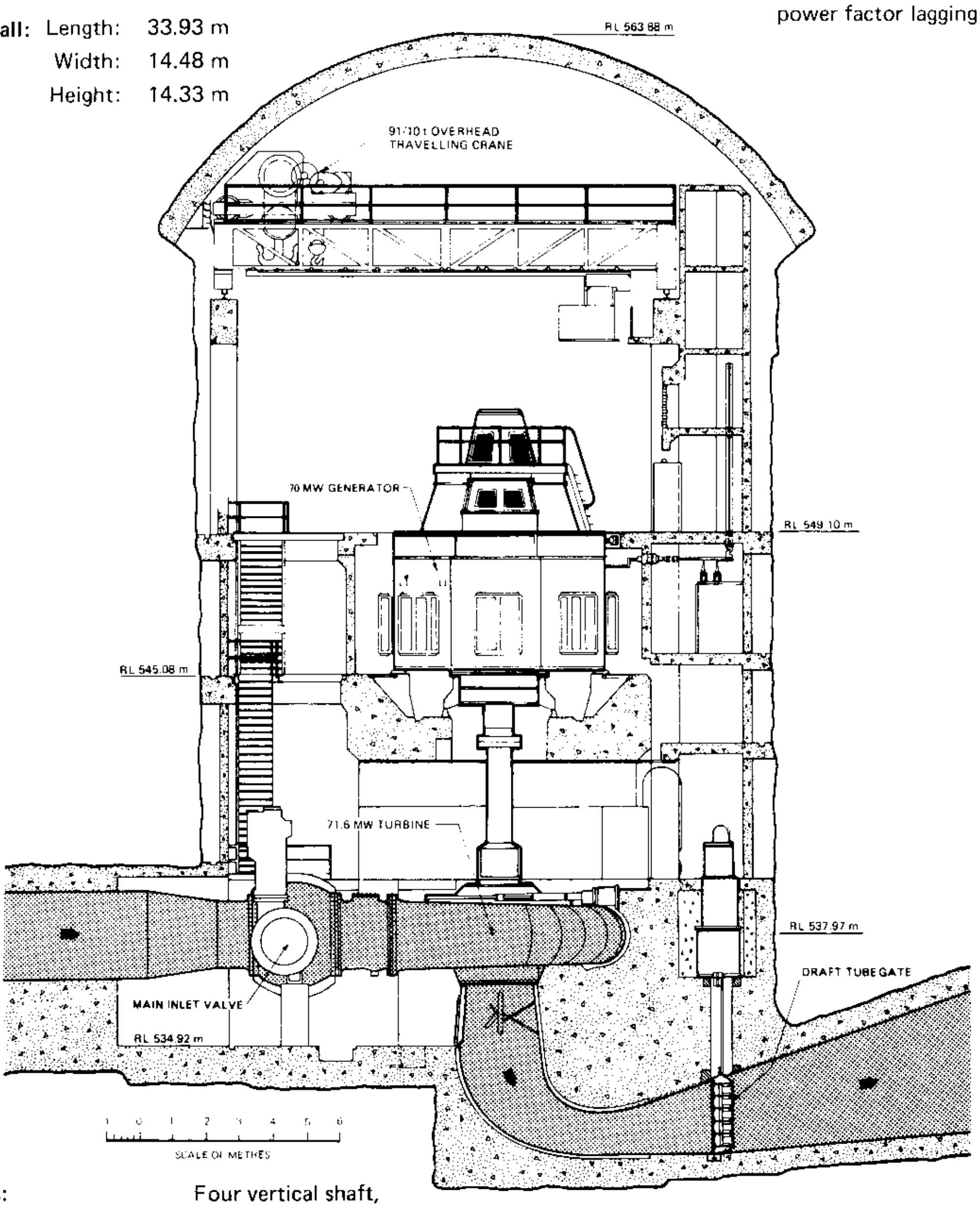
Construction Period: December 1962 to August 1967

TUMUT 2 POWER STATION

Function: Tumut 2 Underground Power Station generates electricity from the waters diverted from Tumut 2 Pondage.

Type:	Excavated machine hall and transformer hall
Generating Capacity:	Four 70 000 kW units – total 280 000 kW
Volume of Excavation:	Machine hall and transformer hall: 51 400 m^3
Volume of Concrete:	Machine hall and transformer hall: 10 400 m^3
Depth below Ground Surface:	244 m
Generators:	Four vertical shaft, salient pole, 12.5 kV 70 MW each at 0.925 power factor lagging

Machine Hall:	Length:	97.38 m
	Width:	15.62 m
	Height:	33.53 m
Transformer Hall:	Length:	33.93 m
	Width:	14.48 m
	Height:	14.33 m

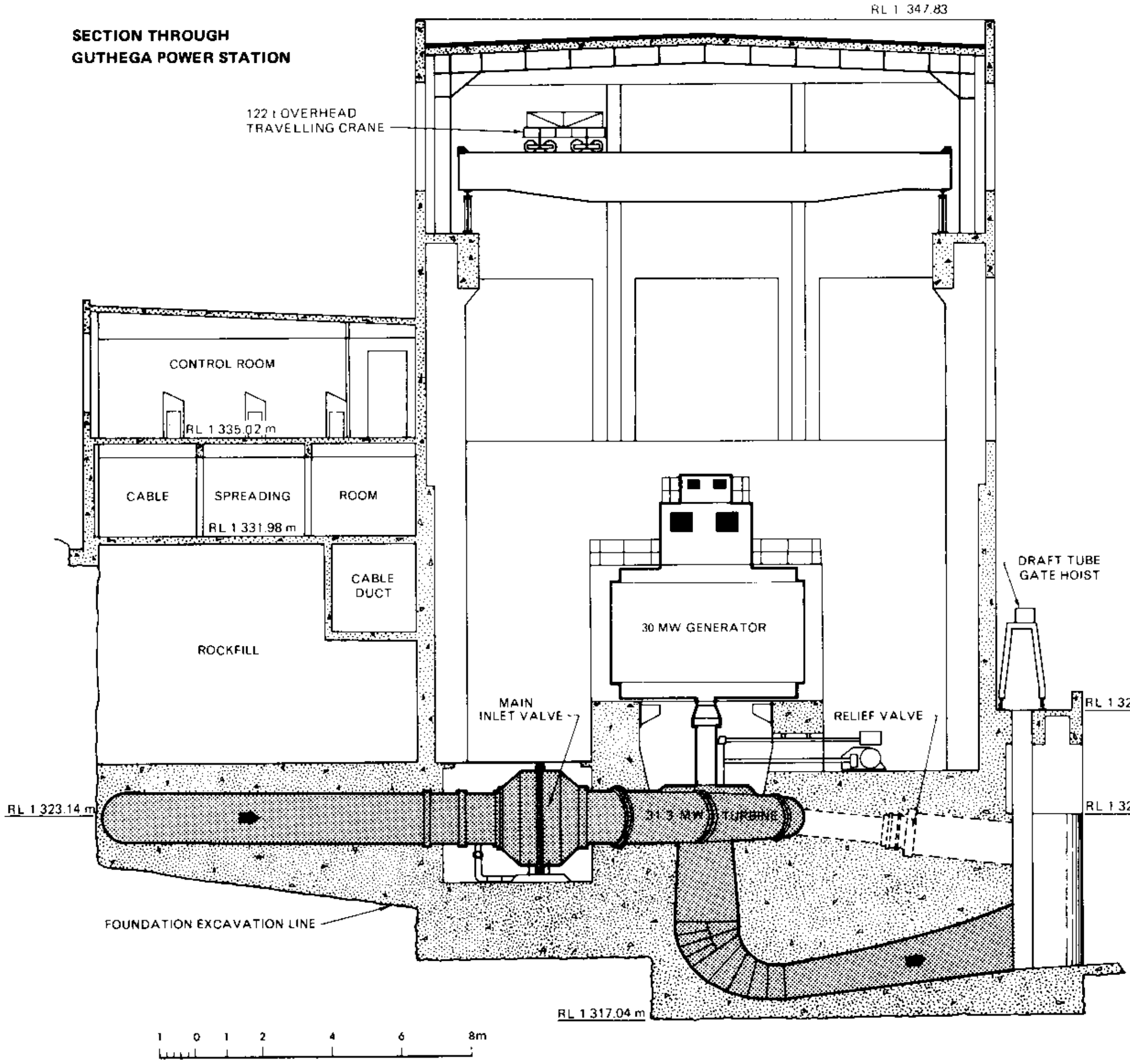


Turbines:	Four vertical shaft, Francis type, 71.6 MW at 428 r/min with rated head of 262.1 m. Total discharge capacity of 118.9 m^3/s
Transformers:	Seven single-phase, oil-filled, water-cooled, 50/25/25/MV.A, $\frac{330}{\sqrt{3}}/12.5/12.5$ kV
Geology:	Granitic gneiss and granite with some porphyry dikes
Other Features:	Outdoor cableyard
Construction Period:	June 1958 to January 1962

GUTHEGA POWER STATION

Function: Guthega Power Station generates electricity from the waters diverted from Guthega Pondage.

Type:	Concrete surface station
Generating Capacity:	Two 30 000 kW units – total 60 000 kW
Machine Hall:	
Length:	51.46 m
Width:	17.83 m
Height:	32.61 m
Volume of Concrete:	6 880 m^3
Generators:	Two vertical shaft, salient pole, 11 kV, 30 MW each at 0.9 power factor lagging
Turbines:	Two vertical shaft, Francis type, 31.3 MW at 428 r/min with rated head of 246.9 m Total discharge capacity of 28.3 m^3/s



Transformers:	Three three-phase, ON AN cooled, two 33 MV.A 138.6/11 kV, one 15/15/5 MV.A 132/66/11 kV
Geology:	Granite
Other Features:	Outdoor switchyard
Construction Period:	November 1951 to April 1955

TUMUT 3 POWER STATION

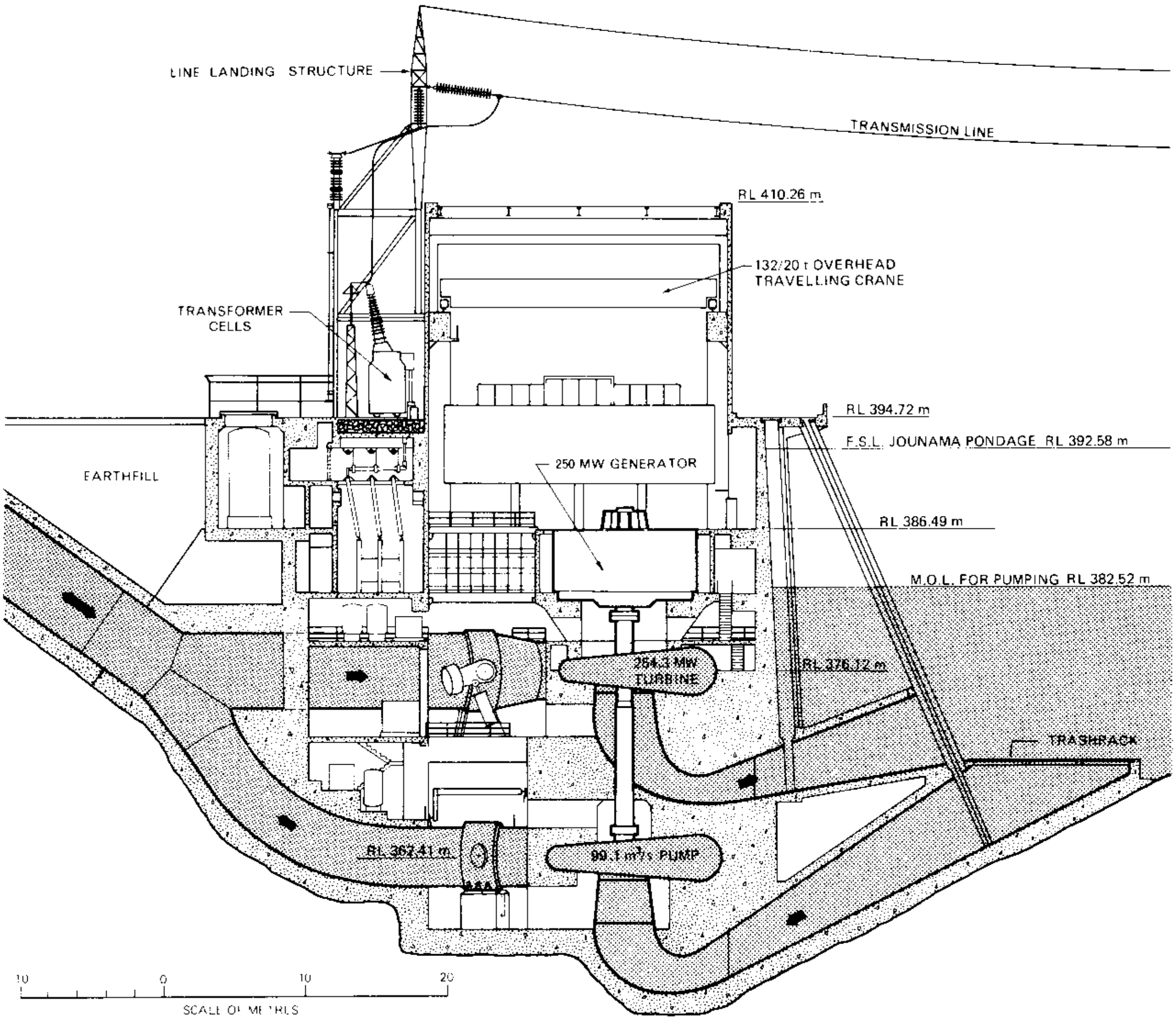
Function: Tumut 3 Power Station generates electricity from the waters provided from Talbingo Reservoir. Additional flexibility is achieved by pumps in the power station which return water to Talbingo Reservoir during off-peak periods.

Type: Concrete surface station

Generating Capacity: Six 250 000 kW units – total 1 500 000 kW

Machine Hall: Length: 154.23 m
Width: 22.48 m
Height: 59.61 m

Volume of Concrete: 85 600 m^3



Generators: Six vertical shaft, salient pole, 15.4 kV, semi-umbrella; three are designed to operate as motors after being started by the turbine. Each generator 250 MW at 0.95 power factor lagging

Pumps: Three pumps each with a capacity of 99.1 m^3/s against a pumping head of 155.1 m

Turbines: Six vertical shaft, Francis type, 254.3 MW at 187.5 r/min with rated head of 150.9 m. Total discharge capacity of 1 132.7 m^3/s

Transformers: Ten single-phase, oil-filled, water-cooled, 176/88/88 MV.A, $\frac{346}{\sqrt{3}}/15.4/15.4$ kV, four of which are adapted to operate generators as motors

Geology: Founded on rhyolite bedrock

Other Features: Line landing structures extending 14.6 m above power station roof

Construction Period: January 1968 to September 1973