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Fact Sheet

INGULA PUMPED STORAGE SCHEME - Technical Brochure

INDUSTRY AND CONSERVATION WORKING HAND IN HAND

Introduction

To build a pumped storage scheme you need a specific combination of factors to be just right, they are the right geology, enough available water, two sites to build dams – close enough together, but with at least 400 metres difference in altitude, and it needs to be close to the National Grid and existing infrastructure.

Eskom started looking for such sites in the 1980s. Initially more than 90 potential sites were investigated, resulting in a short-listing of only three. The best site was selected north-east of Van Reenen's Pass, spanning the escarpment of the Little Drakensberg, and straddling the provincial boundary of the Free State and KwaZulu-Natal.

This escarpment is also the continental watershed between the Vaal River catchment, flowing into the Atlantic Ocean, and the Tugela River catchment, flowing into the Indian Ocean.

Construction began in 2006 and Ingula began operating during 2016.

History behind the name Ingula

Initially known as ‘Bramhoek’, the name was officially changed to ‘Ingula’ in March 2007. The name ‘Ingula’ alludes to the creamy contents at the top of a milk calabash. The quest to find an appropriate name for Ingula Power Station was inspired by the mountains and foamy river-waters, and the rich cultural symbols and traditions of the indigenous people on both sides of the border.

The scheme

The pumped storage scheme consists of an upper and a lower dam, each capable of holding approximately 22 million cubic metres of water. The dams, 4,6km apart, are connected by underground waterways passing through an underground powerhouse with four 333 MW (installed capacity) generators.

To generate electricity during times of peak demand, water is released from the upper dam, passing through the pump/turbines, into the lower dam.

During times of low energy demand, the pump/turbines are used to pump water from the lower dam, back to the upper dam. Unlike, Drakensberg Pumped Storage Scheme, Ingula is not part of a water transfer scheme.

The environment

Eskom took the decision to manage the area surrounding the dams and construction sites as a conservation area. This area, located in both the Free State and KwaZulu-Natal, is of significant value as a source of water for the Highveld and serves as a habitat for a variety of special plants, birds, and animals. During construction, a team of full-time, professional environmentalists monitored construction activities on site, ensuring legal requirements were met and that the project operated within the terms of the government authorisation.

Conservation
Eight thousand hectares around the power station is protected for posterity. With the cooperation of surrounding landowners, Ingula will, hopefully, form the core of a larger conservation area protecting the moist, high-altitude grasslands of the eastern Free State and northern KwaZulu-Natal.

In March 2004 a partnership was formed between Eskom, BirdLife South Africa, and Middelpunt Wetland Trust. The Ingula Partnership, as it is known, is directly involved in the management of the nature reserve. It aims to expand awareness on an international, national, regional, and local level. The partnership's vision is for Ingula to become a world renowned, sustainable conservation area. In 2018 Ingula was officially declared a nature reserve.

Birdlife

More than 350 bird species have been sighted at Ingula, 25 being threatened species. The Bedford/Chatsworth wetland is recognized by BirdLife South Africa as an Important Birding and Biodiversity Area (IBA).

Wildlife

The threatened oribi occurs on site, grey rhebok and steenbok are also present. Historically, the site was heavily utilised by livestock which resulted in large tracts of erosion. Livestock numbers were reduced and eroded areas were rehabilitated or stabilised. Previously, the area was subjected to poaching and illegal plant harvesting. Through the development of the nature reserve, the numbers of animals on site have increased and are establishing viable populations.

Wetlands

Wetlands comprise around 1 000 hectares and supplies the water to the Wilge River throughout the year. The wetland system is host to a variety of species and is now protected following years of overgrazing and inappropriate burning. The pristine status of the wetland gained Ramsar certification in 2021. Ramsar is the world convention for the protection of wetlands, this means that the Ingula wetlands and the reserve are globally recognized.

Grasslands

Grassland ecosystems are most in need of conservation in South Africa. The conservation of the Ingula area will go some distance towards increasing grassland areas under protection.

The cooperation of landowners, through the development of a nature reserve, will ensure an improved environment and will help in the development of communities in the area, both from a social and economic perspective.

Rehabilitation

All areas disturbed during construction were rehabilitated to their original condition. A massive program was launched and continues to eradicate large stands of invasive, alien Wattle trees and other invasive species.

Ecotourism

As part of the conservation programme, a network of walking and hiking trails will be developed, and other ecotourism opportunities investigated and implemented. These potentially include campsites, river trails, birding and cycling. Marketing of the area may lead to an increased demand for accommodation, an opportunity for surrounding landowners.

Sustainability

Ingula's vision is to become an internationally renowned sustainable nature reserve and all activities on site are carried out with this long-term objective in mind. Because of the sophisticated Environmental Management Plan that governs all activities on site, Ingula was the first Eskom construction site to receive ISO14001 certification in March 2011. It continues to retain this highly esteemed achievement.

Pumped storage schemes

Palmiet Pumped Storage Scheme

Drakensberg Pumped Storage Scheme

A pumped storage scheme is a variation of the more common run-of-river hydroelectric power station. The power station of a pumped storage scheme is built in a waterway that links an upper and lower reservoir. Electricity is generated only during peak demand periods or emergencies. Water is channeled from the upper to the lower reservoir through reversible pump-turbine sets. During periods of low energy demand this same water is pumped back to the upper reservoir by the reversible sets.

The Drakensberg scheme, built in the early 1980s, paved the way for Eskom's second pumped storage scheme, Palmiet, near Grabouw in the Western Cape. Ingula, is Eskom's third and largest scheme. These power stations have the advantage of being able to generate electricity within a few minutes, whereas coal-fired stations require a minimum of eight hours, from cold startup, to generating power.

By pumping water from the lower to the upper reservoirs during low-peak periods, the pumped storage schemes help to flatten the load demand curve on the national system by using the excess generating capacity available in these off-peak periods.

Construction of the power station

Certain aspects of environmental conservation introduced during the construction of the Drakensberg Pumped Storage Scheme had a profound influence on Eskom's approach to the later Palmiet project. Drakensberg witnessed the beginning of the integration of environmental and technical principles, which was to be a hallmark of the Palmiet undertaking. The combined knowledge and experience obtained with Eskom's first two schemes made it possible to successfully develop Ingula as a flagship project. Contractors and Eskom's engineers incorporated environmental protection and restoration to safeguard the natural surroundings.

The underground caverns

The mountain in which the power station is built consists of relatively weak mudstone, siltstone, and sandstone, which are horizontally bedded. Both primary and secondary rock reinforcement were used with fast-resin anchors between one and eleven metres.

Unlike Drakensberg, Ingula has two caverns and boasts the largest single span cavern in soft mud rock in the world.

The construction of the halls was undertaken in stages, working downward from the central crown and inserting rock bolts according to a carefully designed pattern. The cavern walls were lined with shotcrete soon after excavation to prevent rock deterioration. When rock movement became minimal, a second lining of shotcrete was applied with weld mesh reinforcement. The same techniques were applied to tunneling. During construction of the underground power station complex, 1 150 000m^3 of rock was excavated and 390 000m^3 of concrete was used. Around 17 500 tons of reinforcing steel were used in the concrete, with 75 000 rock bolts inserted. If all the reinforcing bars were laid out end to end it would stretch for 7,6 million km - enough to go around the earth at the equator 189 times.

The reservoirs

Two new reservoirs (Bedford and Bramhoek) were constructed - one in the Free State at Ingula's upper site, and one in KwaZulu-Natal on the lower site.

Bedford Dam and intake canal

The dam wall is 810 metres long, 39 metres high, and is a concrete-faced rock-fill type embankment. The total rock-fill comprise 1 050 000m^3 of sandstone, quarried from inside the dam basin. The capacity of the dam is 22 million m^3 at full supply, with a surface area of 255 hectares.

Water is channeled to the intake structure via an 840m canal with a trapezoidal profile. The canal varies in depth from 5 to 15,45 metres. Two control towers are situated at the end of the canal and contain the intake gates and stop-logs. The canal is concrete lined, and the slopes are protected by placed rip-rap.

Due to the sensitivity of the site for the dam, environmental matters were taken very seriously, and the dam design was very much "nature driven". Landscape aesthetics were a serious consideration. The dam wall was designed to blend into the natural landscape to maintain a "sense of place".

Borrow pits and quarries were developed below the dam's minimum operating level. Landscape architects were appointed to comment on the original design drawings.

Their recommendation to curve the left flank of the dam to follow the flowing contours of the site was adopted. The downstream dam slope comprises packed sandstone as sandstone outcrops occur naturally in the area.

To comply with the water license, water is continuously released downstream into the Bedford Wetland. To prevent destruction of the wetland, water flow had to be distributed evenly. This ‘environmental release’ is facilitated through a sunken stilling basin and pond with a long discharge sill at riverbed level, situated against the lower left abutment outside the wetland. Award winning hydraulic modeling was used to ensure the fully effective and optimal function of the environmental stilling basin and pond. This work was done on behalf of the Bramhoek Consultants Joint Venture (BCJV) by specialists Aerotherm using Computational Fluid Dynamics (CFD) modeling. The design was awarded the CESA AON Engineering Excellence Awards - Project value in excess of R250-million, in 2011.

Bramhoek Dam

The dam wall is a roller-compacted concrete (RCC) embankment. During construction 67 000 m³ RCC was used and a further 81 800 m³ of concrete. The dam wall is 335 metres long and 31,1 metres high. At full supply the surface area is 240 hectares, and it holds 26,26 million m³ of water, of which 19 million m³ is the live volume used for generation. The Bramhoek Spruit was impounded on 10 April 2010.

Quarry

Aggregate required for concrete was mined from within the basin of Bramhoek Dam. A total of 2 600 000 tons of dolerite was blasted and crushed by B&E International Quanza Joint Venture from May 2007 to September 2010.

Very strict environmental controls were maintained for dust, emissions, water management and the rehabilitation of stockpiles and quarry areas. No quarrying was allowed within five metres of the banks of the spruit. No area of the quarry is visible above the full supply level of the reservoir (1270 metres above sea level). The whole area was rehabilitated to blend in with the surrounding environment.

The crushing plant supplied an average of 5400 tons of aggregate a day and continued until September 2010. The plant produced all the required sizes of aggregate for the construction of Ingula, from 900mm rip rap to sand. The crushing machines used were Osborne and Metso crushers, which crushed up to 350 tons of rock per hour.

To mine these huge quantities of rock, around 700 000 tons of explosives were used to fracture the rock into suitable sizes for its intended purpose. A water-based gel emulsion explosive was used.

Mechanical Aspects

The four reversible Francis sets are designed to generate a rated output of 333 MW each at 428rpm and to pump against a maximum head of 441m.

Cavitation posed a challenge since cavitation erosion increases exponentially with the relative flow rate. In the case of the Ingula machines, this velocity reaches nearly 80m³/s. Submergence of 80m to 95m below the level of the Bramhoek reservoir guarantees that no unacceptable cavitation damage occurs, even when pumping against a maximum head. An interesting aspect of the machines is that they are controlled by electronic governors of the electrohydraulic type with proportional-integral-derivative characteristics. The control output is at the frequency of the generated power.

Each machine can be isolated from the water in the penstocks by its own spherical shut-off valve. These valves are 2.5m in diameter and are operated by hydraulic servomotors. They can be closed during operational conditions even when water hammer is taking place. A special upstream seal is provided for maintenance purposes.

Electrical Aspects

The generator-motors of the pump-turbines can run unloaded as synchronous condensers in the generating and pumping direction of rotation to provide reactive compression. In this case, the spherical valves are shut, and compressed air is used to depress the water in the draft tubes to below this level of the runner, thus minimizing the torque required to rotate the unit. The excitation is then adjusted to give the required reactive compensation. The synchronous condenser mode of operation can be considered as a spinning reserve since it allows the machine to be loaded as a generator by releasing the compressed air from the turbine chamber and opening the spherical valve and guide vanes.

Static frequency converter

The Static Frequency Converter (SFC) operates as a starter motor for the pump mode. The machines are automatically controlled from this point. Electricity is imported at 400 kV from the grid and stepped down to 18 kV for running the machine up in the pump mode; once the machine is synchronised with the system the SFC cuts out and lets the generator take over as a pump motor, to pump the water from the lower dam to the upper dam. It is also used as a brake to bring the machine to standstill (this takes approximately 6 minutes)

Unlike normal hydroelectric generators, the generator motors run in both directions in a regular cycle. The severe fatigue stresses affect the design of the stator core and windings.

The generation voltage of 18kV is transformed to the national grid voltage of 400kV. For several reasons, including security, proximity to the generators, reduction of busbar lengths and environmental considerations, the transformers and switchgear are located underground up to 80m below the lower reservoir level. Consequently, a special cooling system is necessary. Each transformer is fitted with three oil/water heat exchangers, two being standby.

The high-voltage Gen Circuit Breaker is gas-insulated with phase-reversal isolators for changeover between pumping and generation. Installation is designed to allow ease of maintenance.

All MV switchgears are metal clad, segregated, Unigear switchgear.

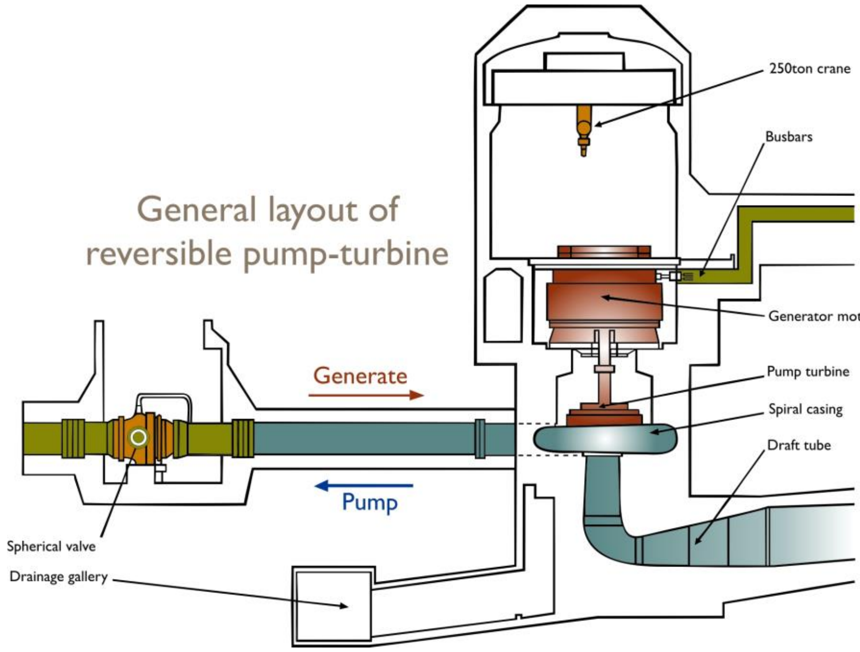
The step-up transformers step up the generated voltage from 18 kV up to 400 kV and the power is transmitted to the HV yard on the surface via High voltage cables, which are in the Cable Access Tunnel. These cables evacuate power from the station during generation modes and provide power to the units during pumping and SCO modes.

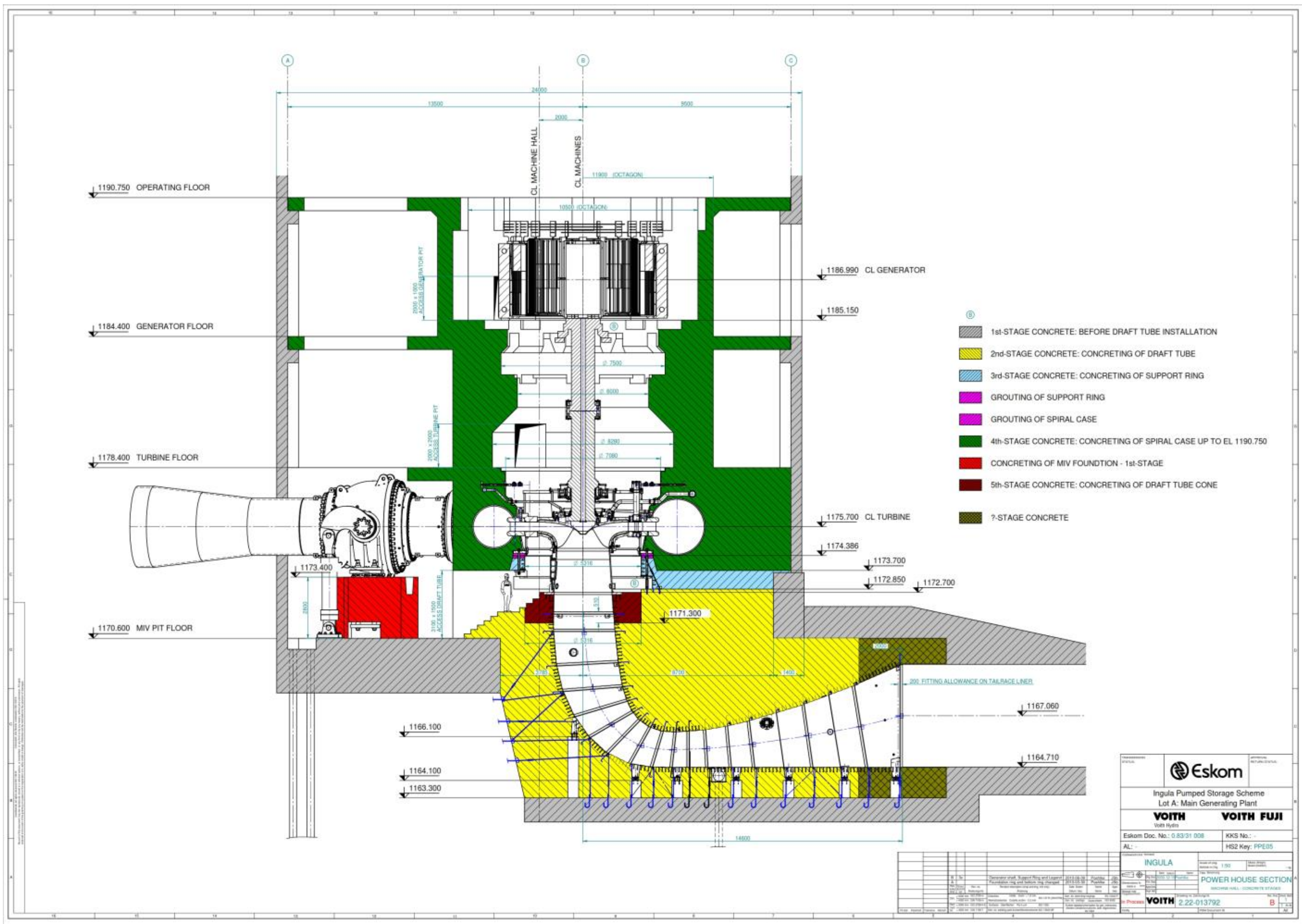
Operational efficiency

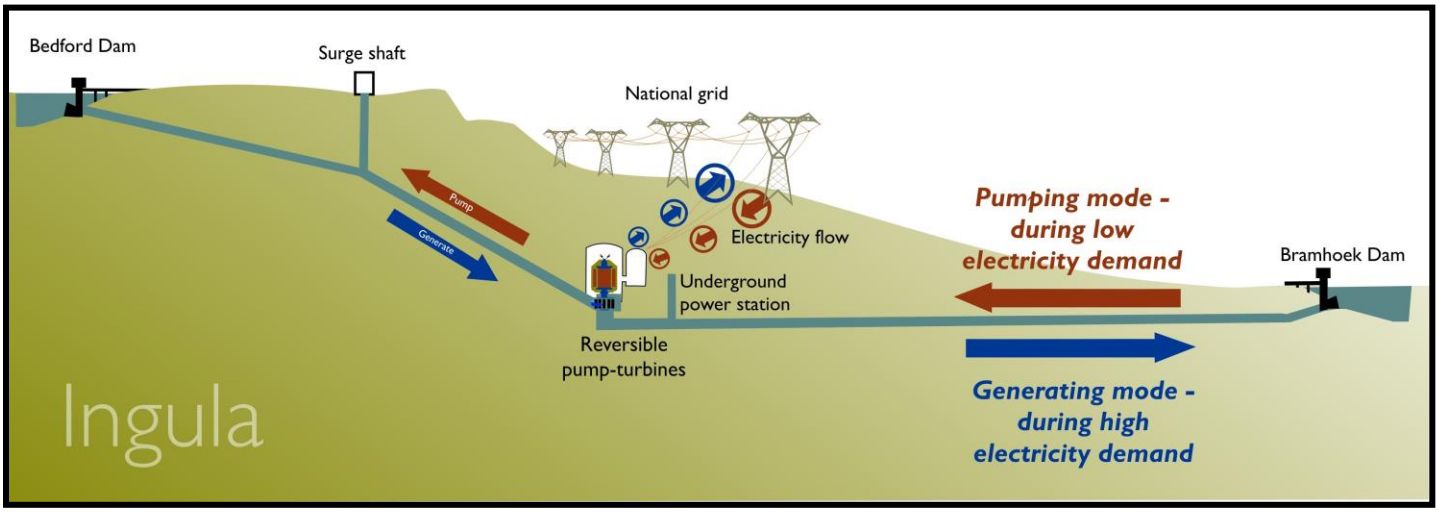
Losses during pumping and generation mean that the scheme requires about 1,3 units of pumping energy for each unit generated. As the same plant is used for pumping and generation, the maximum theoretical load factor for generation is roughly 78%.

Each machine at the Ingula scheme can be brought from standstill to full load within three minutes. The loading on each machine can be brought from speed-no-load to full load in approximately 80 seconds. The change from maximum pumping load to full generation can be achieved in approximately eight minutes. This results in a load swing of 2 666MW on the national grid.

The Ingula Pumped Storage Scheme operates on a weekly cycle. For a period of just over 40 hours during the weekend, Eskom experiences a low-demand period when surplus power is used to pump water back from the lower to the upper reservoir.


General layout of reversible pump-turbine
250ton crane
Busbars
Generator motor
Pump turbine
Spiral casing
Draft tube
Generate
Pump
Spherical valve
Drainage gallery


CL MACHINE HALL
CL MACHINES
1190.750 OPERATING FLOOR
1186.990 CL GENERATOR
1185.150
1184.400 GENERATOR FLOOR
1178.400 TURBINE FLOOR
1175.700 CL TURBINE
1174.386
1173.700
1173.400
1172.850
1172.700
1171.300
1170.600 MIV PIT FLOOR
1167.060
1166.100
1164.710
1164.100
1163.300
200 FITTING ALLOWANCE ON TAILRACE LINER
1st-STAGE CONCRETE: BEFORE DRAFT TUBE INSTALLATION
2nd-STAGE CONCRETE: CONCRETING OF DRAFT TUBE
3rd-STAGE CONCRETE: CONCRETING OF SUPPORT RING
GROUTING OF SUPPORT RING
GROUTING OF SPIRAL CASE
4th-STAGE CONCRETE: CONCRETING OF SPIRAL CASE UP TO EL 1190.750
CONCRETING OF MIV FOUNDTION - 1st-STAGE
5th-STAGE CONCRETE: CONCRETING OF DRAFT TUBE CONE
?-STAGE CONCRETE
Eskom
Ingula Pumped Storage Scheme
Lot A: Main Generating Plant
VOITH
VOITH FUJI
Eskom Doc. No.: 0.83/31 008
KKS No.: -
HS2 Key: PPE05
INGULA
POWER HOUSE SECTION
VOITH
2.22-013792



TECHNICAL DATA	
Bedford Dam (upper reservoir)	
Locality	
Province	Free State
District	Thabo Mafutsanyane
Name of farm	Bedford 2 No. 1845
Nearest town	Harrismith
Distance to nearest town by road	51 km
Dam location	28°14'S 29°35'E
Structural and reservoir information	
Full Supply Level (FSL)	1738,6 masl
Spillway crest level	1740,6 masl
Non overspill crest level	1740,6 masl
Minimum level for all machines operating	1720,6 masl
Top of parapet wall	1741,905
River bed level	1701,0
Lowest foundation level	1691
Lowest drawdown level	1720,0
Length of spillway	80 m
Max height above lowest foundation	50,905 m
Max height above river bed	40.905 m
Max water depth at full supply level	37.6 m
Live volume	19,2 million m^3
Maximum storage volume	22,43 million m^3
Minimum storage volume (dead volume)	3,2773m 3 million m^3
Total wall length	773 m
Type of dam wall	Concrete Faced Rock Fill
Rock fill volume	982 000 m^3
Concrete volume	73 000 m^3
Surface area at FSL	255 hectares
Capacity at LDL	3.230 million m^3
Reservoir volume at NOC	28.0 million m^3

Emergency spillway and outlets	
Design capacity	240 m³/s
Outlet capacity at FSL	71.2 m³/s
Outlet capacity at LDL	52.2 m³/s
Peak pumping inflow	348 m³/s
Peak generating outflow	240.9 m³/s
Catchment data	
Catchment drainage number	C81A
River	Small Wilge River Tributary
Catchment area at dam	11.53 km²
Mean annual precipitation	982 mm
Mean annual runoff	1.8 million m³/s
Dam (lower reservoir)	
Locality	
Province	KwaZulu-Natal
District	Uthukela
Name of farm	1220
Nearest town	Ladysmith
Distance to nearest town by road	46 km
Dam location	28°17'S 29°34'E
Structural and reservoir information	
Full supply level	1270 masl
Non-overspill crest level	1274.60 masl
River bed level	1243.50 masl
Lowest foundation level	1236 masl
Lowest drawdown level	1258 masl
Max height above lowest foundation	38.6 m
Max height above river bed	31,1 m
Max water depth at FSL	26,0 m
Total concrete volume	81 800 m³
RCC volume	67 000 m³
Gross capacity at FSL	26 262 000 m³
Surface area at FSL	240 hectares
Capacity at LDL	4 341 000 m³
RDF water level	1272,180 m
SEF water level	1274,575 m
Reservoir volume at SEF	38 470 000 m³
Allowance for evaporation	675 000 m³
Allowance for sedimentation	1 350 000 m³
Minimum level for 4 machines operating	1258 masl
Live volume	19,2 million m³
Volume allowance for evaporation over and above active volume	2,72 million m³
Maximum storage volume	26,26 million m³
Minimum storage volume (dead volume)	4,34 million m³
Type of dam wall	Roller Compacted Concrete gravity
Total wall length	335.0 m
Spillway length	40 m
Spillway crest level	1270.50 m

Spillway and outlets	
Design spillway discharge at RDF	170,0 m^3/s
Spillway discharge at SEF	711,0 m^3/s
Outlet capacity at FSL	77,6 m^3
Outlet capacity at LDL	52,3 m^3
Peak generation inflow	348,0 m^3/s
Flood hydrology: Catchment data	
Catchment drainage no	V12A EWR
River	Bramhoekspruit
Catchment area at dam	60,11 km^2
Mean annual precipitation	1053 mm
Mean annual runoff	14,6 x 10^6 m^3
Mean annual sediment production	450 t/km^2
Mean annual evaporation (Symons Pan)	1449 mm
Intake channel and tower	
Channel Profile	Trapezoidal
Base width	25 m to 49.27 m
Depth	From 5 m to 15.45 m
Length	840 m
Tower height	49 m (16 storeys)
Intake gates & stoplogs	6.6 m high x 5.5 m wide (2 tunnels)
Headrace tunnels	
Number	2
Internal diameter	6,60 m concrete-lined and 5,10 m steel lined
Length up to surge shaft	1 061 m for tunnel 1-2 and 1 058 m for tunnel 3-4
Type of construction	Concrete-lined for 873 m for tunnel 1-2 and 873 m for tunnel 3-4, thereafter steel-lined
Maximum flow velocity in concrete-lined section	5,0 m/s at rated generating flow. 7,3 m/s at generating start-up (transient)
Maximum flow velocity in steel-lined section	8,3 m/s at rated generating flow. 12,3 m/s at generating start-up (transient)
Headrace surge shafts	
Number	2
Type	Cylindrical
Internal diameter	16,50 m
Height	191 m
High-pressure inclined shafts and tunnels	
Number	2
Internal diameter	5,10 m to bifurcation, then 3,60 m to reducer, thereafter 2,50 m to spiral
Length (from surge shaft up to spiral inlet)	1081 m
Type of construction	Steel lined
Maximum flow velocity	Rated generating flow from 8,3 m/s to 17,3 m/s

Underground power station	
Number of machines	4
Continuous rating of each machine for generation	333 MW
Maximum power for pumping per machine	360 MW
Range of net head for generation	433,6 m to 465,8 m
Head range for pumping	462,0 m to 489,7 m
Rated generating flow per machine	84,9 m^3/s
Maximum permissible pressure in penstocks	7,22 MPa
Type of pump-turbine	Single stage reversible Francis
Rated speed for both directions of rotation	428,6 rpm
Method of pump starting	Static Frequency Converter
Type of control	Local and remote
Machine hall cavern	183 m x 26 m x 48.75 m high to machine pit, 55.5 m to drainage gallery
Distance from inlet to outlet	4,7 km
Distance from dam wall to dam wall	8 km
Tailrace surge chambers	
Number	2
Type	Cylindrical
Internal diameter	20 m
Height	109.3 m
Tailrace tunnel	
Number	1
Internal diameter	9,4 m
Length	2 340 m
Type of construction	Concrete-lined
Maximum flow velocity	4,9 m/s at rated generating flow. 7,7 m/s at generating start-up (transient)
Outlet channel & tower	
Channel Profile	Trapezoidal
Base width	50 m
Depth	From 5 m to 21 m
Length	500 m
Tower height	43 m
Outlet stoplogs	10 m high x 4.5 m wide (2 openings)
Operating data	
Maximum energy storage capacity	21 GWh
Time required to pump live volume from lower to upper reservoir	20 hours
Type of cycle for operation	Weekly
Cycle efficiency	78 %
Electrical Aspects	
Rated stator voltage	18 kV
Rated frequency	50 Hz
Lightning surge voltage 1,2/50 s	1 425 kV
Switching surge voltage 25/2 250 s	1 050 kV
AC voltage 50 Hz/min	18 kV
Rated stator current	11970A for GEN and 12662A for Pump
Short-circuit current	
Symmetrical	31,5 kA
Asymmetrical	38,6 kA
Single-phase-to-earth-fault	36,2 kA
Making current, peak value	92,4 kA

Construction/Commissioning history	
Construction commenced	2006
Construction completed	2016
Commissioning (synchronized to the grid)	
Unit 1	30 October 2016
Unit 2	21 May 2016
Unit 3	6 March 2016
Unit 4	24 March 2016
Major Contractors	
Exploratory excavation	Murray & Roberts
Preliminary civil work	
Main civil work	CMI-Joint Venture (CMC, PG Mavundla, Impregilo), Consultants Joint Venture
Supply of aggregate	B&E International Quanza Joint Venture
Headrace civil work	CMI Joint Venture (CMC, PG Mavundla and Impregilo)
Surface buildings	Trencon
Structural steelwork	Whesso (steel linings)
Bedford Dam	Dams Joint Venture (WBHO)
Bramhoek Dam	Dams Joint Venture (Concor)
Road works	Grinaker LTA
Infrastructure	Afriscan
Cranes	Konecranes
Main turbine generators	Voith Siemens / Voith-Fuji
Auxiliary Mechanical	Voith Siemens / Voith-Fuji
Transformers	Siemens
High voltage yard	Tyris, Actom

Additional Information			
Ingula Key Quantities			
Main underground construction works			Toyota quantums
Total surface excavation volume, including intake and outlet channel, switchgear, shafts etc	1,500,000	m^3	65,000
Total tunnel excavation volume	920,000	m^3	40,000
Total cavern excavation volume	230,000	m^3	10,000
Total concrete volume	390,000	m^3	17,000
Total steel liner tonnage	15,000	ton	
Total rebar quantity	17,500	ton	
Dams			
Total concrete volume for Bramhoek, Bedford (excl RCC)	60,000	m^3	2,600
Total RCC for Bramhoek	75,000	m^3	3,250
Total rebar quantity	3,700	ton	
Total fill quantity for Bedford	1,050,000	m^3	45,000
Quarry			
Total aggregate tonnage from the quarry	2,600,000	ton	

Total weight of a unit	Rotating Mass +/- 530 tons: rotor, shaft and rotor
Diameter of a shaft turbine	Turbine shaft diameter 1 410mm, length 5 000m +/- 44 tons
Weight and length of a shaft	Gen shaft 4.15 m +/- 43 tons, diameter 1 050 m
Diameter of a runner	4 170 diameter, weight +/- 28 ton
Guide vane stats	19 Wicket Gates/Guide vanes +/- 1 ton each
Pump rate during pump mode	+/- 63.8 – 68.1 m^3 high head to low head
Flow rate during gen mode	+/- 85 m^3/s per unit
Rotor weight	406 ton
Rotor – how many poles and other stats	14 Poles at +/- 12 tons each
Stator	+/- 180 000 plates per rotor. Duration to stack 6 weeks
Stator weight	+/- 380 tons
Stator and rotor lifting beam weight	+/- 34 tons
Busbars – length, diameter	4 737 mm +/- 5 mm (l), 97.2 mm (w)
Cabling	400 kV
Capacity of cranes on operating floor and weight of couplin section	2 x 265 ton & 12 ton plus 8 ton x 2
Main inlet valves	Each weigh 135 tons, inlet diameter of 2,5 m. 4,5m wide and 3,5 m long

•	Total generating capacity – 1 332 MW (4 x 333 MW units)
•	Energy storage capacity – 16 hours (21 000 MWh)
•	Main access tunnel is 1,4 kms in length with a 1:10 gradient
•	The underground power station is at a level 115 m below the entrance to the main access tunnel and 350 m below the top of the mountain
•	At peak flow, the equivalent volume of eight olympic size swimming pools will pass through the turbines every minute
•	Fossils uncovered during construction are around 255 million years old, much older than the dinosaurs
•	3 of South Africa's critically endangered bird species occur in the conservation area
•	More than two and a half million tons of rock was excavated from the underground works
•	The quarry produced 2,6 million tons of aggregate
•	The concrete works was reinforced by 3 600 tons of steel
•	Almost 17 kilometres of tunnels were constructed of which 8 are waterways
•	450 000 cubic meters of concrete was used
•	Over 3 kilometers of steel lining was manufactured on site, weighing 15 000 tons
•	Over 18 kilometers of welds were done on the steel linings, weighing 96 tons.
•	Time spent on welding the steel linings was 94 000 man-hours.
•	700 000 welding rods were used for the steel linings.
•	Total reinforcing installed is 22 700 tons.
•	If all the reinforcing bars were laid out end to end, it would stretch for 7,6 million km – enough to circum navigate the earth, at the equator, 189 times.
•	The difference in altitude between the upper and lower dam is 441 metres.

Key abbreviations

masl	metres above sea level
MW	Megawatt
GWh	Gigawatt hours (1GW=1000MW)
MPa	Megapascals
m3	cubic metres
r.p.m.	revolution per minute