MIEL I

Hydroelectric Power Plant

The Miel I Power Plant, which is located in the municipality of Norcasia, forms part of the hydro potential in western Caldas. This region comprises the basins of the rivers Guarinó, Miel, Moro, Manso and Samaná Sur and minor tributaries such as the Pensilvania and Tenerife Rivers. The plant has an installed capacity of 396 MW across its three units. It began commercial operation in December 2002.

The Guarinó diversion has been in operation since 2010, and the Manso diversion began commercial operation in 2013, increasing average annual generation capacity.

The Guarinó diversion is located in the department of Caldas along the border with the department of Tolima, on the eastern slope of the Central Andean Mountain Range, in the lower-middle basin of the Guarinó River, and is nearby the municipality of Victoria.

The Manso diversion entered operation in 2013, and is located in the department of Caldas, on the outskirts of the municipalities of Samaná and Norcasia, on the eastern slopes of the Central Andean Mountain Range.


Installed capacity of
396 MW

Guarinó **Diversion**

The Guarinó diversion began commercial operation in 2010. The works consist of a concrete dam on the Guarinó River, of approximately 7 m in height, intake structures, headrace, filter channel, environmental flow structures, and a 3,378 m long diversion tunnel.

The intake and diversion tunnel are located in the area where the Guarinó and Miel Rivers are nearest one other, within the jurisdiction of the Cañaveral district, which is located approximately 29 km upstream from where the Guarinó River empties into the Magdalena River. The diversion tunnel's outlet is close to the channel of the La Miel River.

The Guarinó diversion has a radial gate that is 3.5 m wide x 3.0 m high for the environmental flow channel.

Manso **Diversion**

This diversion entered operation in 2013. It is located in the department of Caldas and borders the municipalities of Samaná and Norcasia, on the eastern slopes of the Central Andean Mountain Range. It diverts a certain volume of water from the Manso River to the Amaní reservoir that serves the Miel I Hydroelectric Power Plant, via a tunnel.

The works comprising the Manso diversion consist of a small concrete dam on the Manso River, intake structures, headrace, filter channel, environmental flow diversion structure, and a 4,015 m-long tunnel to channel water diverted from the Manso River to the Santa Bárbara Stream and ultimately, the Miel I Power Plant's Amaní Reservoir.

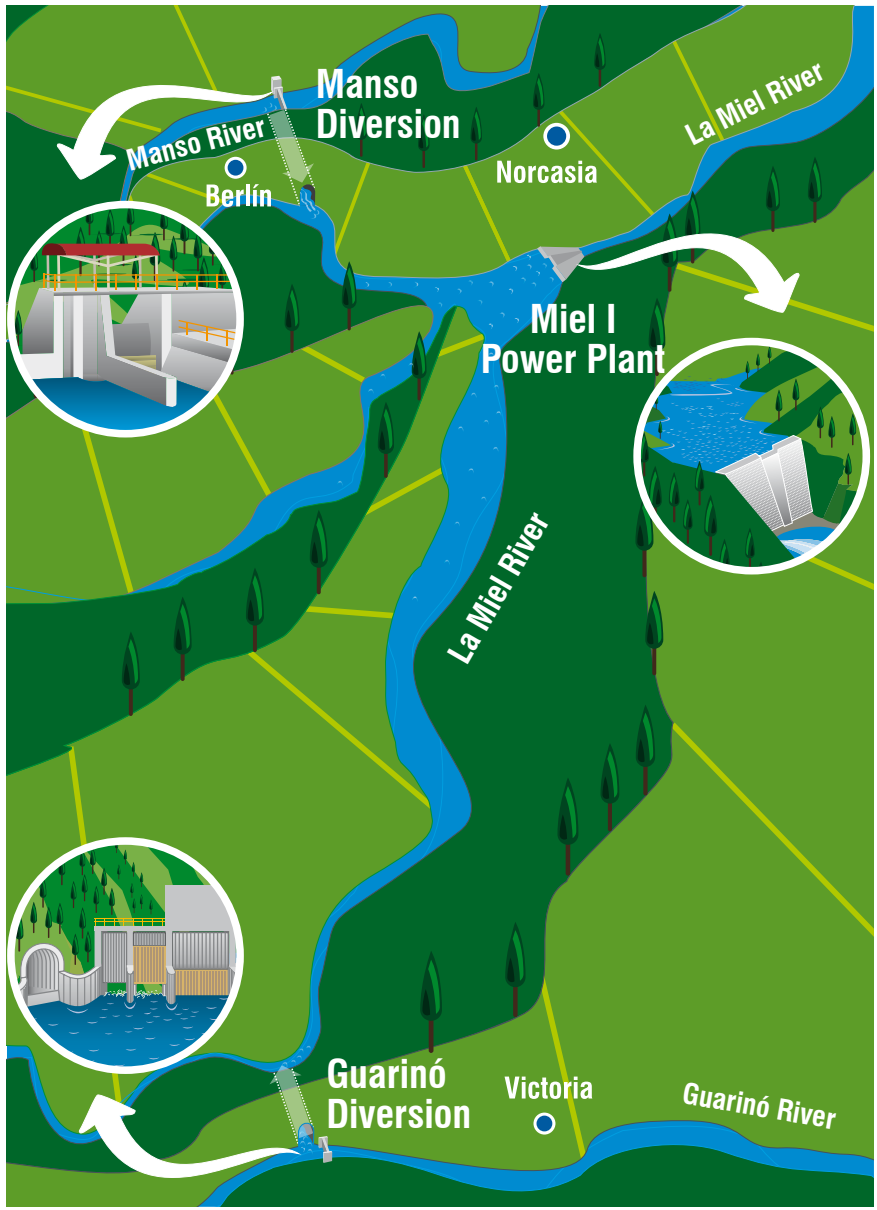
In addition, the diversion includes a road for access to the tunnel's outlet. This road has two bridges, one over the Montebello stream, and another over the Soto stream.

In terms of electro-mechanical equipment, the Manso diversion has a 1.0 m x 1.2 m sliding gate in its intake system, a 4.5 m x 5.0 m radial gate with a radius of 6.0 m for the filter channel, and a 1.0 m x 1.0 m sliding sluice gate for the environmental flow.

Civil **works**

The Patángoras dam, which is part of the Miel I Hydroelectric Power Plant, was built over the Miel River. It is a 188 m-high gravity dam (constructed with roller-compacted concrete) and is the second-highest in the world. Its crest spans a length of 340 m, thereby creating a reservoir with a storage capacity of 571,000,000 m^3, of which 444,980,000 m^3 is useful volume.

The dam's impermeability is achieved thanks to the waterproof shield facing the upstream waters.



1

Withdrawal is performed through an intake and a penstock tunnel. The tunnel has a main gate and a guard gate, which are operated by hydraulic actuators. The main gate is designed to operate with flow.

2

Downstream of the gates is the upper penstock tunnel is that coated with reinforced concrete, which is 90 m long and 6.55 m in diameter. It ends at a duct elbow that connects with a 119.2 m vertical shaft. The bottom of the vertical shaft joins another duct elbow that connects to the lower penstock tunnel.

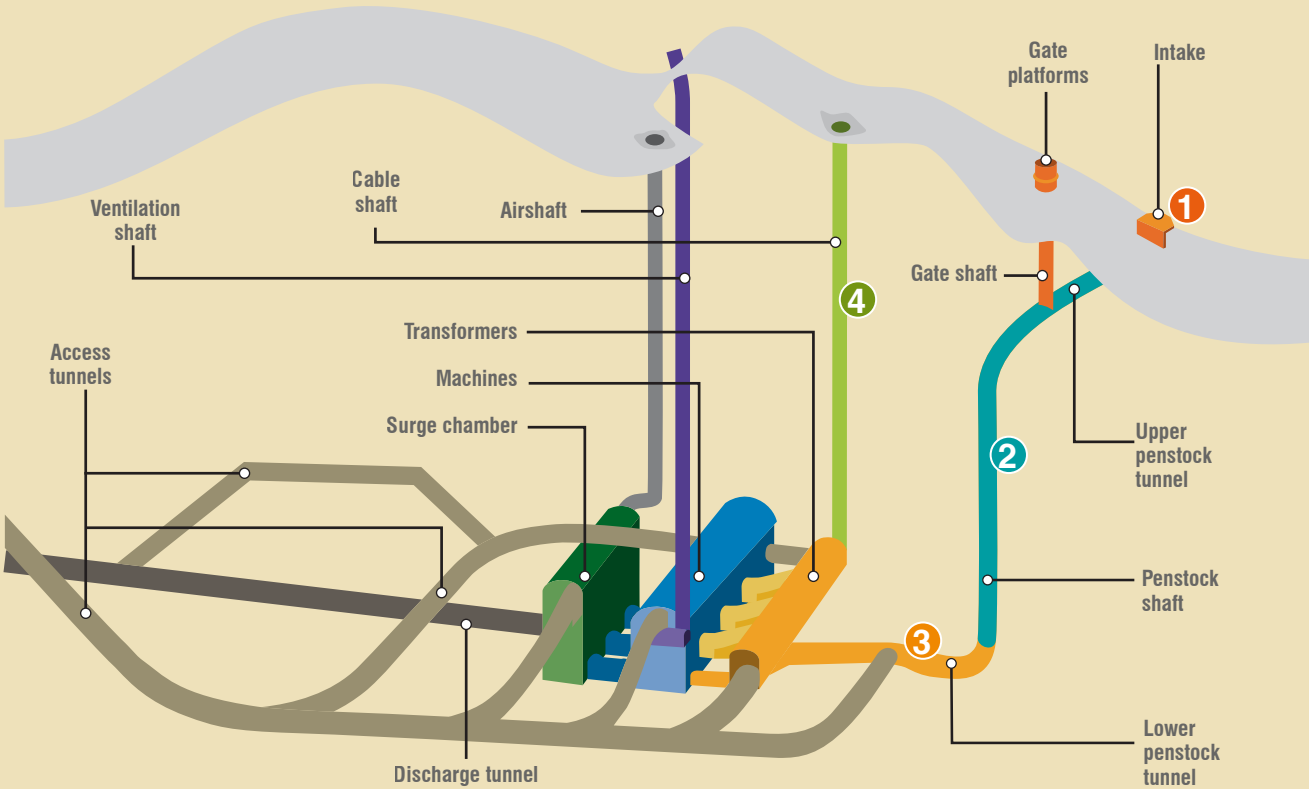
3

The 58 m long lower penstock tunnel includes a section coated with reinforced concrete. At the end, there is a 45 m section reinforced with steel to feed the three turbines through reinforced segments that are 3.35 m in diameter.

4

In order for the 230 kV dry cables to exit from the transformer room to the outside, there is vertical shaft with a diameter of 3.20 m and a depth of 176.7 m. At the end of the shaft, at the surface, there is a gateway where two overhead lines exit from (one a single circuit and the other a double circuit), which lead to the Miel substation. This shaft has an elevator, and carries the pipes for the fire-fighting system and drinking water for the plant.

The bottom outlet consists of an outlet through a shaft, which feeds into two tunnels controlled by two butterfly valves and two Howell-Bunger valves. The discharge capacity is 250 m^3/s, and makes it possible for the environmental flow to be deposited downstream of the dam. It has a “ski-jump” spillway above the surface of the water downstream from the dam with a 65 m opening over the crest of the dam, which does not have regulating gates. It is designed to evacuate estimated probable maximum swells of m^3/s .


Gate platforms
Intake
Cable shaft
Ventilation shaft
Airshaft
Gate shaft
Transformers
Access tunnels
Machines
Surge chamber
Upper penstock tunnel
Penstock shaft
Lower penstock tunnel
Discharge tunnel
1
2
3
4

Main generating **equipment**

There are three Francis turbines (vertical shaft) that have rated power of 132 MW at 300 rpm, and they are attached to synchronous 150 MVA generators, with an output voltage of 13.8 kV.

Each turbine has a 3.3 m diameter butterfly valve activated by single-acting hydraulic actuators. In emergencies, this valve is designed to close with flow.

The energy produced by the three generators is supplied to 3, 150 MVA three-phase transformers, which increase the voltage to a 230 kV transmission level.

In order to connect with the transformer, each unit has a SF6 circuit breaker with its corresponding switch and two grounding blades.

A 230 kV three-phase circuit exits each power transformer in dry, XLPE insulated, unipolar cables.

Connection to the **National Grid**

Energy is carried to the Miel substation through XLPE-insulated cables and short overhead line sections. This is a conventional 230 kV substation.

Monitoring and **control system**

The control system for the Miel I Hydroelectric Power Plant is a distributed control system that uses the latest technology in automated control centers. This system monitors and controls all the plant's equipment across three levels of control: automated mode, centralized monitoring, and remote control from the National Dispatch Center. This system records events sequentially and automatically stores the historical record of the main variables.

Operations control (SCADA system) has five servers that have real-time and historical functions, three operating stations and one engineering and operations station, with full redundancy for operating from both the powerhouse and the administrative building, such that all operating and control functions have high standards of system reliability and availability. This is carried out via a high-speed data network using a star topology, with a fiber optic connection between the field control network and the SCADA network, thereby obtaining greater data storage capacity, improved reliability in data management and easier communication between the plant and higher-level systems.