

## Main transformer

The oil-immersed self-cooled transformer is equipped with a voltage tap changer.

This unit can be easily pulled out for maintenance, thanks to the casters attached to the bottom.

## 150kV system substation equipment

Double-bus power transmission lines have been installed up to the Tomohon and Kawangon Substations.

The system voltage is 150kV.



150kV system substation

## Control Equipment

This geothermal power plant operates with base-load operation in normal. After all the preparations for plant startup are complete, the turbine speed is automatically increased from the turning operation speed to the initial load operation speed via the Automatic Turbine Starting system (ATS).

The speed is increased up to the rated load via command from the Distributed Control and Information System (DCIS). Inlet steam pressure control for turbine is performed in parallel operation. If transmission line fails, house load operation is performed by the open of circuit breaker for transformer.

When the transmission line is black out condition, to restart the power supply as swiftly as possible after system restoration, this plant can charge the power to the transmission line to the Tomohon area, and start operating the plant under load when the charging is completed.

Runback control is performed with the failure of one of the hotwell pumps, immediately decreasing the output up to approximately 50% without interrupting the power supply.

The DCIS is a redundant system. However, if the DCIS main unit should fail to function at any time, a soft-logic backup system is used to maintain the current operation status or safely shut down operations.

This backup system also allows the operator to start or stop the plant operation manually without the DCIS.



Central control room

# Geothermal Power Plant

**PT. PLN (PERSERO), Indonesia**  
**Lahendong Geothermal Power Plant Unit No. 3**  
**20,000kW**



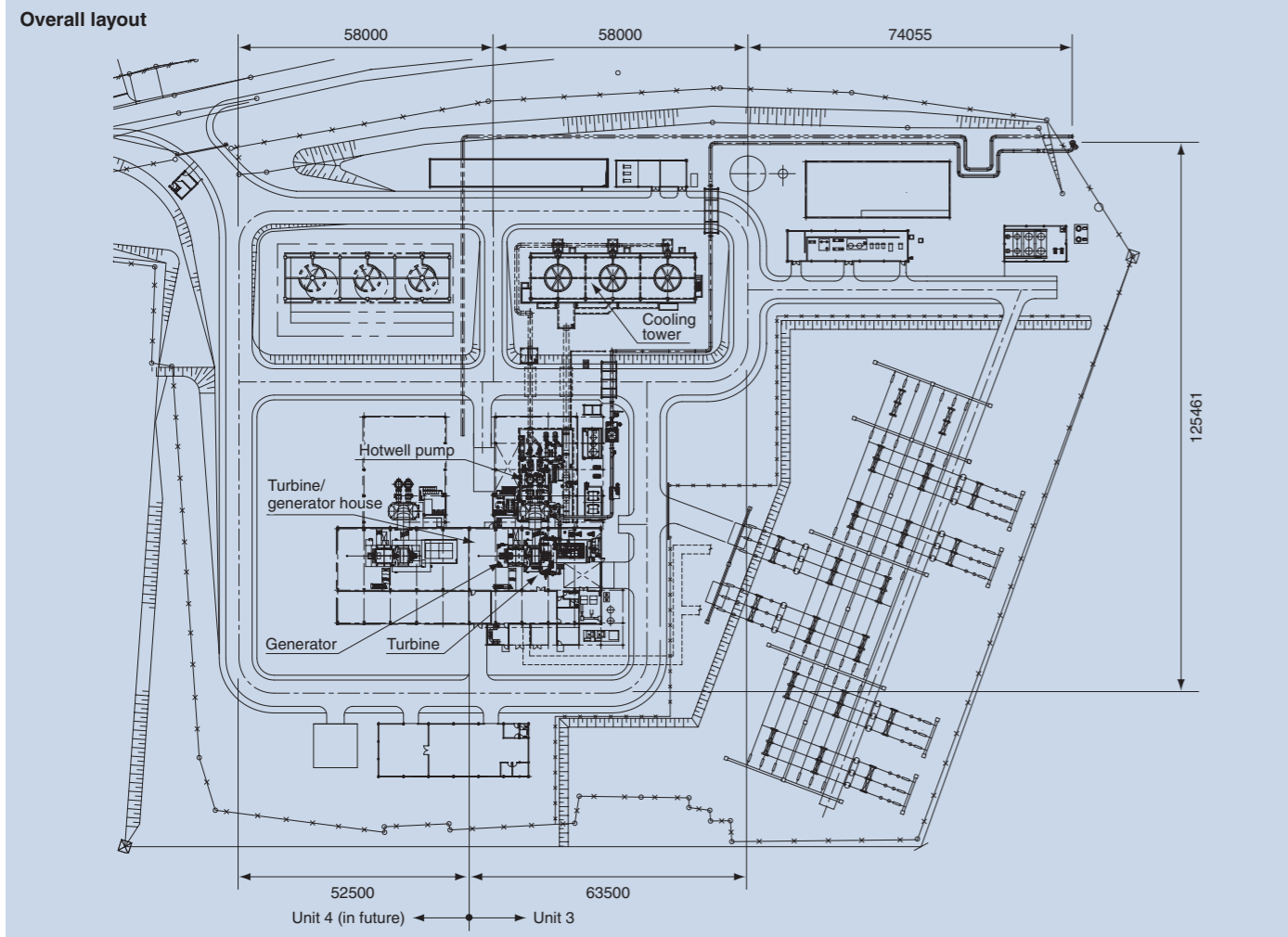
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## Outline

The Engineering, Procurement, and Construction (EPC) contract for the 20MW Lahendong Geothermal Power Plant, including civil engineering works and the installation of unit No. 3, following that of unit No. 2, was awarded on March 21, 2007 by PT PLN (PERSERO), an Indonesian power company, under the name of Sumitomo Corporation, the prime contractor. The plant was constructed in the Lahendong area, which is approximately one hour's drive from Manado City in Sulawesi Island, Indonesia. Unit Nos. 2 and 3 are located approximately 10 minutes' drive apart.

The facilities delivered by Fuji included a geothermal steam turbine, generator, condenser, main steam piping, circulating water piping, gas removal system, hotwell pump, cooling tower, and ancillary facilities.

Since the commencement of operations in February 2009, this geothermal power plant has functioned as the base load of the northern Sulawesi area.



## Mechanical Equipment

### Steam turbine

A semi-skid type compact turbine was adopted to minimize the on-site installation period.

This geothermal steam turbine features the following:

- (1) Reaction blades
- (2) Full arc admission without control stage
- (3) Integral shroud band on moving blades
- (4) Three-dimensional low-pressure twisted blades

### Specifications

Type	: Single cylinder, single flow, condensing turbine
Rated output	: 20,000kW
Speed	: 3,000r/min
Steam condition	
Pressure	: 7.13bar a
Temperature	: 165.7°C
Steam flow	: 41kg/s

### Condenser

A spray-nozzle, low-level, direct-contact condenser was adopted. The body of the condenser is made of stainless-clad steel.

The compactly-designed condenser integrates the gas cooling area, where non-condensable gas contained in the geothermal steam is cooled down.

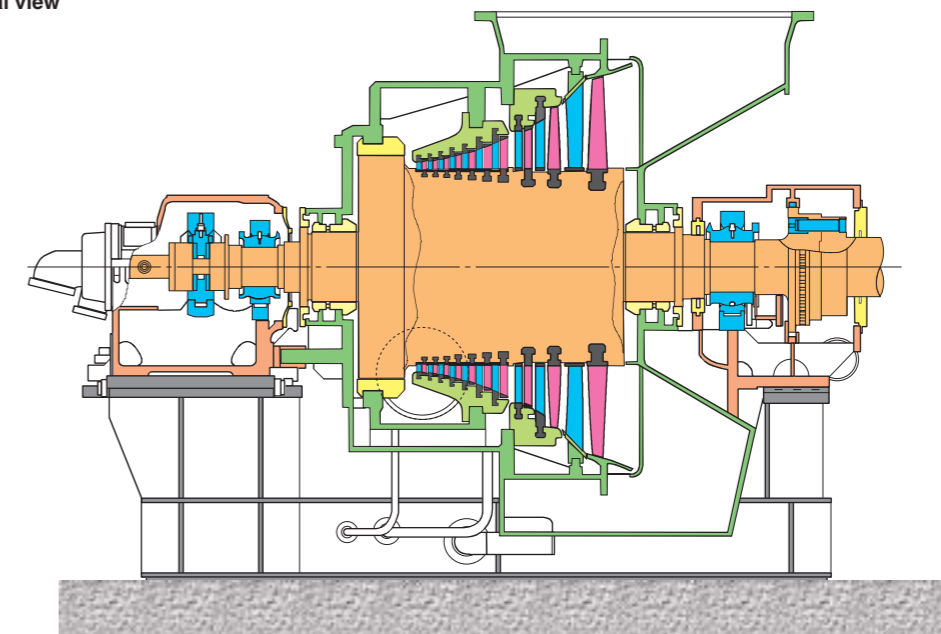
### Specifications

Type	: Spray-nozzle, low-level, direct-contact condenser
Pressure	: 0.115bar a
Cooling water	
Flow	: 4,471m <sup>3</sup> /h
Inlet/outlet temperature	: 29.5/45.5°C



Condenser

### Turbine sectional view



## Gas removal system

The steam ejector system was employed, as 1% (wt), of the main steam is composed of non-condensable gas. The double two-stage (including spare) ejector is equipped with inter- and after-condensers. The cooling water from the inter-condenser is fed to the condenser through the U-seal, while that from the after-condenser is fed through the level control valve.

### Specifications

Type : Double two-stage steam ejector  
Motive steam pressure : 7.13bar a  
Motive steam consumption: 5,544kg/h  
Cooling water flow : 282m<sup>3</sup>/h



Gas removal system

## Cooling Water System

The cooling water flows from the cooling tower under differential pressure between the atmospheric pressure of the cold water basin and the vacuum pressure of the condenser.

Geothermal steam is mixed with cooling water in the condenser, and the condensate water is fed to the cooling tower by the hotwell pumps.

The water cooled in the cooling tower is fed back from the cold water basin to the condenser, hence generating a cyclic flow.

The cooling water within the facilities consists of the primary cooling water, which is channeled from a circulating water system, and the secondary cooling water, which is used to cool the temperature of each bearing within the facilities.

A plate-type heat exchanger is installed to cool the secondary cooling water, the temperature of which has increased by conducting the heat away from the bearings.

## Cooling tower

The cooling tower made of concrete is of the mechanical-draft counter-flow suction type.

### Specifications

Type : Mechanical-draft counter-flow type  
Cells : 3 × 110kW  
Flow : 4,926m<sup>3</sup>/h  
Inlet/outlet temperature: 45.5/29.5°C



Cooling tower

## Hotwell pump

Two barrel-shaped, vertical, mixed flow pumps, each carrying 50% capacity, were installed, and runback control ensures continuous operation at approximately 50% output; even if one of the pumps fail.

### Specifications

Type : Barrel-shaped vertical mixed flow pump  
Capacity : 2,540m<sup>3</sup>/h (per pump)  
Net pump head: 25m  
Motor output : 250kW (per pump)



Hotwell pump

## Electrical System

### Turbo-generator

A two-pole air-cooled turbo-generator was adopted. The power factor of the generator can be set from 0.9 leading to 0.8 lagging, in order to perform the line charging when the transmission line is black out. The generator main unit features a skid structure, while the main and neutral generator terminals are upward removal structures.

### Generator

#### Specifications

Type : Air-cooled turbo-generator  
Output : 25,000kVA  
Excitation : Brushless  
Voltage/frequency : 11kV, 50Hz  
Insulation/  
temperature increase: Class F/Rise B



Generator