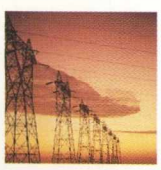
Combined Cycle Power Plant
Lavrion - Greece - 1 x 550 MW

ALSTOM

General Presentation

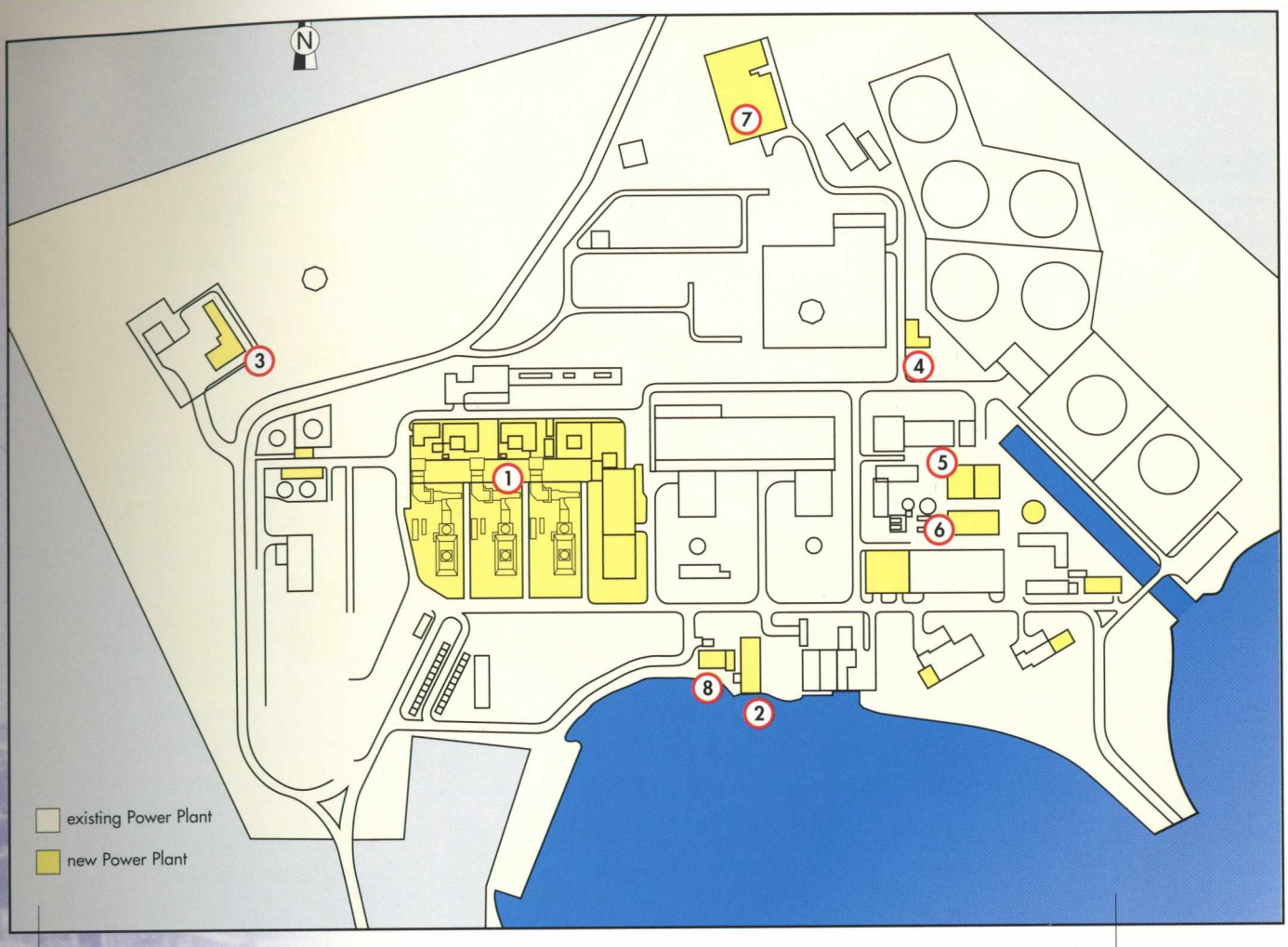
The Public Power Corporation of Greece awarded the Consortium ALSTOM Centrales Energétiques SA / Metal Constructions of Greece (METKA) a contract for the supply and installation of a turnkey combined cycle unit of 550.2 MW net power, located in southern Attica, about 40 km south of Athens and some 4 km east of the town of Lavrion. The contract was signed on March 08, 1996.



The combined cycle unit (1 VEGA 309 E) includes 3 x 125 MW gas turbines, which exhaust either into three heat recovery steam generators producing steam to power a 191 MW steam turbine in the combined cycle mode, or into three bypass stacks in the open cycle operating mode.The gas turbines are of the dual fuel type, the main fuel being natural gas, while diesel oil is the back-up fuel.

ALSTOM Energy is in charge of the overall design of the plant (including civil design, process and installation) and of the supply of the steam turbine, gas turbines, turbo-generators, balance of plant equipment and heat recovery steam generators design. Cegelec is in charge of the electrical and control equipment.
METKA is in charge of civil works execution, erection and local manufacturing of specific equipment such as the condenser, the low pressure turbine casing and the heat recovery steam generators.

Very low level of noise, low level of NOx and CO emission and high availability rate are some of the major advantages offered by this combined cycle.



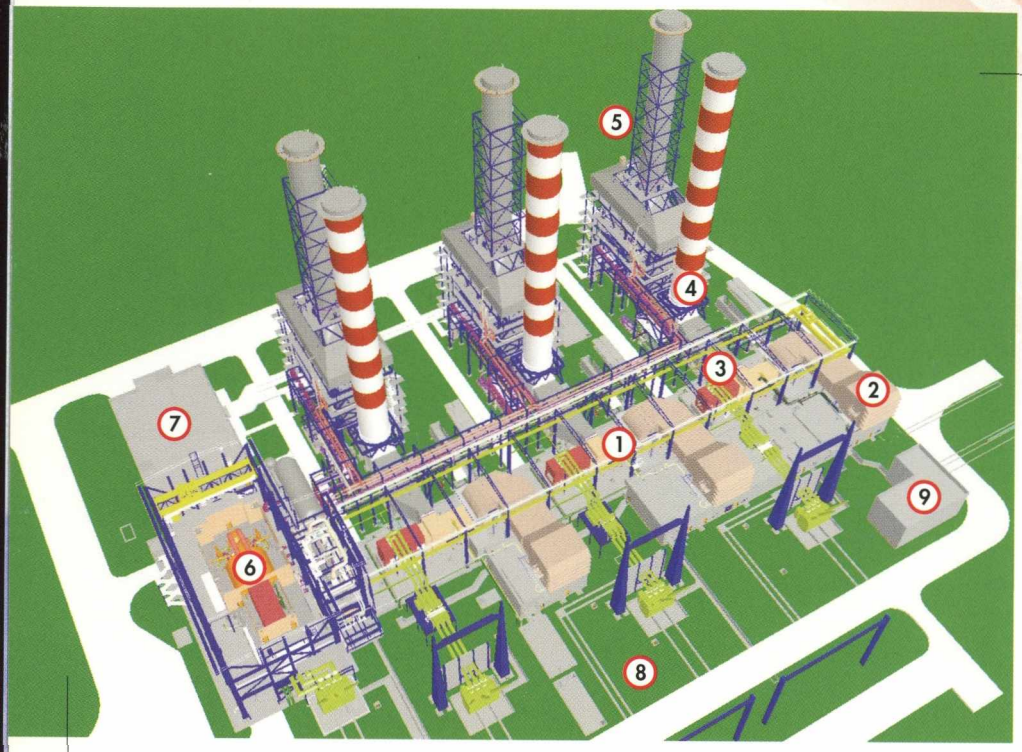
General Layout

1. Power block
2. Circulating water pumping station
3. Gas receiving and treating station
4. Fuel oil treatment plant
5. Desalination/demineralization plant
6. Demineralized water storage tank
7. Waste water treatment plant
8. Chlorination plant

Lavrion Power Plant under construction (August 98)

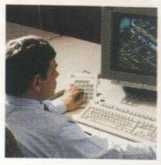
The LAVRION 1 x 550 MW combined cycle unit is located between the existing thermal plant (1 x 150 MW + 1 x 300 MW) and the existing combined cycle plant (1 x 173 MW).

Plant Arrangement



CAD view of the power block

1. Gas turbine generator sets
2. Air inlet filters
3. Air exhaust ducts
4. Bypass stack
5. Heat recovery steam generator
6. Steam turbine generator set
7. Main electrical control room
8. Transformer area
9. Black-start generator building



■ The three gas turbines are on the same axis perpendicular to the steam turbine. Their buildings follow the same arrangement and are joined by a building comprising mainly of the feed water tank and the feed water pumps.

■ An inlet elbow is needed to connect each gas turbine to its relevant air filter. Each machine exhausts to the side and into the corresponding HRSG. An exhaust gas bypass stack is installed at the inlet of each HRSG.

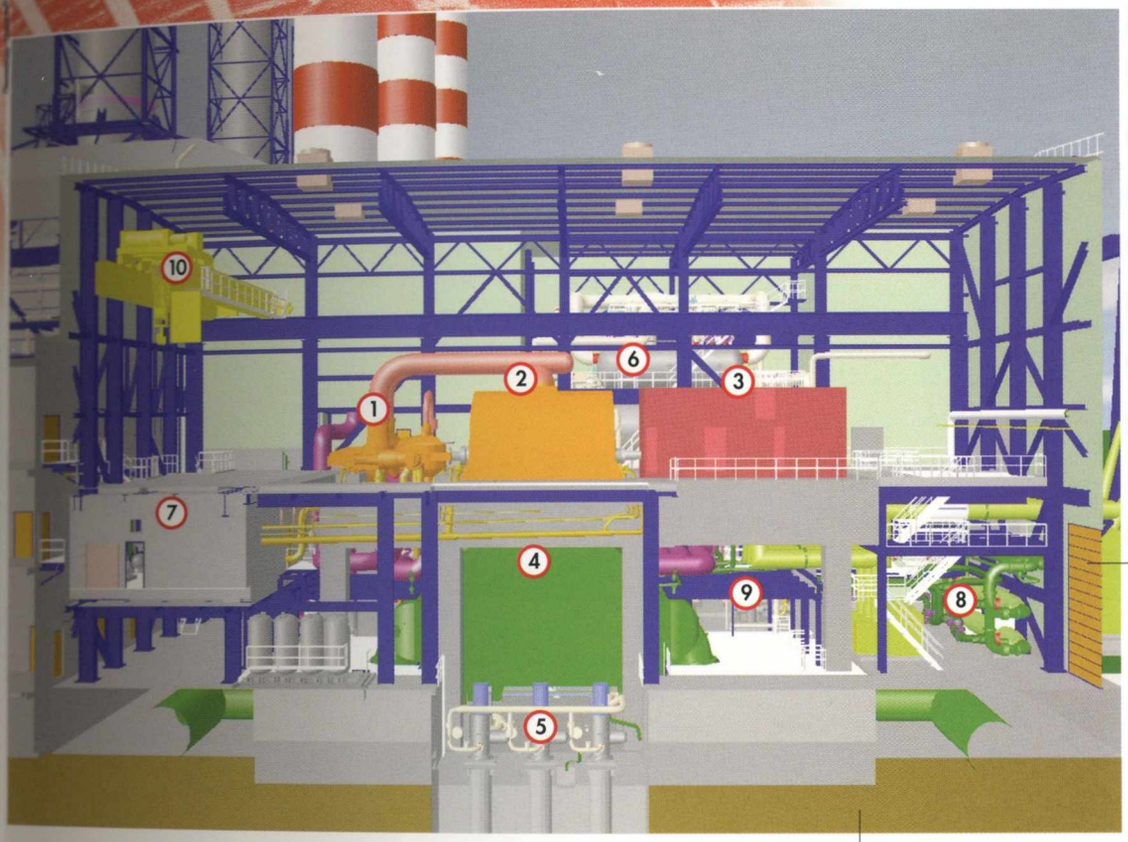
■ The gas turbine electrical buildings are beside the machine's building and support the air filters. The main electrical building is an extension of the steam turbine building.

■ The sea-water pumping station supplying cooling water to the condenser is located next to the existing station.

■ A waste water treatment plant dedicated to treat all the effluents of the existing and new units is located at the North of the site. The location of the other plant facilities such as the desalination/demineralization building, the fuel oil treatment plant, the gas receiving station, the black-start building, etc., is dictated by the site configuration.

Northern view of the Power Plant

Main Components



1. HP steam turbine
2. LP steam turbine
3. Generator
4. Condenser
5. Condensate pumps
6. Feed water tank deaerator
7. Lube oil room
8. Auxiliary cooling system exchangers
9. Busbars
10. Travelling crane

CAD view of the turbine hall

The combined cycle unit is of the VEGA 309 E two-pressure type. The main components are as follows :

■ 3 gas turbine-generator sets

The gas turbines are of the 9171 E type, manufactured by ALSTOM Gas Turbines, and are fed with natural gas or diesel oil as a back-up. For the second alternative, injection of demineralized water is provided in order to reduce NOx emission. At an ambient temperature of 15°C, each gas turbine produces a maximum gross output of 119 MW in a combined cycle operation. The generators, manufactured by ALSTOM Energie, feature closed circuit air cooling and a rotating diode exciter.

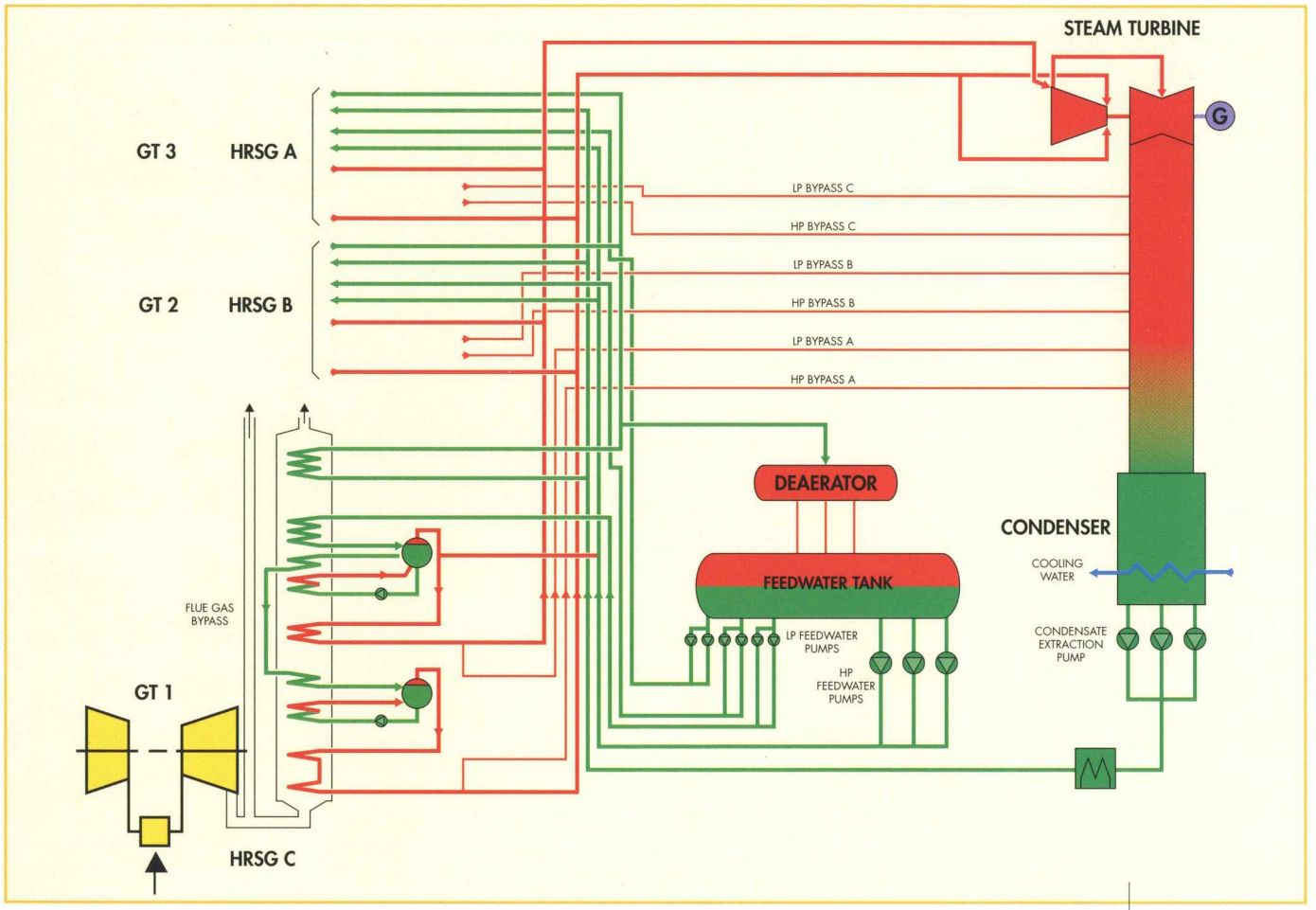
■ 3 heat recovery steam generators

The HRSGs, manufactured by ALSTOM Energy Systems, generate steam from the hot exhaust gases of the gas turbines (546°C), and are of the vertical type with pump-assisted circulation designed for a two-pressure cycle.

■ 1 steam turbine-generator set

The steam turbine and its generator are manufactured by ALSTOM Energie. The turbine is a two-cylinder model comprising a single-flow HP casing and a double-flow LP casing. The guaranteed maximum gross output in continuous operation is 203 MW. The generator is of a similar design to the gas turbine generators (air-cooled, rotating diode excitation).

Steam/Water Loop Performance



Water-steam diagram

The steam water diagram illustrates the cycle operation principle.
The values hereafter concern the LAVRION two-pressure cycle in base load operation on natural gas.

■ The HRSGs produce HP and LP steam whose characteristics are shown on the tabel below.

■ After expansion in the turbine, the steam is condensed in a sea-water-cooled, single-pass condenser with titanium tubes. The water temperature increases from 22°C to 31°C.

■ The condensate pumps transfer the condensate to the feed water tank deaerator via the in-boiler pre-heaters. The HP and LP feed water pumps feed the HRSGs with the necessary flow of water for steam production.

■ 100% HP, IP steam bypasses ensure the operation flexibility.

Performance values :

Ambient air temperature	15°C
Condenser pressure	53 mbar
Vega Plant Performance	
Total gross output	560 MW
Total gross heat rate	6962.5 kJ/kWh
Total gross efficiency	51.7%
Gas turbine	
GT hourly heat consumption (on LHV)	1299.5 GJ/h
GT heat rate	10920 kJ/kWh
GT exhaust gas temperature	546°C
GT exhaust flow	1451 t/h
Output at generator terminals	119 MW
Steam turbine	
Number of pressures	2
HP steam	555 t/h, 170 bar, 520°C
LP steam	127 t/h, 4.7 bar, 210°C
Output at generator terminal	203 MW
Emissions	
NOx	50 mg/Nm³
CO	24 mg/Nm³
Particles	100 mg/Nm³

Electrical Distribution - Control and Instrumentation

The generators of the gas turbines connect with the grid through three 15 kV / 400 kV step-up transformers and the generator of the steam turbine connect with the grid through one 13 kV / 400 kV step-up transformer. The gas turbine transformers each have a power rating of 141 MVA and the steam turbine transformer is rated 235 MVA.

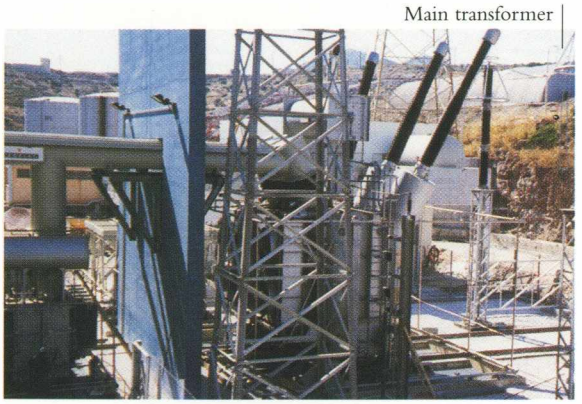
A 6 kV busbar set, fed by a 15 kV / 6 kV step-down transformer, is connected to the main busbar of the gas turbines 1 and 2 and feeds the main auxiliaries (circulating water pumps, condensate pumps, feed water pumps and auxiliary cooling water pumps).

An emergency diesel generator set rated 4 MVA assures an emergency power supply to the 6 kV busbars.

A Modern Control and Instrumentation System

Organised around microprocessor-based automation units communicating with the computerized control room equipment through a dual network, the C&I system also enables communication with the specific control equipment of the gas turbines and the steam turbine. The system integrates hardware redundancies and self-monitoring features assuring its high degree of availability and security.

Main transformer



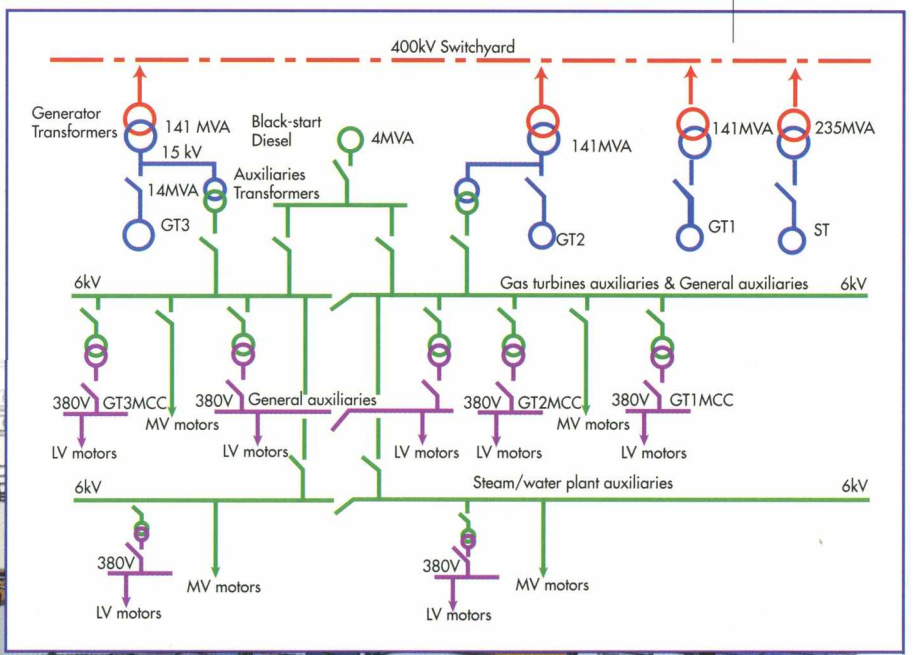
Automatic Operation

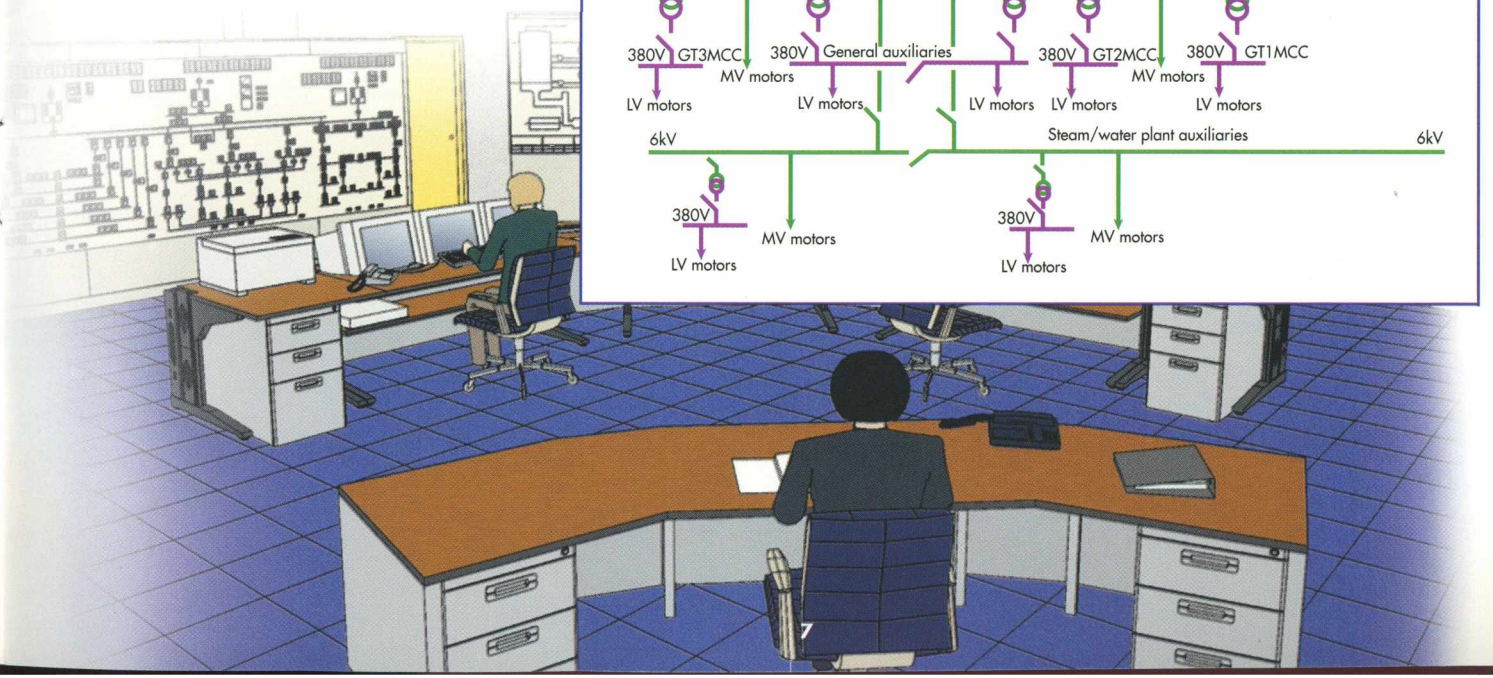
Automatic operation is conducted from computer workstations providing access to information concerning all the equipment of the power block.

This sophisticated monitoring system enables for example the comparison between expected performances and actual performances and is able to detect the fouled element responsible for the differences.

The system includes trends and plots, as well as efficiency calculations throughout the life of the plant.

Single-line diagram





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