Success Story

Modernization of Large Thermal Power Plant Maintains a Key Lifeline for the People of Mongolia

Thermal Power Plant No.4 (TPP4)

Location: Ulaanbaatar, Mongolia
Plant type: Coal-fired
Capacity: 8 x 420 t/h, 3 x 123 MW / 1 x 120 MW / 1 x 100 MW / 1 x 80 MW
Project type: Brownfield
Completion: 2001 (Phase 1), 2007 (Phase 2), 2019 (Phase 3)

Phase 1-2 Boiler Control Modernization

Executive Summary

In Mongolia, temperatures fall as low as -40°C in mid-winter. The heat and electricity generated by Thermal Power Plant No.4 (TPP4) in the capital city of Ulaanbaatar is an important lifeline for the people living there. This is the largest coal fired power plant in Mongolia and it generates 70% of the electricity for Mongolia's central energy system and 65% of the heat energy used by Ulaanbaatar district heating system.

TPP4 was built many years ago and has been severely affected by the scarcity of spare parts for its legacy systems. Plant shutdowns were a frequent occurrence due to equipment malfunctions and accidents, disrupting the supply of heat and power. In addition, the plant caused severe air pollution due to inefficient control of coal combustion. Efforts to correct these problems were also hampered by the loss of many of the plant's original blueprints and other design related documents.

To solve these problems, the Mongolian government decided to execute a plant revamping project in two phases using an official development assistance (ODA) loan. Phase one for boilers one to four started in 1998 and was completed in 2001. Phase two for boilers five to eight started in 2001 and was completed in 2007. For this project, Yokogawa delivered control systems and field instrumentation for all eight boilers.

TPP4 in winter

TPP4, a lifeline for Mongolia

The Challenges

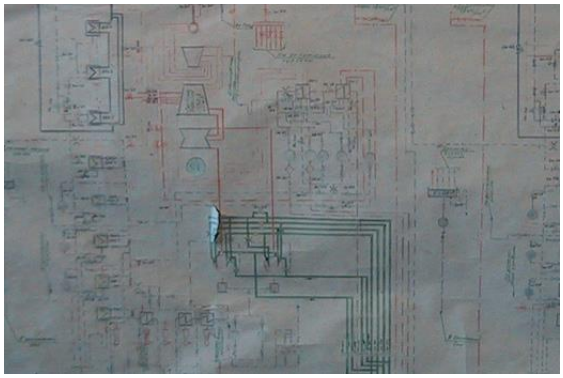
The original combustion system used indirect firing, with pulverized coal being transferred from a storage silo whenever the boiler was started up. With the exception of feed water control, all the boilers and mill burners were manually controlled by operators. There were many equipment problems, a high risk of explosions, and extremely low combustion efficiency.

In addition, there were just a few of the original blueprints dating back to when the plant was built in the 1980s, and none showed the boiler design in detail. As a result, no one completely understood the actual workings of the plant.

However, the Mongolian government had an urgent need to rehabilitate this large plant and thereby secure this major lifeline for its people. The customer's specific requirements were as follows:

1. Full automation of the boilers, burners, and balance of plant facilities
2. Change from an analog control system to a modern digital control system
3. Use of a power plant simulator to train operators and achieve a smooth transition to screen-based operations.

An original boiler control panel



An old plant drawing

The Solutions

First of all, information had to be gathered that would provide a starting point for the automation design. This was followed by conversion to a direct firing boiler combustion system in which pulverized coal is directly loaded into the boilers and the replacement of the old mill burner control systems with a Yokogawa DCS.

Automation of boilers, burners, and balance of plant facilities and changeover to a new boiler combustion system

To meet the customer's requirements for changing the old indirect combustion system to a direct combustion system, a Yokogawa project team of Russian, English, Mongolian, and Japanese speakers conducted a detailed investigation of the original boiler combustion control system and coordinated its activities with a new burner vendor. They had to crawl around every nook and cranny of this plant to create a piping & instrument diagram (P&ID) and a cabling drawing that accurately described the plant configuration. This was dirty and challenging work and it took many days to complete. Finally, they succeeded in bringing together the documentation needed to design the automation for the plant's boilers, burners, and balance of plant facilities and change to a direct firing boiler combustion system.

Replacement of conventional analog control system with state-of-the-art digital control system

With the completion of both phases of this project, the control of all eight boilers has been integrated with a Yokogawa CENTUM CS 3000 DCS. The operator stations were changed over from conventional analog panels to a modern graphical user interface, and this has improved the efficiency and safety of plant operations. In addition, a Yokogawa Exaquantum Plant Information Management System was installed to enable remote monitoring of all boiler operations from the administration building, which contributes to correct and prompt plant operation management. As for the system architecture, a redundant remote optical network was used for the I/O system to reduce the cabling cost and improve safety and reliability.

Power plant simulator improves skills and eases transition to screen-based operations

Together with a state-of-art DCS, a power plant simulator was provided that operators can use to upgrade their skills. This made possible a smooth transition from the conventional analog control panels to an all-new graphical user interface.

New central control room

Results

Reduction of boiler trips and accidents

One by one, the eight boilers were changed over to the new control system and resumed operation, starting at the end of 1998. Reliability and safety have both been dramatically improved as a result of a steady decline in the number of boiler trips and accidents. With production up and oil consumption down, it has been possible to significantly reduce energy imports from Russia.

Reduction of CO2 emissions through improved combustion efficiency

With the reduction of boiler trips and plant accidents, boiler combustion efficiency has been dramatically improved. In addition to ensuring a stable supply of heat and electricity to the city of Ulaanbaatar, this has made it possible to generate more electricity from the same amount of coal. The amount of oil consumed for plant restarts has also been decreased, further reducing CO2 emissions.

Technical transfer to TPP4

The Yokogawa project team worked together with TPP4's engineers from start to finish of this project, providing them the opportunity to improve their skills in such areas as engineering design and commissioning. A number of the boiler control systems were successfully replaced by the TPP4 engineers. This transfer of power plant engineering expertise was one of the main aims of this ODA project, and this ensures that the skills and know-how are in place to sustain operations at this plant.

Customer Satisfaction

More than a year after phase one was fully completed, one of the four boilers caused a trip. Yokogawa dispatched engineers immediately and made every effort to solve the problem. The investigation found that the boiler trip was caused by a malfunction in one of the conventional components left over the old plant control system. Even though a Yokogawa product was not at fault, the company's engineers provided the TPP4 engineers the support they needed to get the plant safely operating again.

Mr. J. Osgonbaatar, Executive Director of TPP4 at the time, says, "Seeing is believing. Whatever beautiful things sales people say, I will not believe until I see them at work. When we experienced the plant trip, I learned what makes Yokogawa different from others. I admire their sincerity and devotion toward customers."

Mr. J. Osgonbaatar

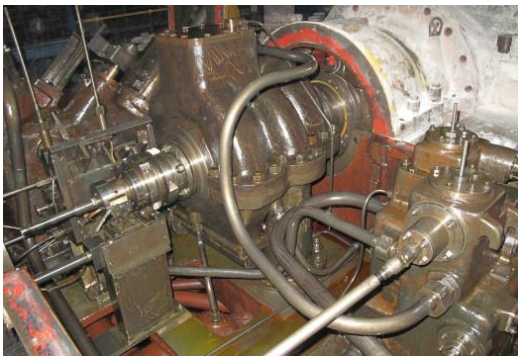
Phase 3: Turbine Control Modernization

Executive Summary

Even after the successful completion of the Phase 1 and 2 projects, TPP4 still suffered serious problems due to the original turbine control systems and mechanical governing systems. The Mongolian government decided to execute a project to modernize the turbine controls and operation of Units 1–6 using an official development assistance (ODA) loan, following the successful improvement of the boiler control system. Yokogawa delivered control systems and replaced turbine governing systems and field instrumentation for six steam turbines.

The Challenges

For all six turbines, most of the existing mechanical governors, control system, and instrumentation equipment had been in use since the plant was built in the 1980s and had deteriorated significantly. There were frequent abnormalities due to equipment malfunctions, as well as turbine emergency shutdowns from time to time due to erroneous manual operations, hindering the stable supply of electricity and heat, which is the ultimate purpose of TPP4. Furthermore, most of the equipment had been made in the former Soviet Union and it was difficult to obtain and replace parts for maintenance.



Original mechanical governor

With this background, the main requirements of the customer were as follows:

- Improve controllability by upgrading the existing turbines' mechanical governors to electronic governors
- Automate turbine operation by refurbishing the existing turbine controls and instrumentation equipment
- Provide a training environment with a simulator for seamless transition after renewal

The Solutions

This project encompassed a broad range of mechanical modifications and instrumentation equipment upgrades, including upgrades of the existing mechanical-hydraulic control systems (MHC, or "mechanical governors") to electro-hydraulic control systems (EHC, or "electronic governors"). It was necessary to grasp the current situation through repeated discussions with TPP4, and to analyze appropriate upgrade proposals and specifications.

Improvement of controllability by upgrading the existing turbine's mechanical governors to electronic governors

In order to replace the aging mechanical governor controls appropriately, Yokogawa and its partner companies carefully studied the drawings written in Russian and Mongolian and the existing facilities, and repeatedly consulted TPP4 staff. As a result, the team decided to renew the entire governor equipment. In addition to designing and delivering mechanical equipment such as cylinders, actuators, control oil filters, turbine protection devices, speed sensors, and vibration sensors, it was decided to modify or replace peripheral equipment and install suitable new equipment. The CENTUM VP was installed as the control and protection system, and the turbine governor was successfully upgraded to electronic governors, thus improving controllability.

Automatic turbine operation by refurbishing existing turbine controls and instrumentation equipment

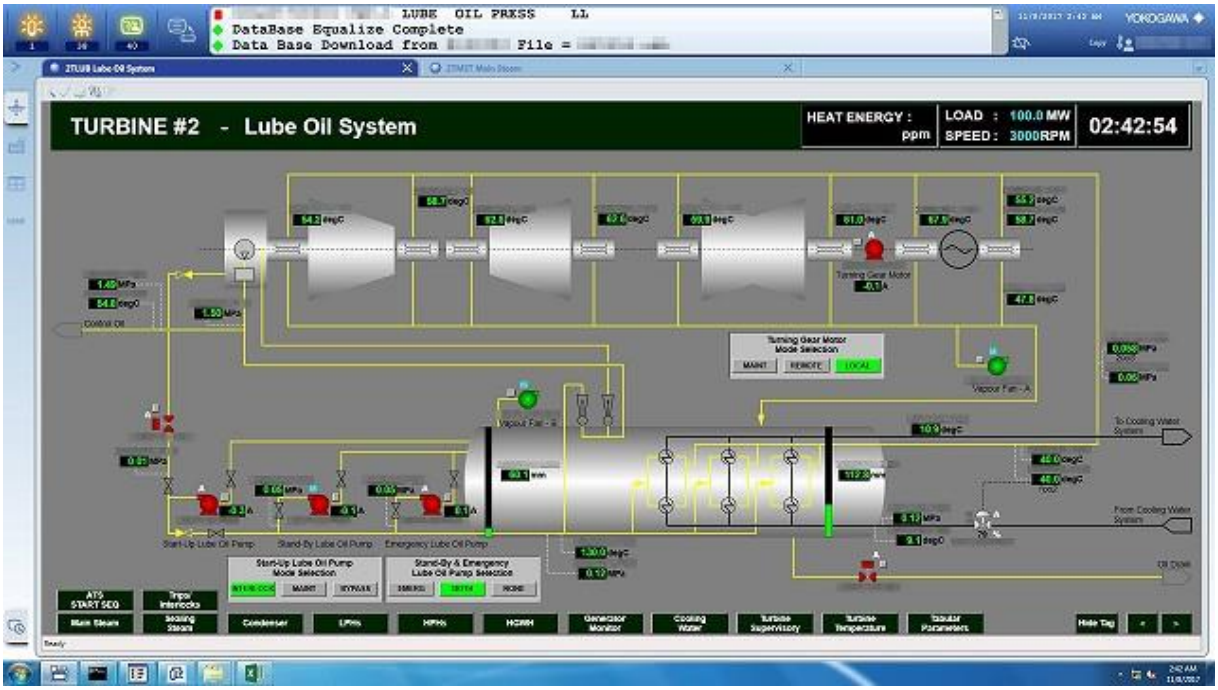
To automate turbine operation, the existing analog control system along with instrumentation equipment such as pressure transmitters, valves and analyzers required for automation were upgraded, and monitoring and control were achieved by the CENTUM VP DCS. The control panels were set up in remote I/O houses newly installed on site, and optical cables were used to integrate the Vnet/IP control network. This resolved the constraints on installation location and allowed the cable materials and cabling work to be optimized. Furthermore, in addition to normal real-time plant monitoring and control, Yokogawa installed Exaquantum, a software system that enables centralized analysis of operational data, and Plant Resource Manager (PRM), a software system that enables streamlined field equipment maintenance. These tools helped improve plant operations and streamline facility maintenance by leveraging the centralized plant information. For plant monitoring and control, apart from the central control room, similar monitoring and control screens were installed adjacent to the individual turbines, enabling both on-site staff and staff in the central control room to share the same information via identical screens and communicate more effectively.

Provision of a training environment with a simulator for seamless transition after renewal

Just like in Phases 1 and 2, a DCS simulator for turbine control was introduced in Phase 3 as well, and multiple training sessions were conducted by skilled engineers to enable a smooth transition of operations, from the existing analog control system to the CENTUM VP.

New electronic governor

New tooth wheel with new speed probes and TSI (Turbine Supervisory Instrument)



A DCS graphic display of Unit 2

Results

Reduced turbine trips and unexpected accidents

Thanks to the improved controllability of TPP4, reliable and safe operation were achieved and production losses minimized, thus contributing to the stable supply of electricity and district heating and energy security for Mongolia.

Technical transfer to TPP4

The Yokogawa project team worked together with TPP4's engineers from start till completion of the project, helping to improve their skills in such areas as engineering design and commissioning. This technical transfer of the new EHC turbine governing system and DCS operation was one of the main aims of this ODA project, and transferred the expertise needed to sustain operations at TPP4.

Customer Satisfaction

As most of the existing systems and equipment had been installed in the 1980s, little information and documentation about their operation and maintenance was available. There were many blind spots even during site installation and commissioning; Yokogawa engineers boldly and flexibly tackled unexpected challenges that arose. Finally, modernization of the turbine control and governing systems resulted in more flexible and stable operation.

Mr. U. Tumurkhuyag, Executive Director of TPP4, commented, “Yokogawa is a trusted partner for TPP4. No one took shortcuts amid the numerous challenging situations. Yokogawa is always fully committed to maximizing value for customers. We believe that TPP4 will continue to grow through our long-term relationship with Yokogawa.”

Mr. U. Tumurkhuyag

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