Sustainable energy solutions for reducing CO$_2$ emissions in the power industry
Redefining VigilantPlant

For years, Yokogawa has used the word “VigilantPlant” as our vision for operational excellence. What this meant was bringing out the best in your plant and people through visibility of information, predictability of process, and agility of business.

We now believe VigilantPlant means much more than just what goes on in your plant.

Yokogawa is committed to sustaining your business, the environment, and the society that we all are a part of. We are doing this by developing more energy-efficient technology, helping operations produce a smaller carbon footprint, and building rock solid products that protect our environment from contaminants.

Sustainability is not just a job for Yokogawa but for all industry.

Will you join in embracing a new VigilantPlant?
Sustainable energy solutions for a promising future

Carbon dioxide (CO₂) is one of the major greenhouse gases causing climate change and global warming. In the power industry, Yokogawa has taken the lead in providing solutions to improve power efficiencies by reducing emissions.

Yokogawa has been providing control solutions for generating power from solar, wind, hydro, biomass, geothermal, and other renewable energy sources based on its extensive experience in this field and technologies. For a brighter future, Yokogawa offers sustainable energy solutions that minimize the impact of CO₂ emissions and achieve the operational excellence that is the hallmark of the VigilantPlant.
Leading-edge technology for reducing CO₂ emissions

The advanced technology, excellent product quality, and extensive application know-how that go into Yokogawa’s optimum solutions help you reduce your power plant’s CO₂ emissions.

Efficiency improvement control solution
CENTUM VP is a core platform and a key component of our comprehensive control solutions that make it possible for power plants to operate more efficiently.

Renewable energy control solution
STARCOM with FAST/TOOLS provides an innovative web-based SCADA solution for renewable energy plants.

Combustion gas analysis solution
The TruePeak TDL2200 analyzer utilizes powerful and highly sensitive lasers and can detect and analyze combustion gases under a wide variety of conditions.

Multi-sensing digital technology solution
DPharp series transmitters with multi-sensing digital technology offer unmatched performance and precision.
Yokogawa’s control strategy to reduce CO₂ emissions

Protecting the environment has become a pressing concern in many industries, and the power industry is no exception. Many new regulations are forcing businesses to reduce their emissions of CO₂ and other greenhouse gases to prevent global warming.

CO₂ emissions reduction is crucial at coal-fired power plants, which discharge much greater amounts of this gas into the atmosphere than other types of fossil-fired power plants. By bringing to bear its technologies and expertise, Yokogawa is focused on improving environmental control over the entire plant lifecycle and ensuring clean air for generations to come.

The 3Es of efficiency improvement, emissions reduction, and economic returns are a key part of Yokogawa’s control strategy for reducing CO₂ emissions. Our unparalleled control schemes for coal-fired power plants help reduce CO₂ emissions and create clean power.

Efficiency improvement
Optimal combustion and seot blowing inside the boiler enhance the heat rate, reduce outages, and reduce fuel consumption.

Emissions reduction
Control strategies reduce emissions by optimizing combustion and improve emissions measurement.

Economic returns
Improved performance reduces fuel and operating costs.
Benefit estimation of CO₂ emissions reduction and cost saving

Example of typical benefit estimation
Annual returns from “3Es” for a 300 MW coal-fired unit

Efficiency improvement
Approx. 0.3 - 1%

Emissions reduction
Approx. CO₂ 3 - 10 kilotons/year

Economic returns
Approx. 0.3 - 1.1 million US$/year

Coal-fired power plant

Improvements

Boiler efficiency

Turbine & BOP efficiency

Plant output

Balance of plant (BOP)
Example of boiler efficiency improvement

Overview

Estimated 3Es

Efficiency improvement
Approx. 0.3 - 0.9%

Emissions reduction
Approx. CO₂ 3 - 9 kilotons/year

Economic returns
Approx. 0.3 - 0.9 million US$/year

In a power generation unit, the main conversion process takes place in the boiler, where superheated steam is generated to drive the turbine. The thermodynamics inside the boiler are a complex, multivariable process, where it is possible to both improve the efficiency and reduce emissions. Hence, the boiler model is constantly updated based on the operating status, and appropriate optimizing algorithms are used to improve the heat rate and minimize fuel consumption.

The resultant fuel saving is converted to an equivalent emissions reduction. The economic returns are calculated from both the optimal heat rate and emission reduction initiatives.

Know-how & technology

- Improves heat rate
- Improves steam temperature control
- Implements coordinated control
- Minimizes opacity violations
- Adapts to various fuel properties
- Enables optimal use of fuel-air mixing
- Optimizes closed-loop combustion
- Quickly analyzes hotspots inside boiler
- Performs multivariable predictive control
- Enables smart automatic seal blowing

Steam turbine

Coal-fired power plant
Know-how & technology

- Minimizes condenser back pressure loss
- Minimizes feed heater loss
- Minimizes high/low-steam pressure loss
- Minimizes low-steam temperature loss
- Minimizes auxiliary power consumption
- Optimizes feed pump operation
- Reduces forced outages

Overview

Efficiency can also be greatly improved in the turbines and BOP. For the turbines, the condenser back pressure loss, steam pressure loss, and temperature loss can all be minimized.

For BOP, which is vulnerable to variations in fuel feed, improvements can be attained by closely coordinating control strategies to optimize the operation of the feed pump and minimize auxiliary power consumption.

Estimated 3Es

- **Efficiency improvement**: Approx. Up to 0.1%
- **Emissions reduction**: Approx. CO₂ up to 1 kilotons/year
- **Economic returns**: Approx. Up to 0.1 million US$/year

Coal-fired power plant

Balance of plant (BOP)
Example of plant output improvement

Overview

Plant output can be improved by carrying out proper operating and maintenance procedures, having advance warning of tube leaks, and optimizing soot blowing operations.

The resulting benefits are calculable based on the recovered megawatt-hours from the reduction in forced outages, improvement of plant availability, and reduction of start-up plant operation.

Economic returns

Approx. Up to 0.1 million USS/year

Know-how & technology

- Improves plant availability
- Improves operating procedures
- Improves maintenance procedures
- Improves ancillary plant performance
- Smoothen plant operations
- Recovers megawatts of power
- Reduces oil usage for start-ups
- Enables the creation of feasible maintenance schedules

Coal-fired power plant
Key services and products for reducing CO2 emissions

Building a lasting future
Envision a plant where people are watchful and attentive while your power generation business responds to changes quickly and efficiently. Now picture an operation that delivers non-stop power generation while confidently improving your plant efficiency and reducing CO2 emissions long into the future. Imagine no further. This is the reality attained by VigilantPlant, the clear path to operational excellence.

With the VigilantPlant vision, Yokogawa delivers comprehensive solutions to ensure that environmentally friendly plants run continuously at maximum efficiency and optimal profitability throughout their lifecycle.

Comprehensive solutions for your plant lifecycle
From planning to project execution, operations, and maintenance, Yokogawa helps power plant users achieve operational excellence throughout their facility’s lifecycle with the following sophisticated solutions:

- Plant audits
- Plant simulators
- Advanced management
- Total power plant control
- Renewable energy control
- Combustion gas analyzers
- Intelligent field devices

Long-term partnership for your business
During the relatively long life cycle of a power plant, there comes a time when the instrumentation and control systems must be renewed to maintain a competitive edge. Yokogawa supports power plants with expert services that maximize efficiency and minimize cost over the entire life cycle. From initial planning, design, engineering, construction, and operation to revamp and re-instrumentation, Yokogawa stands by your power plant. This long-term partnership ensures bottleneck-free performance and ongoing optimization that bring speed and flexibility to your business.
Maximize your cost benefits and returns

Yokogawa delivers cost benefits through the refurbishment of power plant controls and instrumentation. This improves the performance of older plants and ensures that they can operate competitively in today’s open power markets, and also reduces their CO2 emissions.

Audit your plant performance

Yokogawa assists power plant owners and operators to identify areas of plant operations that will benefit from modern controls running on the latest digital control system platform, with modern field instrumentation.

Our experts will visit your site to carry out field surveys and assess the status of your plant. We collect plant operating data and cost details, then prepare a plant survey report along with our recommendations on a control system and field instrumentation upgrade.

Based on this data and these recommendations, a cost-benefit report is drawn up. This report, along with pricing information for a control and instrumentation upgrade project, is provided to the plant owner for consideration, discussion, and action.

Audit items

- Plant availability, reliability, and efficiency
- Operating regime (daily and seasonal load profiles)
- Benchmarks against other facilities of similar age
- Review of organizational structure
- Review of maintenance management
- Review of costs, routine, and capital
- General plant condition and life expectancy
Key services and products for reducing CO₂ emissions

Plant simulators

Reassure supreme accuracy

You no longer have to ignore the complexity of real-life processes. No other simulators available today can match the accuracy of a Yokogawa power plant simulator. Flexible training scenarios can help your operators learn how to control the entire plant with complete confidence. Experience the reassurance that comes from having a Yokogawa power plant simulator.

Features

- High fidelity
  - 99% accuracy (>99% steady state; >95% dynamic state)

- Flexible training and evaluation
  - Freely devise any training scenario to improve and evaluate operator skills in the following areas:
    - Executing routine operational procedures
    - Responding to plant malfunctions
    - Performing unusual operations such as forced cooling and cold start-ups

Benefits

- Faster commissioning
  - The DCS is fully tested before it is installed, drastically reducing the number of modifications to logic, set points, and tuning parameters during the commissioning phase.

- Smoother plant startup
  - Before a DCS is installed at a power plant, it is fully tested using dynamic simulation. In this way, both operators and engineers become familiar with the DCS operation and controls.

- Minimized risk of plant damage
  - By dynamically testing the safety interlocks prior to DCS installation, the simulator reduces the risk of major equipment damage occurring during the commissioning process.
Secure the predictability of your critical process

Making plant information fully visible is vital in preventing disruptions to your critical plant processes. Our knowledge-based tools and advanced management solutions help you steadily improve efficiency and attain operational excellence.

Performance-based operation

Our key performance indicator (KPI) monitoring solution makes KPIs visible and enables you to efficiently operate the production.

Plant information at your fingertips

Exaququant, a comprehensive plant information management package integrates and delivers operational information that helps enterprises meet complex business requirements.

Increase operational efficiency

Exapilot, an easy-to-use tool can be used to standardize operating methods by creating automatic sequences that incorporate the know-how of experienced operators.

Benchmark your operational efficiency

Exaplog is an easy-to-use suite of tools that analyze the historical logs of the DCS plant and the results on various graphs, allowing you to analyze and benchmark your operational and controllability performance.

Predict availability

Plant Resource Manager (PRM) provides easy-to-use tools for asset management and intelligent diagnostics for field instrumentation, actuators, and rotating equipment to increase plant availability.
Key services and products for reducing CO2 emissions

Total power plant control

Raise plant availability and performance

With its state-of-the-art architecture, the highly reliable CENTUM VP platform is fully up to the challenge of monitoring and controlling an entire power plant’s turbines, boilers, and balance of plant (BOP) facilities.

Human interface station/ engineering station

Field control station (FCS)

The FCS provides powerful control functions with a highly reliable dual redundant configuration that incorporates Yokogawa’s own palaeosaurus technology.

Turbomachinery control & protection

Boiler & BOP controls

Steam turbine

Control LAN (Vert/ip)

Performance-based operation

Plant resource management

Safety control station (SCS)

The ProSafe-RS SCS is a TÜV SÜD certified safety system that incorporates Yokogawa’s palaeosaurus technology.
Shift to renewable energy

STAROM is a network-based control system that brings operational excellence to renewable energy plants that may be widely distributed. STAROM autonomous controllers have remote management and stand-alone capability, and reduce running costs by making flexible use of e-mail, the web, and supervisory control and data acquisition (SCADA) technology. STAROM is widely used in the renewable energy industry with the FAST/TOOLS distributed SCADA system. FAST/TOOLS is a scalable product to cover a wide range of very small up to large distributed applications. FAST/TOOLS supports remote web-based operations and maintenance.
Key services and products for reducing CO₂ emissions

Combustion gas analyzers

Enhance combustion control

The TruePeak TDLS200 is a pioneering combustion gas analyzer with a powerful tunable diode laser that is ideal for making direct measurements in harsh process environments. It can be used to optimize the combustion process in boiler plants to reduce both CO₂ and NOx emissions, and is a highly cost-effective solution that makes no compromise in speed, accuracy, or reliability.

Features
- Measures gases directly in the process (no sampling system required)
- Powerful laser overcomes the effects of high particulate loading (fly ash and dust)
- Measures gases continuously, accurately, sensitively, and selectively with no lag time

CO measurement for highest efficiency improvement

Continuous measurement of carbon monoxide (CO) and oxygen (O₂) concentrations allows operators at fossil fuel power plants to fine tune the air-fuel ratio to boost combustion efficiency and reduce NOx emissions.

The TruePeak TDLS200 utilizes powerful lasers that are highly sensitive and selective for CO. In boilers it can directly measure CO, eliminating lag time in detecting CO breakthrough and producing no false low readings.

NH₃ measurement for NOx reduction

Ammonia (NH₃) gas is injected to remove NOx and thus reduce the NOx concentration in the stack flue gas, as well as to increase the dust collection efficiency of the electrostatic precipitator (EP) and prevent corrosion. However, excess ammonia injection increases running costs and residual NH₃, resulting in foul odors. Therefore, the NH₃ concentration in the stack flue gas is measured, controlled, and monitored.

With conventional ammonia analyzers that perform measurements indirectly, NH₃ concentrations are obtained through a sampling system, causing problems with the maintenance and running costs of the sampling system, and time delays in measurement. The TruePeak TDLS200 solves all these problems.
Key services and products for reducing CO₂ emissions

Intelligent field devices

Take your plant into the digital era

DPharp digital pressure transmitters are the first to use a revolutionary silicon resonant sensor technology that provides superior stability and repeatability in the most demanding process applications. They are ideal for use in highly critical power plant processes.

This intelligent field device a best-in-class and reliable digital solution that meets present and future needs in the power industry by being fully interoperable with an extensive range of open industrial protocols.

**Best-in-class performance**
- Precision and quick response time

**Field-proven reliability**
- No-error-prone A/D converter; Full end-to-end digital communications from process to control system

**Drift free, long-term stability**
- Unparalleled stability guarantee

**Multi-sensing**
- Measurement of differential pressure and static pressures (DP and SP) by a single transmitter minimizes your instrumentation cost.

**Multi-variable**
- DP, SP, and inline temperature measurement in a single transmitter enables mass flow to be calculated by an on-board flow computer.

**Full interoperability**
- Open industrial communications: Whether you choose BRAIN, HART, FOUNDATION™ fieldbus or Profibus, our transmitters will deliver their full benefits.

For all ultra critical processes

**Boiler drum level measurement**
- Very high static pressure
- Varying pressure affecting density
- Very small measurement span

**Feed water flow measurement**
- Very high pressure surges (water hammer)
- Varying flow for varying head
A case study of CO₂ emissions reduction

Retrofit of Mongolia’s largest thermal power plant

Project background

In Mongolia, temperatures fall as low as -40°C in mid-winter. The heat and electricity generated by Thermal Power Plant No.4 (TES4) in the capital city of Ulaanbaatar is an important lifeline for the people living there.

TES4 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.

Plant information

- **Plant name**: Thermal Power Plant No. 4
- **Location**: Ulaanbaatar, Mongolia
- **Owner**: Mongolian Ministry of Minerals and Power
- **Steam outputs (boilers)**: 8 x 420 t/h (including steam for town heating)
- **Electricity outputs (turbines)**: 560 MW (4 x 100 MW and 2 x 80 MW)
- **Fuel**: Lignite coal
- **Construction**: 1980 - 1990
- **Retrofit**: 1997 - 2007
- **Output/fuel**: Boilers - 8 x 420 t/h, lignite-fired
  Turbines - 2 x 80 MW, 4 x 100 MW with town heating
- **Scope of replacement**: Retrofit of control and safety systems, and replacement of field instruments and actuators

TES4 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 1996 and was completed in 2000. Phase two for boilers five to eight started in 2002 and was completed in 2007. For this project, Yokogawa delivered control systems and field instrumentation for all eight boilers.
A case study of CO₂ emissions reduction

The challenges

- The existing combustion boilers employed an indirect firing system.
- This system stores pulverized coal in a silo and feeds it to the boilers as required.
- The indirect firing system caused frequent equipment troubles and there was a high risk of explosion.

- The boilers and mill burners were manually controlled by operators except for feed water control.
- The combustion air was always sent by fans fully opened, thus the combustion efficiency was extremely low.
- The control operation system was a board operation type equipped with analog and discrete control logics.
- Only a few very old Russian documents for the control logic scheme were available.

Customer’s requirements

- Full automation of boilers, burners, and balance of plant (BOP) facilities
- A highly reliable and expandable distributed control system (DCS)
- A power plant simulator for training DCS operators

Yokogawa’s solutions

Design of fully automated control logic

TES4 converted the existing indirect combustion system to the new direct combustion type. Yokogawa performed a detailed investigation of the original boiler combustion control system and the direct combustion control logic together with a new burner vendor and TES4’s engineers. Yokogawa succeeded in designing a fully automated burner management system that replaced the old manually operated system. Other major controls for the boilers and BOP facilities were also reviewed and designed based on the new control strategy and Yokogawa’s expertise.

Replacement with state-of-art DCS

The control systems for all eight boilers at TES4 were changed over to a state-of-the-art Yokogawa CENTUM CS 3000 DCS, which provides a highly reliable platform for the comprehensive control and operation of the entire power generation plant. As a result, operation efficiency and safety were dramatically improved. For interfacing with the existing I/O signals, a redundant remote fiber-optic network was installed that reduced the cabling cost and improved both safety and reliability.

Supply of power plant simulator

In line with the replacement of the DCS, a power plant simulator was supplied for operator training, allowing operators to get experience with plant operating procedures, gain familiarity with the DCS, and improve their skills. As the result, they achieved a smooth transition from the conventional analog control panels to an all-new graphical user interface.
A case study of CO2 emissions reduction

Efficiency improvement

The new control system for TES4’s eight boilers was changed over one boiler at a time, starting at the end of 1996 and finishing in 2007. Fuel consumption was dramatically reduced thanks to improved boiler efficiency. This has enabled the power plant to provide a stable supply of electricity and district-heating steam to the city of Ulaanbaatar.

Emissions reduction

Improved boiler efficiency and reduced coal and heavy oil consumption have made it possible for this power plant to generate more electricity from the same amount of fuel, and has significantly reduced CO2 emissions.

Economic returns

Improved reliability and operation safety at TES4 have decreased the number of plant outages caused by boiler trips and accidents and reduced the amount of oil consumed for boiler start-ups. With the improved reliability of this plant, the Mongolian government no longer has to purchase as much electricity from other countries.

Total CO2 emissions amount of electricity & district-heating steam

Coal consumption rate for electricity generation

Coal consumption rate for district-heating steam

Total heavy oil consumption

Note: Coal consumption and CO2 emissions are estimated based on coal consumption rate at 7,000 kcal/m³ in 1997 with the following values:

Calorific value: 29.3 GJ/ton  
Emission coefficient: 0.0267 t CO2/GJ  
CO2 conversion coefficient: 3.6667

TES4 plant control room with CENTUM system
Yokogawa Vigilance at your service worldwide - representative projects

Sustainable energy solutions for reducing CO2 emissions in the power industry

vigilantplant.

The clear path to operational excellence

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VigilantPlant is Yokogawa’s automation concept for safe, reliable, and profitable plant operations. VigilantPlant aims to enable an ongoing state of Operational Excellence where plant personnel are watchful and attentive, well-informed, and ready to take actions that optimize plant and business performance.

Represented by: