OPTIMAX® Plant Optimization Solutions for Power Generation

ABB

OPTIMAX® Plant Optimization

Summary
Faced with ever-increasing competition, utilities are constantly striving to optimize plant operation and life cycle costs, and reduce emissions of their plant investments.

They search for powerful diagnostic and optimization tools to identify performance deviations so that corrective action can be introduced early. In addition, these tools reduce the maintenance effort for all plant equipment, extend the life of critical capital equipment and increase the utilization of the existing asset base.

ABB's **OPTIMAX®** plant optimization solutions support plant personnel in achieving higher plant efficiencies and expected performance of assets, thus improving total plant availability and productivity.

Introduction
ABB has used technological advances in the areas of control and software engineering to develop innovative plant optimization systems. The ABB OPTIMAX® suite of solutions consists of decision-support tools which continuously assess plant condition and provide root cause analysis in case of deviations.

The OPTIMAX® suite consists of a wide variety of systems and products, ranging from field instrumentation all the way to business solutions at enterprise level. The OPTIMAX® suite of solutions addresses the following application areas:

- **Operations:** Monitor and predict plant performance, issue early warnings for equipment diagnosis, sensor validation and preventive maintenance. Improve plant efficiency by reducing fuel consumption and resulting emissions.
- **Environment:** Optimize the combustion process and reduce emissions by monitoring flame quality, measuring coal flow and carbon in ash content, and improving controls by implementing advanced process control solutions.
- **Asset Lifecycle:** Schedule the most economical operation of different generating units and trade-off income from sales against emissions and life cycle costs.
- **Maintenance:** Reduce downtime and costs of maintenance activities and improve data access for daily inspections as well as planned outages (resources, material, documents, work flow and personnel).

Information management is the backbone of plant optimization systems. OPTIMAX® applications are designed to be independent of the information management system, hence they can be connected to a 3rd-party system, or to an ABB system. The latter ensures seamless linking between multiple applications and systems in real-time.

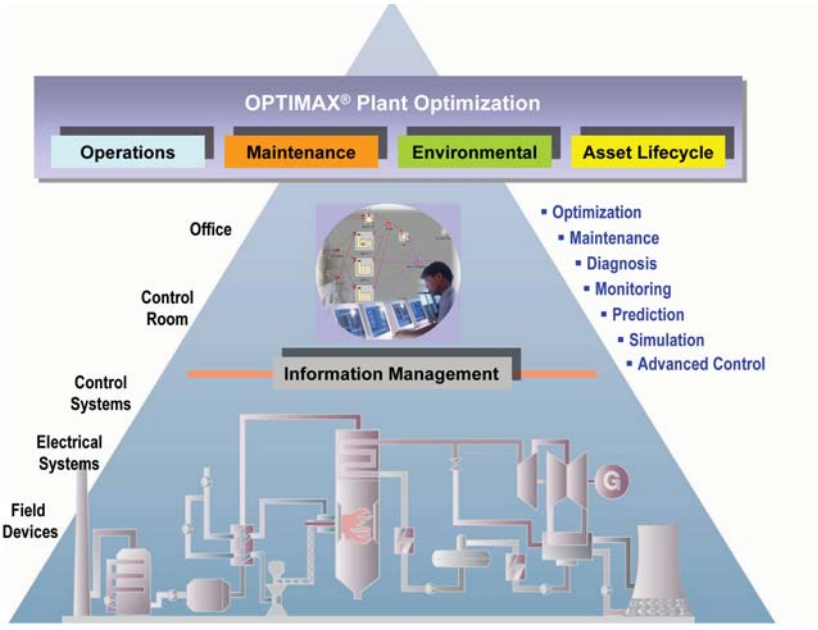
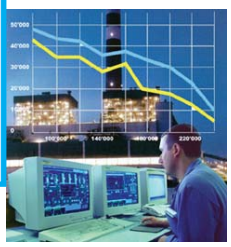


Fig. 1: OPTIMAX® application areas

OPTIMAX® Operations Systems

Performance Monitoring
Regardless of a plant's age, the major portion of a power plant's life cycle costs is attributed to fuel and operation, whereas maintenance represents most of the remaining costs. Plant Performance is a system designed for performance monitoring of the plant and its equipment. It facilitates online or offline analysis of the process so that the user can determine how current operating conditions affect, for example, plant efficiency and therefore plant fuel costs.

A 675MW plant in the USA reported yearly savings of 140k$ by improving unit efficiency and availability with OPTIMAX®. In the same unit the customer could reduce the cost for conducting performance tests by 100k$ per year.



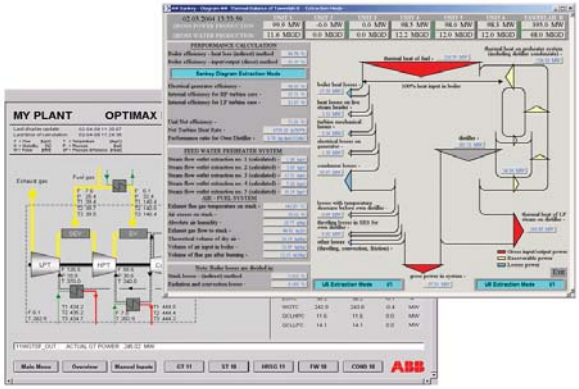


Fig. 2: Performance monitoring displays

Condition Monitoring
In today's business climate, service centers are being asked to monitor more machines over greater distances, and do it more efficiently. ABB technology allows to monitor, analyse and protect rotating machines with online or portable data acquisition and diagnosis software.

SpriteMAX™ is a cost-effective wireless network data acquisition and fault diagnostic system for assessing the condition of your critical plant rotating equipment.

Analyst™ is a user directed graphical analysis tool with specialized plots of significant patterns and trends for efficient assessment of machine condition.

Expert Advisor™ is a rule-based automated diagnostic system that continuously monitors incoming data to determine faults in any common type of rotating machinery.

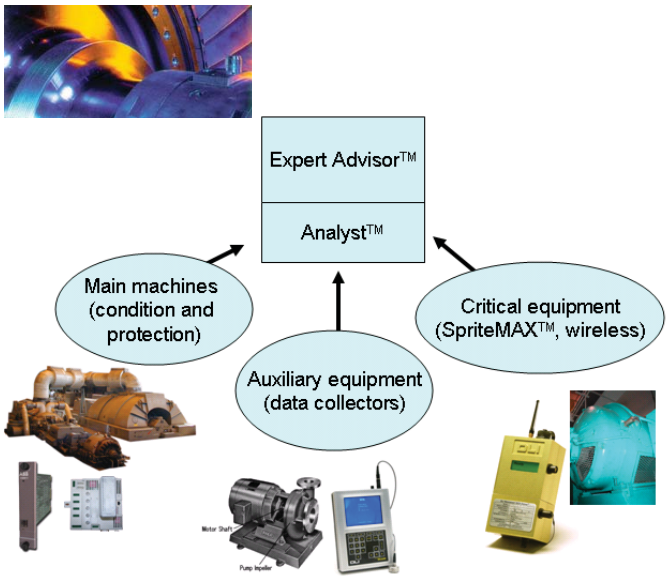


Fig. 3: Condition monitoring of rotating machinery

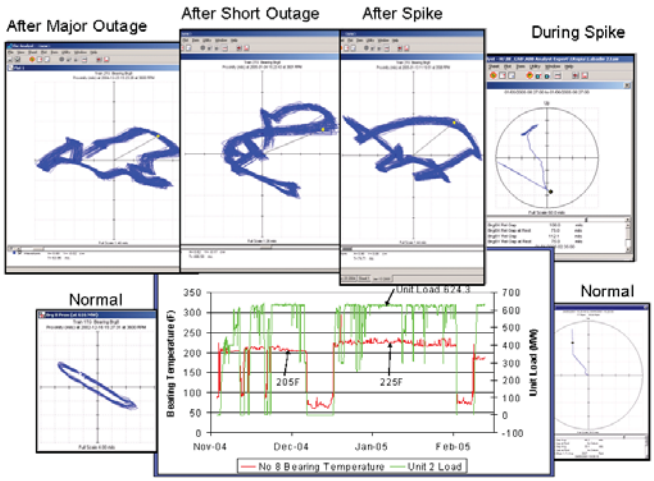


Fig. 4: Analyst™ displays

OPTIMAX® Operations Systems

Simulation, Validation and Optimization

The calculation of detailed performance values (pressures, temperatures, flows, etc.) at several hundred locations throughout the plant has become a standard requirement. Simulation models can be easily designed using the PowerCycle tool to compute the expected plant equipment process values at current operation mode. In addition, PowerCycle can also be used for "what-if" simulations and for developing process optimization strategies.

A plant for combined power generation and desalination in the Middle East has achieved more than 4% total fuel savings through OPTIMAX® process optimization and load optimization.

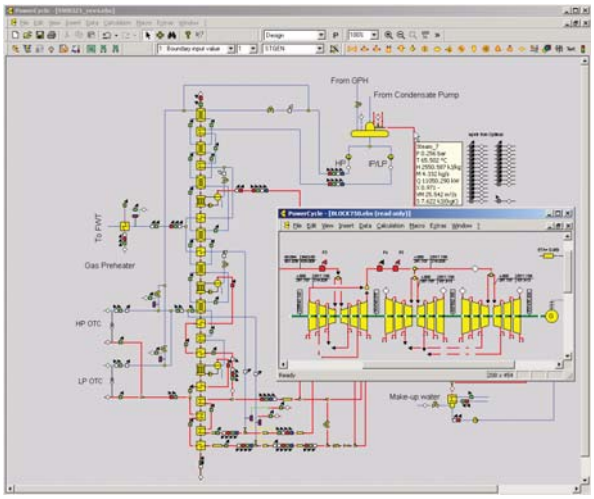


Fig. 5: PowerCycle model display for simulation, data validation and process optimization

Measurement inaccuracies are usually the reason why mass- and energy-balances are not consistent, neither for single components nor for the entire plant. Data validation with PowerCycle systematically computes corrections to obtain consistent energy balances, and simultaneously indicates the inaccurate measurments. This improves the reliability of calculations and helps the maintenance crew in their calibration work.

Resource Optimization

Companies running power plants or desalination plants need a sound basis on which to optimize their unit loads (unit commitment) or trade energy on the open market. Optimization strategies merely based on human know-how have become insufficient for companies operating multiple generation or cogeneration units.

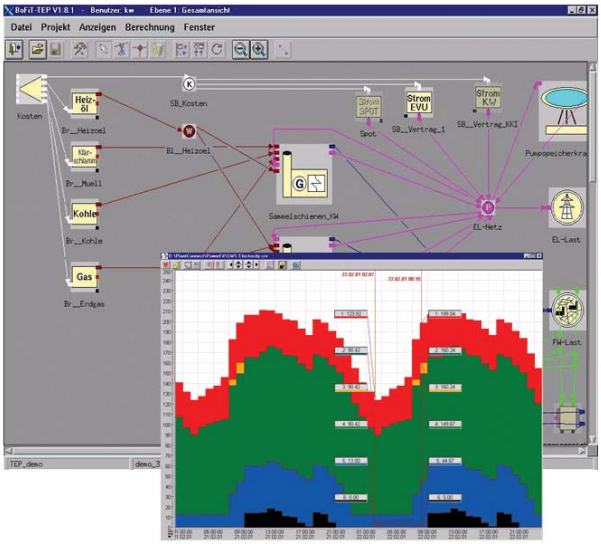


Fig. 6: PowerFit model display for load optimization

PowerFit solutions combine fully developed asset and market models with the latest optimization techniques. This solution can handle utilities with complex generation portfolios which are seeking to optimize their costs and energy generation, be it electrical or a combination of electrical and other forms of energy (heat, hydro, waste, etc.). In addition, deciding whether or not it makes sense to buy or sell power or fuel, start or stop a unit, save lifetime, or postpone a preventive maintenance outage can be easily answered.

Advanced Process Control

The control performance limits the economical performance of a plant. OPTIMAX® Advanced Process Control (APC) solutions reduce the variability of key process variables (e.g. temperatures, pressures, emissions) and improve process quality (e.g. maintain efficiency closer to its optimal level). In addition, this permits controllers to keep better track of target setpoints and to move closer to constraints.

OPTIMAX® APC solutions offer a variety of techniques, from Model Predictive Control (linear and non-linear MPC) to state-space control with Kalman filters for state estimation. In addition, the ABB Inferential Modeling Platform with neural networks can be used for designing data-driven models. Some examples amongst the multiple available APC applications, are:

OPTIMAX® Environmental Systems

- Improved steam temperature control to reduce spray flow
- Condensate valve throttling to optimize reserve power availability
- Unit control under economically optimized conditions demanded by the load dispatcher
- Various advanced boiler controls for optimization of startup, combustion, emissions, heat rate, etc.

Operator Training Simulators

ABB's Operator Training Simulators (OTS) are used to train new plant operators, and refresh and deepen the knowledge of experienced plant personnel. Ultimately, increased operator efficiency can be directly translated into cost savings in the form of optimal plant operation under all conditions.

Emissions Reduction

The Combustion Optimizer helps power plant managers optimize their combustion process and reduce emissions by improving boiler controls. A unique characteristic of the software is its ability "to learn and predict", resulting in reduced response times to changing conditions. Critical variables influencing the heat rate are excess O2 and the exhaust gas temperature. Past projects have reached up to 0.75% efficiency improvement while maintaining emission limits, thereby providing a return on investment of 1 to 2 years.

A large utility in the USA reported significant reductions of NOx and Carbon-in-ash, while simultaneously improving heat rate and maintaining CO levels.

The combination of OPTIMAX® monitoring and optimization software with ABB combustion instrumentation, such as flame scanners, coal flow measurement and carbon-in-ash, provides total combustion management solutions.

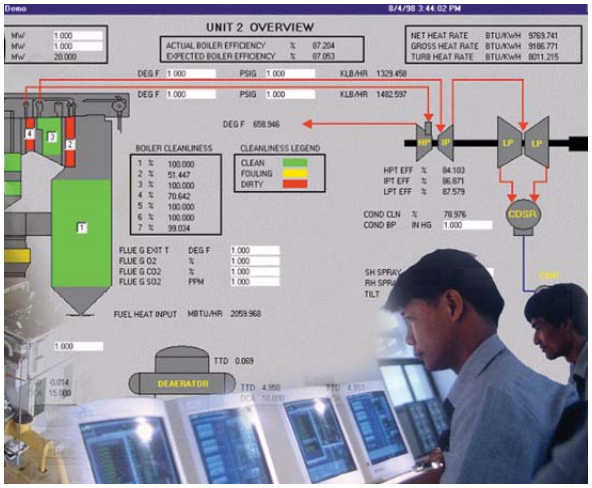


Fig. 8: Sootblowing Advisor

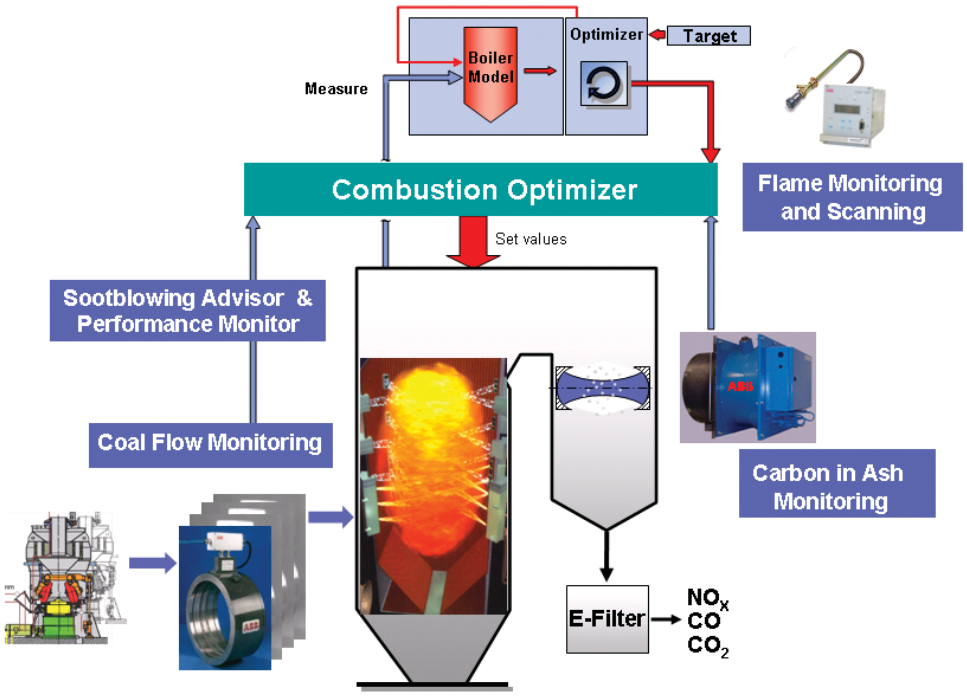


Fig. 7: OPTIMAX® combustion management solutions

OPTIMAX® Asset Lifecycle Systems

Heat exchanger surfaces inside boilers continuously degrade due to fouling caused by soot. Because of this, it is necessary to use sootblowing cleaning techniques to recuperate these losses as much as possible. The Sootblowing Advisor supports plant operators and engineers in optimizing the current plant sootblowing scheme, which by reducing steam consumption, translates into significant fuel savings.

The **BoilerMax** solution in OPTIMAX® was developed by applying model-based closed-loop control and reduces boiler startup times. For a typical 700 MW coal-fired plant which frequently shuts down during the year, this solution minimizes start-up times and reduces emissions with total cost savings of up to 10%.

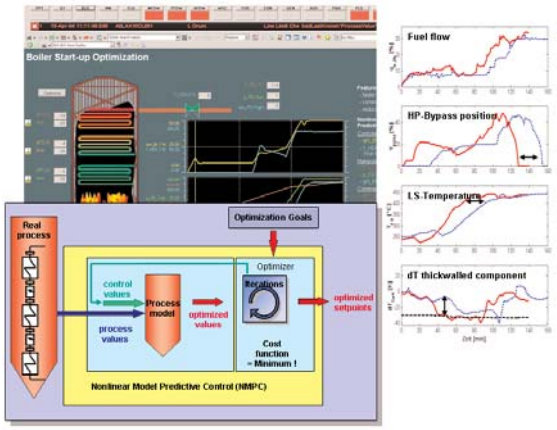


Fig. 9: Boiler startup optimization with BoilerMax

Emission Monitoring

The measurement of hazardous emissions is increasing in importance and regulatory standards are getting stricter every day. ABB provides emission monitoring and reporting solutions utilizing powerful infrared analyzer technology. Calibration without the need of test gas bottles and remote access reduce maintenance and total cost of ownership considerably.

Lifetime Monitoring

Due to frequent start-up and shutdown procedures, as well as load cycles, numerous components of power generation systems are subjected to cyclic stress. To determine and monitor this service life consumption, OPTIMAX® Lifetime Monitoring applications (e.g. BoilerLife and TurbineLife) support the plant maintenance managers in improved maintenance scheduling based on actual documented service life and provides operations with feed-back related to ramifications of the selected operational methods.

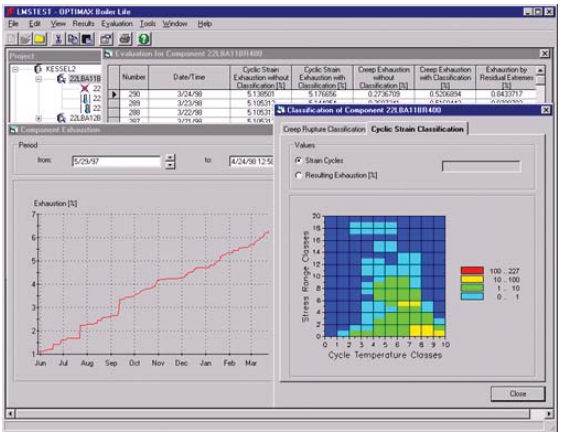


Fig. 10: BoilerLife display

Lifecycle Optimization

In today's energy markets it is important to consider emission costs as well as plant lifetime costs in the optimization. The Lifecycle Optimizer takes equipment ageing into account, based on lifecycle models. It uses parameters such as power prices and emission credits or penalties calculated against long-term maintenance costs to

OPTIMAX® Maintenance Systems

optimize economic plant performance. The advantage of this approach is the ability to include plant ageing models to find the optimal operational strategy between maintenance outages. This assists plant managers in finding a trade-off between short-term profits and long-term asset costs, especially when operating under environmental constraints.

Optimized Maintenance Scheduling

The OPTIMAX® parameter estimation technology is a powerful method which is particularly useful to improve equipment predictive maintenance. For example, the GT Compressor Wash Optimizer parameter estimation is used to estimate the natural degradation in gas turbine compressors and to optimize online and offline compressor washing cycles.

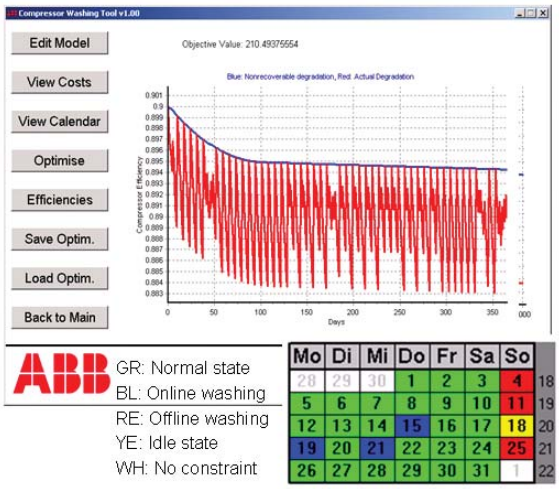


Fig. 11: GT Compressor Wash display

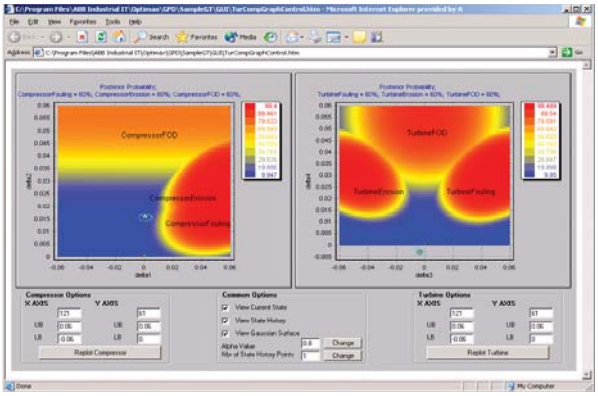


Fig. 12: GT Gas Path Diagnosis display

The same technology is used to diagnose the degradation in the gas path of gas turbines. The GT Gas Path Diagnosis quantifies the probability of fouling, erosion, damage etc. within the engine's gas path. This improves predictive maintenance and decision support for maximizing efficient operating time, thus reducing performance losses, and avoiding downtime.

Maintenance Management

Work preparation and planned condition-based maintenance are increasingly important for reduction of plant downtime costs. The Computerized Maintenance Management Systems (CMMS), provided in the OPTIMAX® portfolio, are designed to fulfill exactly these requirements. Based on its experience in power plant engineering, ABB has the expertise required for implementing effective maintenance systems and integrating them into plant management systems, or Enterprise Resource Planning systems (ERP).
The benefit of ABB's CMMS solutions is to achieve and maintain a high level of availability, quality and safety of the plant. This applies to current plant operation but is particularly valid for inspection, overhaul and service activities.

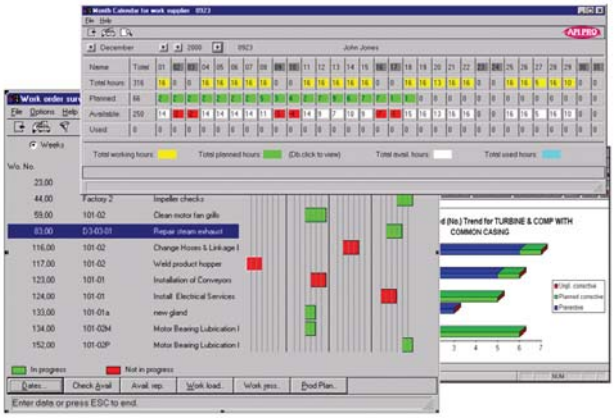


Fig. 13: Example CMMS displays

OPTIMAX® Plant Optimization for Power Generation

Operations	Maintenance	Asset Lifecycle	Environmental	System	Feature	Combined Cycle Power Plant	Fossil Fired Power Plant	Waste-to-Energy	Hydro Power Plant	Water
	x			APIpro	CMMS for complete maintenance management.	x	x	x	x	x
	x			SAP PM interface	Interface between a plant SAP and the PIMS system.	x	x	x	x	x
x				Analyst	Graphic analysis tools for condition assessment of rotating machinery.	x	x	x	x	x
x				SpriteMAX	Wireless data acquisition and fault diagnostic for rotating machinery.	x	x	x	x	x
x				Expert Advisor	Automated condition diagnosis system for rotating machinery.	x	x	x	x	x
			x	Carbon-in-Ash	Real-time non-extractive determination of carbon content in ash.		x			
			x	PfMaster	Online pulverized coal flow monitoring system.		x			
			x	EMI3000	Complete range of emission monitoring instruments and computer.	x	x	x		
			x	GT Emission Predictor	Prediction of GT emissions based on load and weather conditions	x				
x				GT Gas Path Diagnosis	Probability based diagnosis of degradation effects in the GT gas path.	x				
x				Loop Performance Monitor	Monitoring of DCS control loop performance.	x	x	x	x	x
x				Performance Monitoring	Monitoring of actual plant and equipment performance vs. expected.	x	x	x	x	x
x				PowerCycle	Steady-state simulation, validation, opimization of process data.	x	x	x		
x				PEMS	Advanced online Pump Efficiency Monitoring System.	x	x	x	x	x
x				SensorVali	Detection of sensor data deviations from normal operating trends.	x	x	x		
x				Sootblowing Advisor	Determination of where and when to blow soot in a boiler.		x			
			x	BoilerMax	Closed-loop optimized boiler startup including dynamic constraints.		x			
			x	Combustion Optimizer	Closed-loop combustion optimization to reduce emissions and losses.		x	x		
		x		GT Compressor Wash	Cost-optimized scheduling of GT compressor wash cycles.	x				
		x		BoilerLife	Monitoring of life consumption of the boiler and its major components.	x	x	x		
		x		TurbineLife	Monitoring of turbine life consumption.	x	x	x		
		x		Lifecycle Optimizer	Load optimization for multiple units, including ageing and emission costs.	x	x	x	x	x
x				PowerFit	Load optimization for multiple units, by minimizing total generation costs.	x	x	x	x	
x				MODAN	APC unit control for coordinated operation of boiler and turbine.		x			
x				CONDSTOP	APC unit control option for reserve power generation by steam throttling.		x			
x				Live Steam Calculator	APC calculation of the live steam flow, to replace the measuring device.		x			
x				State Space Controller	APC for control of superheater temperature, better than PI controls.		x			
x				TensoMax	Calculation of steam turbine rotor stresses for startup, gradients, and limits.	x	x	x		
x				OTS	Different types of Operator Training Simulators.	x	x	x	x	x
x				Water Leakage Manager	Water loss calculations using field instruments to quickly localize leakages.					x

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