Power Generation: Combined Cycle
Bently Nevada* Asset Condition Monitoring
Introduction

The first industrial gas turbine power plant went on line in 1939, in Neuchatel, Switzerland. The simple-cycle turbine generated 4 MW of electrical power at an overall efficiency of 17%. Today, gas turbine power plants generate 30% of the world’s power with combined-cycle efficiencies three times greater than the original simple-cycle plant.

While renewable technologies form an increasing percentage of generation capacity, combined-cycle plants will continue to play a vital role for the foreseeable future in meeting the world’s demand for electrical power.

GE has been there since the inception, with Edison’s first light bulbs and the necessary mechanical equipment such as turbines and generators. But our pioneering achievements do not stop there. For more than 50 years, our Bently Nevada systems have also been monitoring the condition of machinery in power plants, using sophisticated technology that was invented in our own labs by our rotor dynamicists.

Whether it’s turbine supervisory instrumentation on the main turbine-generator trains, portable data collection systems on numerous low-criticality pumps and motors, wireless vibration monitoring on cooling fans, or software to monitor the thermodynamic efficiency of the entire generation cycle, we have a comprehensive portfolio of systems and services that help you protect your machinery, monitor its condition, and optimize its operation and maintenance.
Your Challenges

With the complexity of a modern combined-cycle power plant, unplanned downtime is exceedingly costly, whether from lost revenues, O&M costs, contractual penalties, or regulatory fines. As such, your mechanical assets need to run at—or even beyond—original design capacity, reliably and predictably.

Our asset management solutions can help you meet many of your most critical challenges, such as:
- Extending the time between planned outages
- Reducing the duration of planned outages
- Maximizing an asset’s useful life while optimizing its maintenance and operating costs
- Minimizing unplanned outages and downtime
- Reducing fuel costs
- Protecting critical machinery against catastrophic mechanical failures
- Reducing unnecessary maintenance

In the pages that follow, we will show you exactly where our solutions can be applied and the benefits that they deliver in a typical combined-cycle facility, whether applied at a single plant or across an entire enterprise.
The Business Case

Machinery protection and asset condition monitoring systems are an investment that pays back quickly and in numerous ways. Today, such systems have moved from simply “good engineering practice” to “good business practice.” And for good reason—they have proven their value time and again in not just the power generation industry, but nearly every industry that depends upon its machinery as part of the production process.

Payback through Protection

*Our solutions help protect your machinery from catastrophic failures and their costs.*

For more than 50 years, the Bently Nevada name has been recognized for its industry leadership in machinery protection and condition monitoring. Today, with more than one million channels of machinery protection installed worldwide, customers have made us the proven choice for machine protection. We not only protect your machinery, but our legendary product quality, deep application expertise, and highly competent locally available service help protect your condition monitoring investment as well.

Payback through Mechanical Validation

*Our solutions let you capture baseline machinery conditions, pre- and post-maintenance, giving you a reference for optimal decision making.*

One of the most crucial times in the life of a machine is immediately after maintenance has been performed. We can tell you if “all is well” with systems that capture relevant data both before and after maintenance. You can instantly see if problems are present and make decisions accordingly. For many customers, the ability to knowledgeably continue with or abort the startup of a turbine-generator train can more than pay for their entire system in a single event.

Payback through Predictive Maintenance

*Our solutions deliver information that allows you to perform maintenance when conditions—not calendars—dictate.*

The results of a predictive maintenance program enabled by our condition monitoring solutions speak for themselves. Consider this European power generation customer’s findings when they benchmarked the 25 years they have been using condition monitoring as the basis for their maintenance decisions versus the calendar-based approach they relied on previously:

- Time between outages increased by 80%
- Outage durations decreased by 60%
- Fleet availability increased by 3.5%
Remote Monitoring and Diagnostics Center
- Machinery Health
- Thermodynamic Performance
- Condition Monitoring System Health

Performance and Optimization Software
- Efficiency /Heat Rate Optimization
- Supervisory Control

Machinery Diagnostic Services
- Problem Identification
- Root Cause Isolation
- Baseline Data Collection
- Field Balancing and Alignment
- Failure Analysis
- Rotor Modeling

Site Installation Services

Heat Recovery Steam Generators

Cooling Towers and Fans

Gas Turbines

Cooling Water Pumps

Boiler Feed Pumps

MV/LV Electrical Distribution Equipment

CMMS/ERP System

Plant Data Network

System 1® Software

Steam Turbine Generator

Condenser

Turbine Supervisory Instrumentation (TSI)
Protection and condition monitoring measurements specifically for large turbine-generator sets; includes bearing vibration and temperatures, differential expansion, case expansion, rotor eccentricity, rotor acceleration and speed, overspeed, valve position, zero speed, and more

Protection
Online, continuous machinery protection
Integrated Condition and Performance Monitoring Applications in Combined-Cycle Power Plants

**Condition Monitoring**
- Online continuous
- Online periodic (wired or wireless)
- Offline periodic (portable instrument)

**Performance**
- Online, thermodynamic performance monitoring and optimization

- Demineralized Water System
- Gas Turbine-Driven Generators
- Condensate Pumps
- Lube and Hydraulic Oil Pumps
- Transformers
- Training
Gas Turbines
Performance monitoring can be just as critical as condition monitoring when it comes to maximizing the efficiency of your gas turbines. GE’s EfficiencyMap* software delivers continuous thermodynamic performance information that enables you to identify and correct root causes of efficiency losses.

A combined-cycle power plant uses EfficiencyMap performance monitoring software, and employs GE’s services team to review the data and generate a monthly Performance and Optimization Report. One report uncovered MW losses in the gas turbine and diagnosed the root cause as a measurement error in the barometric pressure instrumentation, causing the gas turbine to underfire. That insight enabled the services team to quickly correct the offending pressure instrumentation and provided a substantial savings in fuel cost for the plant. All totaled, the plant is currently saving over $500,000 USD per year as a result of optimization opportunities identified by EfficiencyMap software and the Performance and Optimization Reports.

Steam Turbines
Our comprehensive suite of Turbine Supervisory Instrumentation (TSI) measurements combined with our thermodynamic performance monitoring capabilities provides a total solution for protecting and monitoring steam turbines and the entire steam cycle.

When a steam turbine exhibited sustained high vibration, concerned plant personnel consulted a Bently Nevada Machinery Diagnostics Engineer who remotely accessed the monitoring system, identified looseness in a bearing assembly, and confirmed that the unit could stay online, deferring repairs until a more convenient time. By conducting planned versus unplanned maintenance, $900,000 USD of lost production was averted.

Generators
Bearing vibration and winding temperatures are key measurements for detecting everything from shorted windings to misalignment to bearing instabilities. We monitor thousands of generators worldwide.

Using System 1 software and Bently Nevada machinery protection systems, a plant was able to diagnose shorted rotor bars on a generator, yet keep the unit online by balancing vibration levels and VARS to keep the thermal bow of the generator rotor to a minimum. VARS were shared across the other four units until this particular generator could be rewound during a planned outage. Since this is a baseload plant, the economic benefits accrued were substantial.
Boiler Feedwater Pumps
Critical to operating your plant at full capacity, loss of a boiler feedwater pump has significant economic consequences. Bearing vibration/temperature measurements on these pumps and their prime movers are essential for protecting against catastrophic failures and for assessing mechanical health.

Increased vibration levels were detected on a boiler feed pump being returned to service at the end of a major planned outage. The Bently Nevada condition monitoring system enabled plant personnel to diagnose and fix the problem without delaying the startup schedule and declaration of full plant availability. $90,000 USD in contract penalties were avoided, as well as potential damage to the machine.

Cooling Water Pumps
Cooling water pumps are a critical part of a plant’s cooling system and require periodic inspection of the bearing and seals to avoid failures. Of course, inspections can be costly due to downtime and maintenance expenses. Further, unexpected problems such as leaks often occur when the pump is returned to service. Clearly, increasing the interval between inspections can result in substantial savings.

When this combined-cycle plant went into commercial operation, the OEM recommended mechanical seals and bearings on four Cooling Water Pumps be inspected every two years. Instead, on the recommendation of GE, the plant used their System 1 software to closely monitor the bearing and seals, collecting vibration data in three-month snapshots, and found no sign of deterioration. This allowed for the maintenance period to be extended by 1½ years, and inspections to be conducted on a 3½-year cycle versus the OEM-recommended 2-year cycle.

Cooling Tower Fans
When operating at or near design performance limits, loss of even a single cooling tower can curtail plant output. Even when curtailment is not a concern, repair costs can be substantial. The speed-reducing gearbox is a particularly vulnerable failure location that warrants vibration monitoring.

A plant lost more than $300,000 USD to cooling tower fan problems before installing permanent monitoring. In one instance, a blade sheared off completely. The resulting unbalance destroyed the entire fan assembly and parts of the tower, even though simple vibration switches were installed and a portable data collector was being used to check the fans monthly. After permanent monitoring systems were installed, no further failures have occurred.
Comprehensive, Globally Available Services

**Technical Support Agreements**
A one-year renewable Technical Support Agreement (TSA) is automatically included with every product we sell. Its structure consolidates all products installed at your site under a single agreement for ease of administration and entitles you to phone, e-mail, and web-based support from our global network of experienced support experts.

**Machinery Diagnostic Services**
Our more than 70 machinery diagnostic engineers around the world are recognized globally for their expertise in gathering and analyzing data to document baseline conditions and troubleshoot even the most vexing machinery problems.

**Remote Monitoring and Diagnostics**
In many cases, traveling to the site to perform machinery diagnostics and assess machinery health is a thing of the past. We can even work with your IT department to engineer remote connectivity solutions that are fully compliant with your corporate data network requirements.

**Supporting Services Agreements**
A Supporting Services Agreement (SSA) is a custom-tailored combination of individual remote and site-based service offerings that addresses the unique needs of your site and your installation. We work with you as a partner to keep your instrumentation performing optimally at all times and to provide hands-on assistance that helps you realize the full potential of your condition monitoring system.

**Training**
We provide in-depth technical training that is routinely praised by customers for its highly effective “learn by doing” labs coupled with classroom-style instruction. A comprehensive suite of product training courses is augmented by courses that teach the fundamentals of rotating machinery behavior and diagnostic techniques. Our courses can be provided at any of our global training centers or at your site.

**Design and Installation Services**
We can provide comprehensive project management services to install and configure our solutions, document the installation, contract and manage site craft labor, and more. You determine the scope, from simple installation consulting to full turnkey services to everything in between.

**Reliability Services**
We provide our customers with the tools, processes, and methodologies to identify and implement the proper condition monitoring technologies, strategies, and predictive services for all maintainable assets required to meet their specific maintenance and operational goals.
• Global Experience
• Local
• Deep Application Expertise
• 24/7/365 Technical Support
• Thermodynamic and Rotordynamic Expertise
• Remote Service Capabilities – Move Data, Not People
• Complete Turnkey Installation Capabilities
• 50+ Years of Condition Monitoring Innovations
For more information about Bently Nevada Asset Condition Monitoring solutions for combined-cycle power generation, contact your local GE sales professional or visit us online at www.ge-energy.com/bently

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