

Power generation: combined cycle

Bently Nevada asset condition monitoring





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.

For more than 60 years, Bently Nevada systems have 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 60 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.



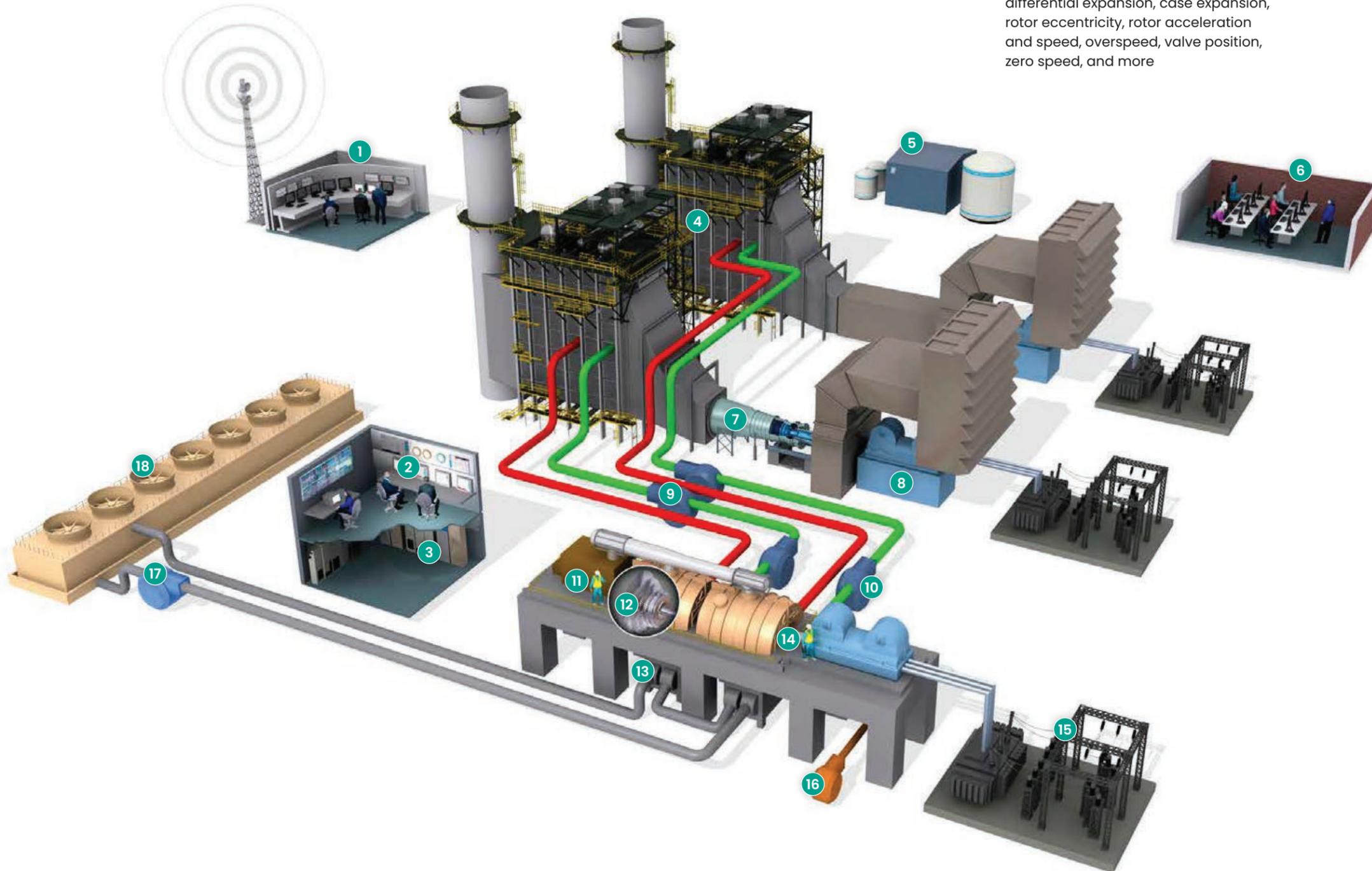
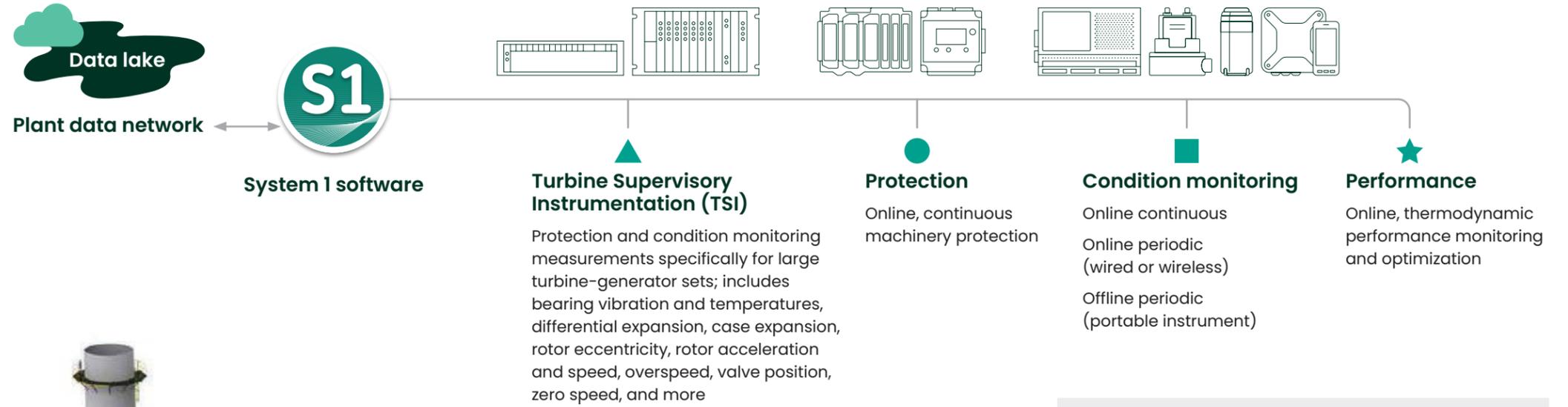
Payback through predictive maintenance

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%

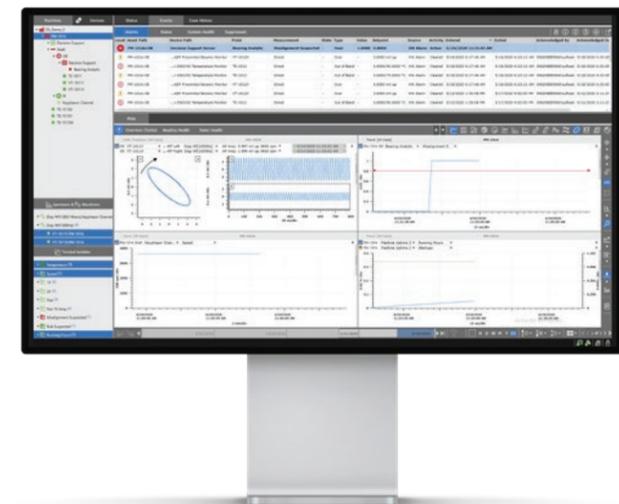
Integrated condition and performance monitoring applications in combined-cycle power plants



1. **Central and/or remote monitoring and diagnostics center**
 - Machinery health
 - Thermodynamic performance
 - Condition monitoring system health
2. **Performance and optimization software**
 - Efficiency/heat rate optimization
 - Supervisory control
3. **MV/LV electrical distribution equipment** ■
4. **Heat recovery steam generators** ★
5. **Demineralized water system** ■
6. **Training** ■
7. **Gas turbines** ● ■ ★
8. **Gas turbine-driven generators** ● ■
9. **Boiler feed pumps** ● ■ ★
10. **Condensate pumps** ● ■ ★
11. **Machine diagnostic services**
 - Problem identification
 - Root-cause isolation
 - Baseline data collection
 - Field balancing and alignment
 - Failure analysis
 - Roto modeling
12. **Steam turbine generator** ▲ ● ■ ★
13. **Condenser** ★
14. **Site installation services**
15. **Transformers** ■
16. **Lube and hydraulic oil pumps** ■
17. **Cooling water pumps** ● ■ ★
18. **Cooling towers and fans** ● ■ ★

Measurable results, tangible value

Plantwide value through condition monitoring occurs asset-by-asset. Our solutions for combined-cycle plants encompass not just your critical equipment where downtime is the dominant economic driver and can reduce or even halt plant output, but also your less critical assets where maintenance and labor costs are of primary concern. Below are just a few examples of the dozens of different asset types we can address.



Gas turbines

Performance monitoring is a very important part of a gas turbine's condition monitoring and can be used for maximizing the efficiency of your operations.



System 1's Bently Performance application software delivers continuous thermodynamic performance monitoring of gas turbines to track and analyze the efficiency and other thermodynamic key performance indicators (KPIs) of these operation-critical assets. These KPIs can then be used to track the overall health of these assets and plan timely maintenance that helps avoid unexpected downtime. It also helps in determining the underlying causes of a machine's degradation. When machinery performance insights enable proactive servicing, it is not unusual for power generation plant operators to see yearly savings of >\$500,000 USD in fuel costs alone.

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 our recommendation, 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 1 year, and inspections to be conducted on a 3-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



Implementation services

Whether it be enhancing existing installations, retrofits, upgrades, or commissioning new systems—our expert services ensure your system is installed, configured, calibrated, and optimized to meet your specific needs.



Proactive support

Our proactive supporting service offerings and programs are designed to ensure your system is healthy, available, secure, and optimized. From technical support and troubleshooting to fully-managed supporting services covering probe tip to machinery health reports and everything in between, we make sure your machinery investments return a maximum ROI while potentially saving you millions in avoidable downtime.



Asset health and consulting

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.



Cybersecurity

Security of your critical processes and operations is a top priority for our asset protection and monitoring solutions. Today it's necessary to ensure these systems are securely designed, deployed, and implemented using industry-standard processes and methodologies while being proactively monitored, maintained, and updated throughout their lifetime.



Training and education

With more than 40 years of technical training experience, we have pioneered the art of long-term skill development. Bently Nevada product training is conducted by our core group of instructors and experienced field engineers to provide a world-class training experience both remotely and in-person. Bently Nevada's training and education offerings can help keep your people up and running alongside your machinery.

- Global experience
- Local
- Deep application expertise
- 24/7/365 technical support
- Thermodynamic and rotodynamic expertise
- Remote service capabilities—move data, not people
- Complete turnkey installation capabilities
- 60+ years of condition monitoring innovations

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