Let GE’s Advanced Technology and Service Help Reduce your Operating Costs While Increasing your Unit’s Availability

The electricity industry is undergoing major changes. Deregulation, power trading, changing environmental emission regulations, growing renewable energy generation, and fuel supply security concerns all can impact your plant—and your bottom line. In addition, an aging generation fleet must support ever-increasing power usage across the globe.

ADVANCED STEAM PATH (ASP)

Such a dynamic marketplace demands flexible, intelligent solutions that optimize generation assets, improve power plant revenues, extend plant life, increase output at lower cost, and reduce emissions. GE’s Advanced Steam Path (ASP) upgrade solutions can provide all that and more for a wide range of applications, such as:

• Independent power producer and utility power stations
• Municipal combined heat and power plants
• Pulp and paper facilities
• Waste-to-energy and other industrial processes
• Mechanical drive installations

As a world leader in steam turbine upgrades, GE’s solutions have improved the efficiency and operation of more than 1,300 steam turbine cylinders, including about 30 percent of them from other manufacturers.
The Benefits
Increased Availability and Life Extension

Older steam turbines can be unreliable and require frequent repairs or component replacement. Even without major operational problems, a unit with high service hours is at risk as it reaches the end of its design life. Advanced Steam Path can solve many maintenance and lifetime problems. The typical post-upgrade regular maintenance interval is 100,000 hours, which is very likely to be longer than the original design, thus saving costs and increasing availability.

Output
Up to 10% output increase
The increasing demand for power puts pressure on an existing plant to increase capacity. But, as well as allowing for more power, an ASP upgrade can be designed to match the steam flow from an upgraded boiler or reactor.

Efficiency
Up to 10% steam turbine cycle better efficiency
With rising fuel prices and increasingly stringent environmental regulations, the improved thermal performance of a steam turbine can be biased towards reducing input rather than raising output. The appropriate balance between fuel savings and power increase can be tailored to meet customer requirements.

Reliability and Availability
Up to 100,000 hours intervals extension between major inspections
A competitive grid also obliges operators to run their assets as long as possible with as little downtime as possible. By replacing major components with more resilient modern equivalents, an Advanced Steam Path upgrade not only reduces maintenance requirements but can also enhance the cylinder’s lifetime.

Profitability
Return on investment can be as little as three years and performance guarantees are provided
The economics of an upgrade compare favorably with the cost of a new plant, and lead time is much shorter. Our services range from technical direction to complete turnkey installation (typically achieved within a scheduled outage period).

Flexibility
ASP, coupled with our Opflex Agility solution, can help improve start-up times up to 56%
With a competitive grid and accommodation of renewable sources, existing thermal plants must operate with greater flexibility. By combining our fleet experience with the latest engineering technologies and digital control systems, an upgraded turbine can respond to cyclic demands with high efficiency and minimal stress.
Latest Technology, High Performance

Advanced Steam Path uses advanced technology developed for the latest generation of steam turbines to improve plant performance. While our innovative and flexible design concepts can be customized to meet your requirements, the proven features used can be developed quickly and precisely. For non-GE equipment, onsite interface measurements are taken before configuration is finalized.

When implementing our ASP upgrades, we work with you to reduce changes to your operating procedures.

Range of New Technologies

GE’s expertise enables us to offer Advanced Steam Path upgrades for all types of steam turbine from any manufacturer, and we uniquely can cover both impulse and reaction steam turbine technologies—irrespective of the original blading technology—to get the best results for you.

Customized Solutions

GE is at the forefront of steam turbine technology development in the areas of steam path, frame architecture, component design and material development. As a leader in upgrade designs, we focus on tailored solutions through a holistic approach with cutting-edge mechanical, aerodynamic, thermodynamic, materials and manufacturing technologies.

Continual Blade Development

Blade design is continually evolving through the use of advanced Computational Fluid Dynamics (CFD) techniques, with the most promising solutions validated in model turbine tests.

Advances in modeling and analysis also provide greater understanding of stresses and vibration, resulting in resilient designs with high operational flexibility. Modern manufacturing capabilities not only allow for better aerodynamics, but also enable features such as integral shrouds and snubbers, which improve the stiffness of blade packets.

Refined Sealing Reduces Leakage

The application of improved gland seal mechanisms significantly reduces leakage, which is particularly important on shorter high pressure (HP) and intermediate pressure (IP) blades. The most effective gland fin geometry of the inter-leaved type is applied throughout at blade tips and shaft glands. Constructional features such as diaphragms and our unique shrink ring technology preserve the small clearances and maintain performance improvement during prolonged operation.

GE’s portfolio of advanced sealing technologies can decrease leakage in all interfacing areas. Flow disturbances within the turbine are reduced through the enhanced shaping of blade hub and tip areas, which helps to smooth the flow transition between stages.

The routine use of three-dimensional (3D) blading has allowed many traditional efficiency limitations to be overcome. With 3D blading, the blade profile and shape are optimized to reduce aerodynamic loss. This has allowed for aft-loaded profiles, which increase velocity distribution and reduce secondary flow losses at hub and tip. For stationary blades, end losses are reduced with the controlled flow design, which enlarges the throat area of the central section by twisting the leading edge.
Steam Valve Upgrades Enhance Performance

GE’s range of standard valve designs provides for all sizes and makes of steam turbine. Flow modeling allows steam chests to operate with minimum pressure drop, while Finite Element Analysis of the steam chest profile helps ensure increased thermal fatigue resistance. The latest creep-resistant alloy steels are used to limit the thickness of the pressure vessel that forms part of the valve chest.

Likewise, valve internals have been improved for performance and reliability. The use of hard-wearing materials, deposits and surface treatments helps to maintain dimensional accuracy and avoid scale buildup. These attributes contribute to long-lasting, reliable and precise valve operation.

Although valve chests and internal components can be replaced individually, maximum benefit and minimum adaptation are achieved when entire assemblies are upgraded.

Advanced Materials Enhance Operational Flexibility

New high-temperature alloys developed in recent years are used in ASP upgrades for blading, rotors and casings. Higher strength at mid to high temperatures leads to compact solutions with greater operational flexibility. Improved materials for low temperature applications also have been introduced.

GE has been a leading participant in joint international efforts to develop advanced materials, such as titanium, for last stage blades. Our extensive in-house research and development, particularly for welded rotors, has enabled us to introduce materials with improved weldability combined with high fracture toughness and hardenability.

Our welded rotor solutions combine different materials with optimum properties in different parts of the rotor. For nuclear applications, a variety of materials with proven long-term capabilities are available.

Robust Blade Design Limits Solid Particle Erosion

Solid Particle Erosion (SPE) can be found on HP and IP turbines that have narrow fixed blades with strongly curved profiles. Solid particles contained in the steam can affect these typically thin blades, sometimes causing severe local erosion, which results in significant loss of efficiency.

GE blade designs (past and present) feature moderately curved and larger blade profiles with more robust trailing edges. These allow most solid particles to pass harmlessly through the turbine. Any particles that do impinge on the blading do so with reduced momentum, thereby limiting SPE damage.

Greater Efficiency Lowers CO₂ Emissions

Upgrading existing units to significantly increase overall efficiency is the fastest way to sensibly reduce emissions. For instance, an upgrade of LP turbine cylinders that improves LP efficiency by approximately 6% will reduce the overall turbine heat rate by about 2%. For a coal-fired power plant, this could translate to a reduction of some 70,000 tons per year of CO₂ emissions.

When an upgrade of HP and/or IP turbine cylinders is considered, the impact on boiler performance should be studied. By optimizing the performance parameters, the overall improvement can be significantly better than it would be from component replacement alone. For example, a steam turbine upgrade in a six-unit 500 MW lignite-fired power plant in Germany resulted in CO₂ emission reductions of about 660,000 tons per year.

Threshold Stress Approach Offers Resistance to Stress Corrosion Cracking

Stress Corrosion Cracking (SCC) occurs in turbine components, particularly nuclear low pressure (LP) turbine rotors, when three contributing factors—material yield strength, stress loading and temperature—are present in a critical combination. Such combinations often are found at blade root attachments, rotor side faces, disc bores and keyways on shrunk-on-disc rotors. GE’s unique method of designing rotors, the Threshold Stress Approach, guards against the occurrence of SCC.

GE’s rotors are of a welded or monobloc construction and inherently are lower stressed than are rotors employing shrunk-on discs. As a result, rotor materials of lower yield strength can be used.
Advanced Steam Path in Action

GE has upgraded more than 1,300 steam turbine cylinders worldwide. Around 30% of those were manufactured by others. In fact, GE has supplied upgraded cylinders for turbines from all major manufacturers, ranging from single-cylinder fossil-fired units of less than 20 MW to half-speed nuclear machines with outputs in excess of 1,000 MW.

Eggborough 3 & 4
UK
Inner module upgrade of the AEI HP cylinders on two 500 MW fossil-fired units

The plant owners wanted to extend plant life, increase performance, and reduce costs and maintenance requirements. Originally commissioned in the late 1960s, the units were upgraded with new HP inner modules, composed of a new inner casing with integral portioned inlet nozzle belt, new rotor with eight stages of advanced rotating blades, and a new set of fixed blade diaphragms. A turbine controller also was supplied. The owner’s objectives were achieved, with successful installations in 2004 and 2007 respectively.

Diablo Canyon 1 & 2
USA
Inner module upgrade on Westinghouse BB81 LP cylinders of two 1,100 MW half-speed nuclear machines

GE’s Advanced Steam Path produced a significant increase in generated power for two units originally installed in 1985 and 1986. The upgrades provided improved steam path efficiency combined with increased reliability and reduced maintenance and inspection requirements for the units’ remaining operational life. Both upgraded units are now in service, having successfully achieved all performance guarantees.
Combined HP/IP inner module upgrade on the G2 cylinder of a 550 MW fossil-fired unit

The aim of this upgrade of a unit originally commissioned in 1992 was to enable the owners to generate electricity more economically over the remaining life of the plant. The upgrade project consisted of a new combined HP and IP module replacement using GE’s advanced impulse technology blades with technical support and provision during the installation. The new rotor had three more stages in the HP section to help provide the additional power required. The upgraded cylinder was commissioned in 2002, and all performance guarantees were met. Further benchmark tests demonstrated that the performance improvements have continued, with degradation measured at a rate lower than ASME guidelines for this type of machine.

HP module upgrades employing GE’s advanced reaction technology blading for six LMZ 500 MW machines

The new HP rotor was fitted with advanced 3D rotating and stationary blades with integral roots and shrouds. This has greatly improved the HP and IP cylinder efficiencies. In addition, the new HP inner casing shell reduced distortion and helped ensure fast load change capability. The existing outer casing shell, valves, loop pipes and bearings were retained. The new rotors featured a welded-on Curtis wheel and provided an additional eight stages, increasing reliability. This Advanced Steam Path provided the unit with improved operational economics over the remaining life of the plant. More recently, GE won a contract to supply Advanced Steam Path upgrades for the IP cylinders on two units.
Herne 4
GERMANY

HP upgrade on 500 MW Siemens fossil-fired unit

Herne Power Station is a 950 MW coal-fired plant located in North Rhine-Westphalia, Germany. Originally constructed in 1962, the plant is owned and operated by Evonik Steag GmbH. Unit 4 was added in 1989 to provide district heating and 500 MW of electrical power.

To increase efficiency, an upgrade of the HP cylinder was completed in 2013. In addition to providing savings in coal consumption and reducing pollution, greater efficiency raised the plant’s status in the merit order of the German grid, thus increasing its chance of selling the plant output. Performance tests following the upgrade showed that the guaranteed efficiency was exceeded.

An additional benefit was improving the maintainability of the HP cylinder. The original Siemens “barrel” design required complete removal and disassembly during an outage. Additional equipment included:

- Two new sets of stop and control valves, each set combined in the same casting
- New control-oil skid and associated piping
- Modern control system for increased flexibility

Castle Peak Power Station B1 – B4
HONG KONG

Inner module ASP of three HP cylinders and extensive unit upgrade at 4.1 GW coal-fired station

Castle Peak Power Station is the largest coal-fired station in Hong Kong, China, generating more than 4.1 GW of power from four 350 MW (Castle Peak A) and four 677 MW (B) units. Located in Tuen Mun District in the New Territories, it was commissioned between 1982 and 1989. It is one of three stations in Hong Kong operated by China Light & Power (CLP).

The turbine generators originally were supplied by GEC. Each shaft line of the 677 MW “B” station machines comprises one HP and one IP cylinder plus two LP turbines. To help reduce station emissions and to cope with the advent of flexible operating schemes, such as two-shifting and load following, CLP contracted with GE to undertake upgrade work on these machines.

The HP cylinders of units B1 to B3 were given a full inner module upgrade while B4 received an extensive upgrade. The LP cylinders of all four units received a full set of new diaphragms of an improved design.

In addition to reducing emissions and extending the working life of the units, efficiency in each case improved by about 1%.
Full shaft line upgrade services on 300 MW fleet

Mawan Power Station is a 6 x 300 MW coal-fired station in Guangdong Province of China that is owned by Shenzhen West Power Company, a subsidiary of Shenzhen Energy Group. GE’s upgrade solutions for the Shanghai Electric (SEC) and Harbin Electric (HEC) 300 MW machines, manufactured under license from Siemens Westinghouse, significantly increased their performance.

The standard solution includes a new bladed rotor, fixed blades and blade carriers in the LP turbine, and it incorporates GE’s highly successful RS37T last stage. Optional components include a new inner casing and shaft end glands.

The Mawan solution includes a new combined HP/IP turbine inner module. GE thus became the first non-Chinese manufacturer to provide full shaft line Advanced Steam Path on the domestic 300 MW fleets.

GE has invested in research and development of upgrade solutions for a variety of domestic Chinese turbines in direct response to government pressure to improve the efficiencies of these machines, and the need for these high-performing and cost-competitive solutions likely will continue to grow. Furthermore, using local content enables these solutions to be offered at competitive prices.

HP inner module upgrade and new moisture separation reheaters (MSR) on two STAL-LAVAL 870 MW full-speed nuclear machines

The new HP inner block provided an additional two stages, longer blades and improved sealing, delivering increased efficiency and reduced maintenance frequency. The new MSRs, combined with the change to two-stage reheat, provided further power increases. These HP upgrades are in operation on both units and have delivered the guaranteed performance improvements. In a second project phase, GE was awarded the contract for LP upgrades on both units. This was achieved with all eight double-flow inner cylinders being supplied, installed and returned to service within the allotted time.
Fleet360* Total Plant Service Solutions

- 230+ years of combined “plant-as-a-system” expertise
- 90+ OEM brands serviced
- 120+ million hours of operating data analyzed
- 1 partner to deliver all of your plant solutions

While delivering tailored Advanced Steam Path upgrades for steam turbines, our broadened understanding of plant-wide operations can help customers unleash better performance, reduce risk and realize greater value from their plant and fleet assets.

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