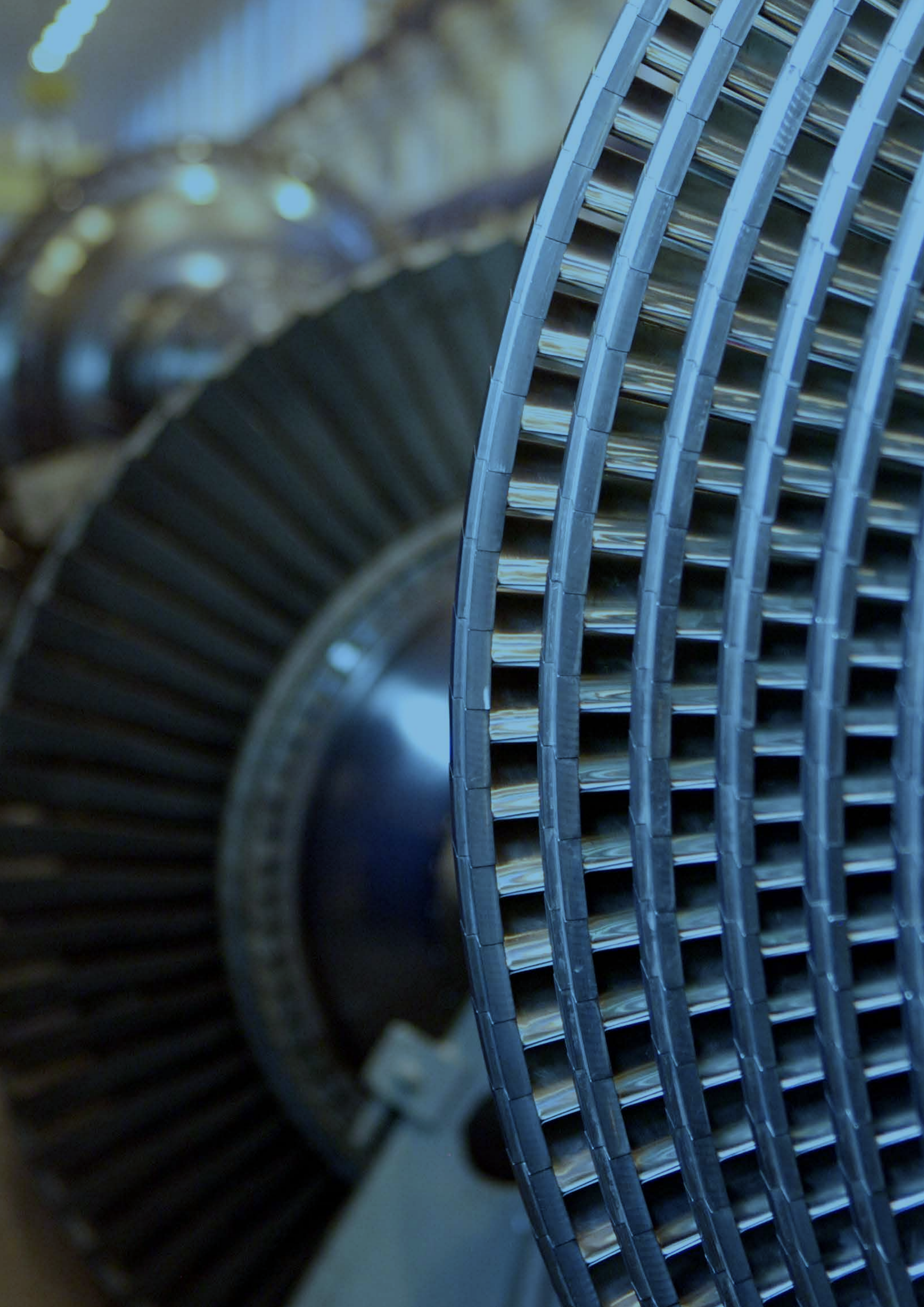




GE Power

**Fleet360* Total Plant
Service Solutions**

Steam Turbine Retrofit & Upgrade





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.

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 retrofit 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 retrofits, GE's solutions have improved the efficiency and operation of more than 1,000 steam turbine cylinders.



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. Retrofitting can solve many maintenance and lifetime problems. The typical post-retrofit 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

The increasing demand for power puts pressure on an existing plant to increase capacity. But, as well as allowing for more power, a retrofit can be designed to match the steam flow from an upgraded boiler or reactor.



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.



Flexibility

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, a retrofitted turbine can respond to cyclic demands with high efficiency and minimal stress.



Reliability and Availability

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, a retrofit not only reduces maintenance requirements but can also enhance the cylinder's lifetime.



Profitability

The economics of retrofitting 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). Return on investment can be as little as five years and performance guarantees are provided.



Latest Technology, High Performance

GE's retrofit solutions use 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 designs are finalized.

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

Range of New Technologies

GE's expertise enables us to offer retrofit solutions for all types of steam turbine from any manufacturer, and we uniquely can cover both impulse and reaction steam turbine technologies. This capability means that our retrofit solutions can use reaction, impulse or both—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. A leader in retrofit 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 designs validated in model turbine tests.

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 portion by twisting the leading edge.

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.

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 retrofitted.

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.

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 Materials Enhance Operational Flexibility

New high-temperature alloys developed in recent years are used in retrofits 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.

Greater Efficiency Lowers CO₂ Emissions

Retrofitting existing units to significantly increase overall efficiency is the fastest way to sensibly reduce emissions. For instance, a retrofit 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 a retrofit 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 retrofit in a six-unit 500 MW lignite-fired power plant in Germany resulted in CO₂ emission reductions of about 660,000 tons per year.



Retrofit in Action – Delivering Performance

GE has retrofitted more than 1,000 steam turbine cylinders worldwide. Around 40% of those were manufactured by others. In fact, GE has supplied retrofit 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 retrofit 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 retrofitted 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 retrofits on Westinghouse BB81 LP cylinders of two 1,100 MW half-speed nuclear machines

GE's advanced technology retrofits produced a significant increase in generated power for two units originally installed in 1985 and 1986. The retrofits provided improved steam path efficiency combined with increased reliability and reduced maintenance and inspection requirements for the units' remaining operational life. Both retrofitted units are now in service, having successfully achieved all performance guarantees.



**JK Spruce 1
USA**

Combined HP/IP inner module retrofit on the G2 cylinder of a 550 MW fossil-fired unit

The aim of this retrofit 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 retrofit 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 retrofit 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.



**Jaenschwalde A to F
GERMANY**

HP module retrofits 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 steam turbine retrofit provided the unit with improved operational economics over the remaining life of the plant. More recently, GE won a contract to supply retrofit solutions for the IP cylinders on two units.

Retrofit in Action – Delivering Performance



**Castle Peak Power Station B1 – B4
HONG KONG**

Inner module retrofit 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 and retrofit work on these machines.

The HP cylinders of units B1 to B3 were given a full inner module retrofit 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%.



**Herne 4
GERMANY**

HP retrofit 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, a retrofit 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 retrofit 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



Full shaft line retrofit 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 retrofit 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 retrofit services on the domestic 300 MW fleets.

GE has invested in research and development of retrofit 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 retrofits 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 retrofits on both units. This was achieved with all eight double-flow inner cylinders being supplied, installed and returned to service within the allotted time.

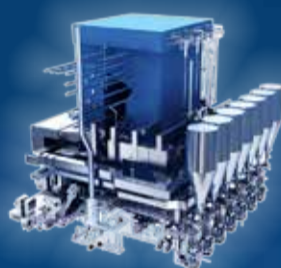
Fleet360* Total Plant Service Solutions

- **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

Environmental Control Systems



Boiler



Generator



Steam Turbine



Balance of Plant

DIGITAL SOLUTIONS | MULTI-YEAR AGREEMENTS

While delivering tailored upgrade solutions and retrofit technology 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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