



INDUSTRIAL STEAM TURBINE SERVICE SOLUTIONS

www.ge.com/power/services/steam-turbines/industrial

KEY COMPETENCE FOR GE AND NON-GE EQUIPMENT

EXPERTISE AND TAILORED SOLUTIONS FOR YOUR SPECIFIC NEEDS

In an ever-changing competitive and regulatory environment, flexibility and expertise are key requirements. Building on GE's global fleet and project execution experience, we partner with owners of GE and non-GE equipment to help maximize performance and lifetime profitability while keeping safety, reliability, and environmental compatibility as top priorities.

GE provides a full range of service solutions to help achieve better performance for your existing steam turbine portfolio. Drawing on GE's advanced service solutions, technology options, and worldwide resources, our Industrial Steam Turbine engineers have the required expertise to re-evaluate and reconfigure your unit to meet your current or future operating needs.



OUR CUSTOMER VALUES:

PERFORMANCE RECOVERY

- Up to **4%** reliability recovery every 10 years
- Up to **16%** efficiency recovery

PERFORMANCE IMPROVEMENT

- Up to **3%** above original performance

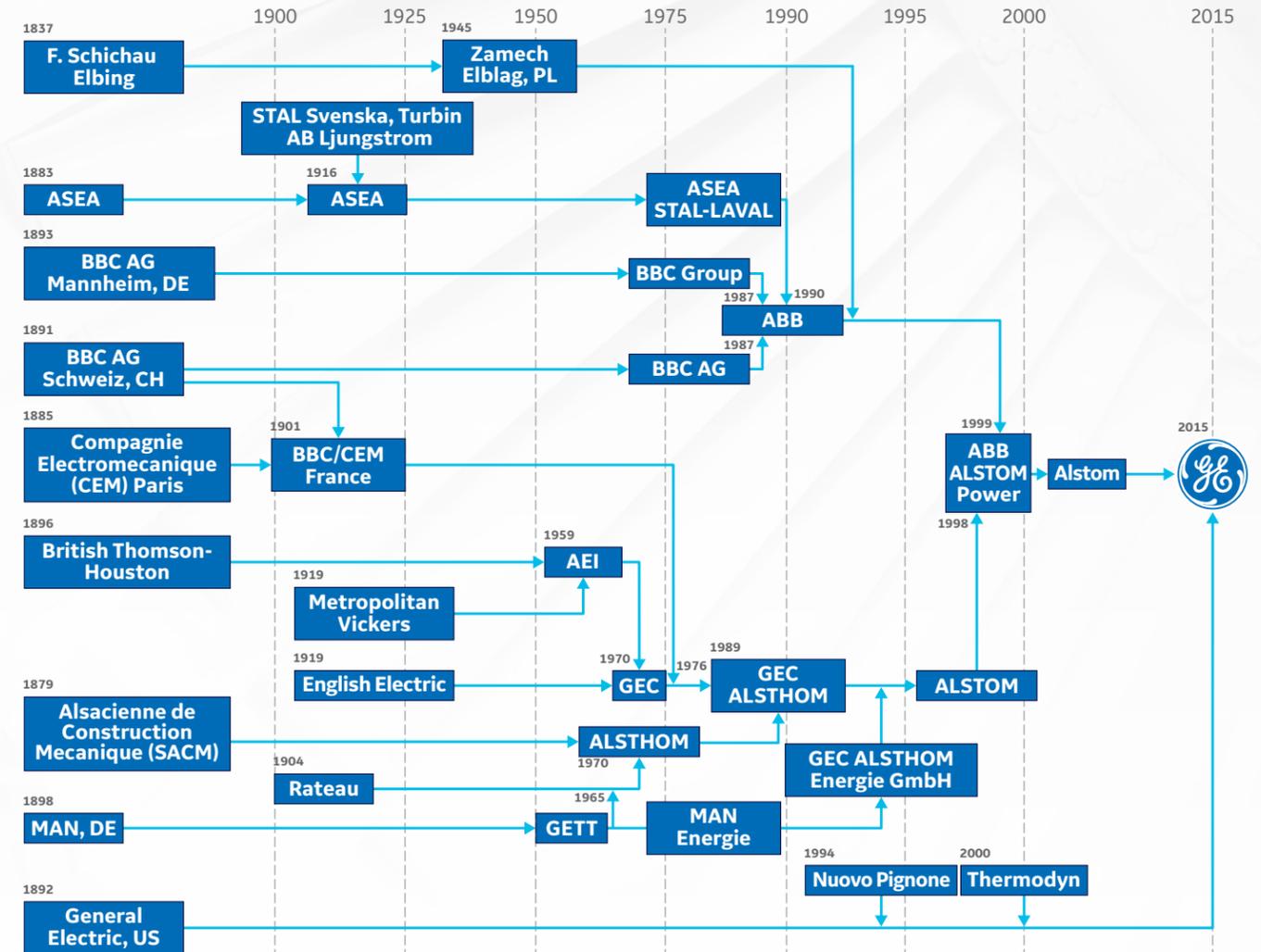
PLANT/PROCESS CHANGES

- Maximize **reuse** of current equipment
- Reduce **cost**

GE'S COMPETENCE AND TECHNOLOGY HERITAGE

Thanks to the depth and diversity of our manufacturing heritage and operational feedback from one of the largest installed bases in power generation, GE's capabilities cover the full range of steam turbine and related technologies on the business sector today. With the integration of legacy technologies and solutions we can deliver a total plant portfolio of planning an installation, maintenance & repairs and upgrade & improvement solutions.

Building on a broad heritage, GE offers a dedicated team of engineers and service technicians to address the needs of all industrial turbine operators across the whole life cycle.



LIFE CYCLE MANAGEMENT AND SERVICE SOLUTIONS

GE offers customized solutions for “trouble-free” operation of your unit during its life cycle. OPEX and CAPEX are predictable and “plannable” opportunities.

OPEX

GE offers support for any operational event a maintenance manager needs during daily operation.

Technical Expertise and Operational Support

- Performance and residual life assessments
- Predictive and condition-based maintenance support
- Outage scope recommendations
- Inspection technologies
- Emergency response planning
- Monitoring and diagnostics
- Training
- Operational and technical support
- Failure analysis

Reconditioning and Repair

- Fast and smart repair of all components
- On-site repairs
- Workshop repairs
- Component modifications and improvements
- Workshop inspection and testing

Parts

- Outage spare parts packages
- Replacement blading
- Emergency spare parts supply
- Reverse engineered spare parts

Field Service

- Outage planning and schedule optimization
- Erection, commissioning, and supervision
- Field service tools

CAPEX

GE provides the technology solution a customer requires for any form of life extension, upgrade, efficiency, or output improvement as well as needed capacity adjustments.

Turbine Upgrades and Modifications

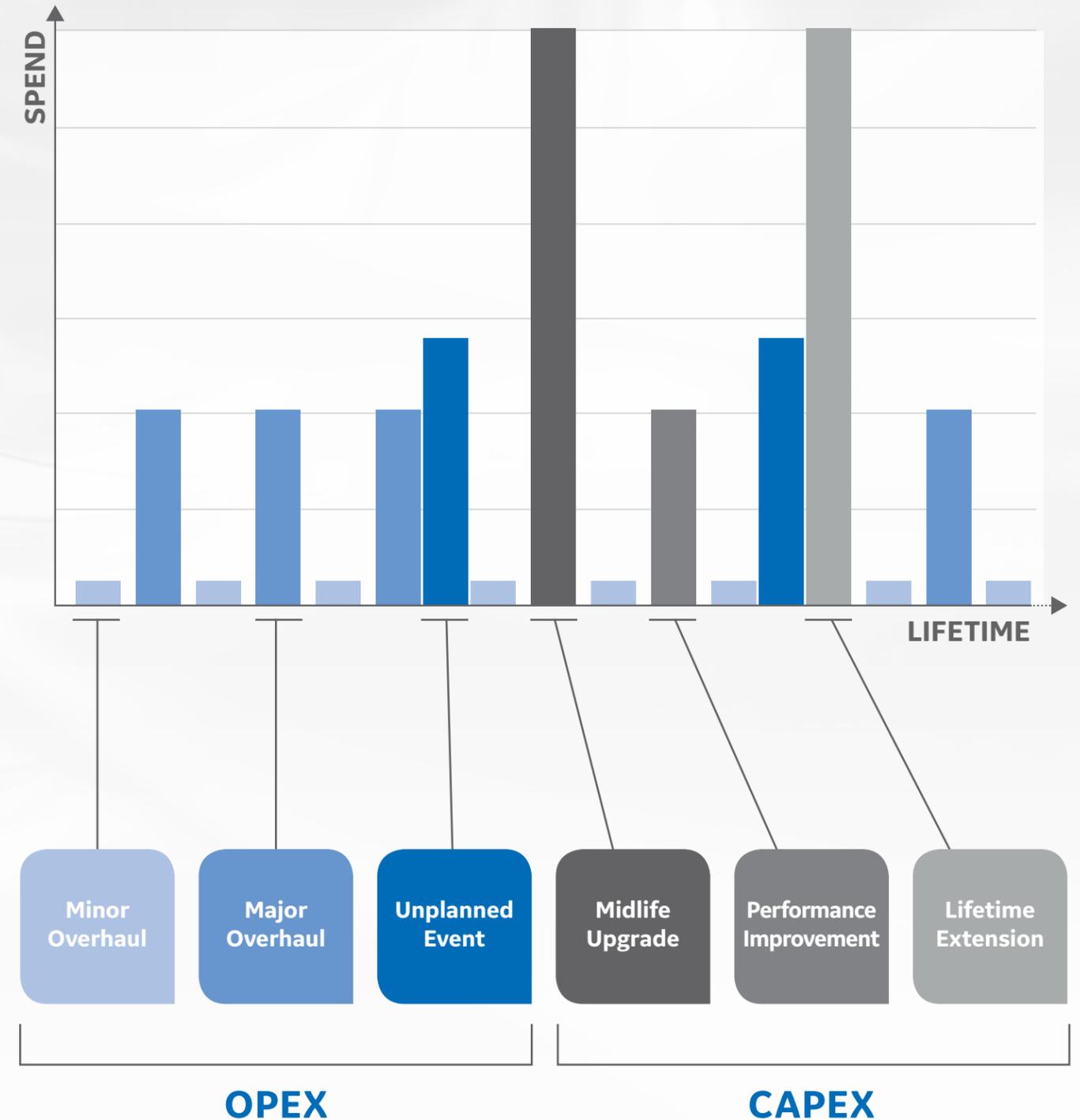
- Steam path upgrades
- Valve upgrades
- Sealing improvements
- Capacity adjustment
- Control system upgrade
- Auxiliaries conversions

Performance Improvement

- Turbine retrofits
- Flange-to-flange turbine replacements
- Valve retrofits
- Performance recovery
- Plant efficiency improvements
- Power output augmentation

Capital Parts

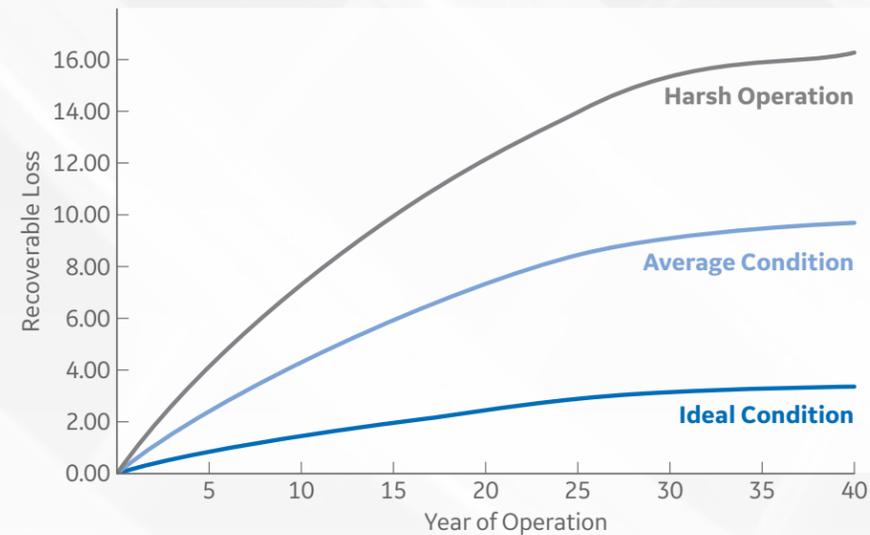
- Replacement rotors
- Replacement stator components



OUR CUSTOMER VALUES

GE's skilled team of engineers work closely with you to determine the value packages that best suit the needs of your plant. Offerings include:

PERFORMANCE RECOVERY

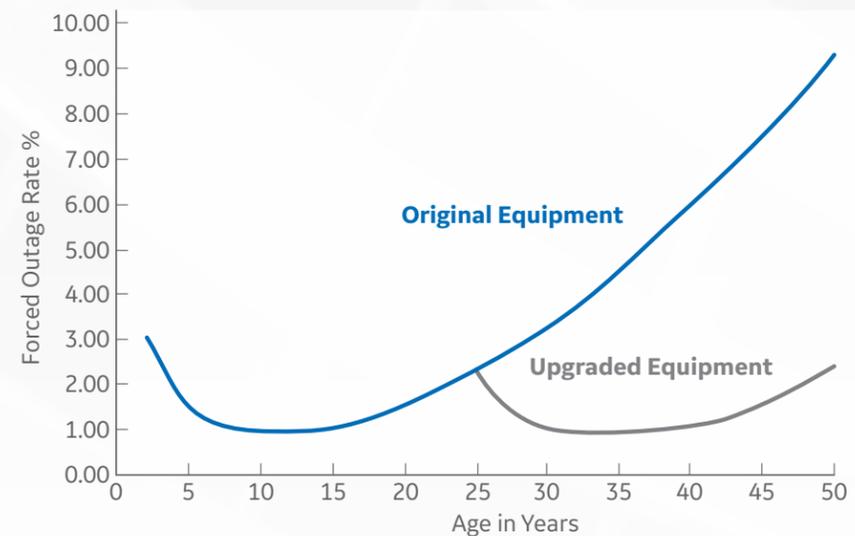


An industrial steam turbine experiences performance deterioration over time. The rate of the deterioration is influenced by the turbine design, the steam quality, and the way the turbine is operated.

Main root causes for performance deterioration are:

- Leakage
- Solid particle erosion
- Moisture erosion
- Steam path deposits
- Foreign object damage

GE's efficiency upgrades usually consist of sealing improvements and high-performance steam path components that recover the degradations, leading to an improved efficiency up to 16% and significantly extending the turbine life and operational reliability.



PERFORMANCE IMPROVEMENT

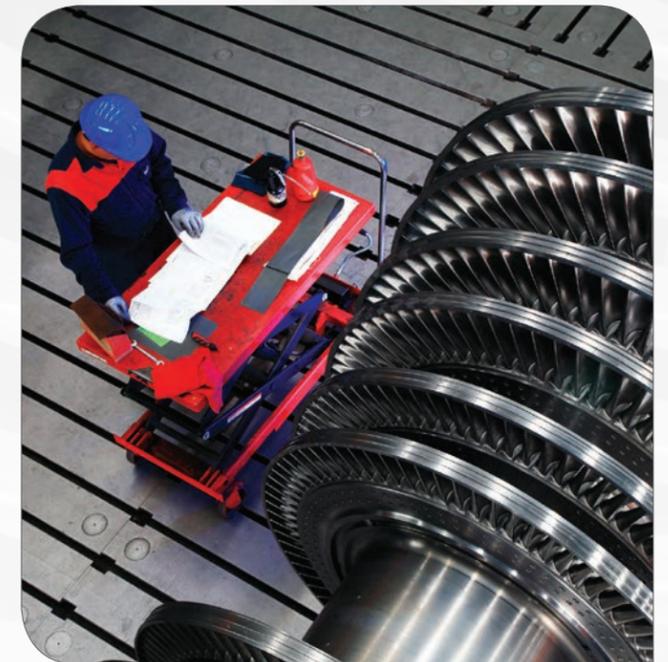
Upgrades and retrofits can give a steam turbine a new lease on life, boost reliability and efficiency, and can help to reduce CO₂ emissions.

This can be achieved by partial or full steam path components replacement, which are designed and manufactured with latest engineering tools and methods.

The upgrade and retrofit replacement scope can include:

- Individual steam path modifications of individual blading stages
- Complete exchange of inner module, including new rotor
- Flange-to-flange turbine replacement

GE's retrofit and upgrade solutions can be installed during a standard or slightly extended turbine outage.



PLANT/PROCESS CHANGES

Changes in the customer's production process may require turbine modifications

- Capacity changes
- Extractions mass flow change
- Controlled extractions
- Admission and/or exhaust modifications

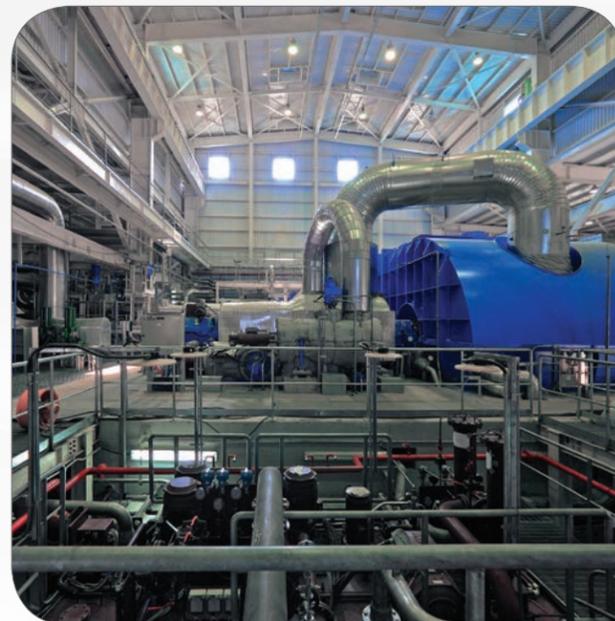
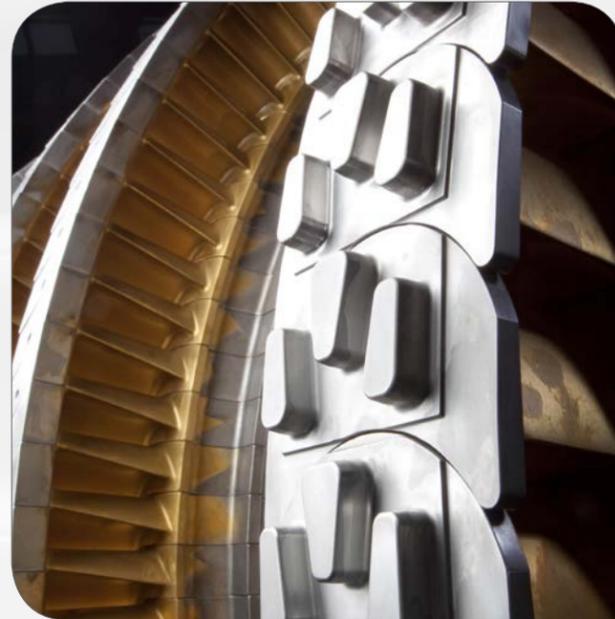
Based on customer requirements, GE determines modifications required for optimal operation at the new conditions.

This could include:

- **Uprate:** Modifying to increased power or flow needs
- **Derate:** improving performance for reduced power or flow needs
- **Process steam adjustments:** Changed or even controlled steam extraction

Our offering:

- Steam path re-calculation and optimization
- Parts replacement scope determination
- Design and component supply
- Installation, commissioning, performance measurement



TECHNICAL EXPERTISE AND OPERATIONAL SUPPORT

GE ASSISTS CUSTOMERS IN MAXIMIZING THEIR MACHINE'S OPERATION, RELIABILITY, AND AVAILABILITY WITH:

Operational Support

- Emergency response planning
- Outage compression techniques
- Remote operations support

Assessments and Analysis

- Performance and lifetime assessments
- Condition assessments
- Monitoring and diagnostics
- Operational analysis
- Layout studies

Outage Planning

- Condition-based and optimized outage schedule
- Material and parts requirements
- Tools and outage site arrangement

TEAMS - Turbine Evaluation, Analysis, and Maintenance Scheduling

GE's periodic surveillance program supports you with a condition-based maintenance program and planning. Four different offerings can be requested.



CHECKUP

Visual Inspection / Operating data

Learn the status of your equipment and which tier of service we recommend



MAX

Mechanical / Thermal / Maintenance Planning

Better outage and parts planning



BASE

Mechanical / Thermal

Improve turbine performance and efficiency



LITE

Mechanical

Prevent unplanned outages, improve reliability and availability

For more information on TEAMS please visit our webpage

<https://www.ge.com/power/services/steam-turbines/industrial>

OUR OFFERINGS

FIELD SERVICE

With best practices and advanced tools for disassembly and assembly, GE plans carefully to reduce downtime and ensure on-time completion with the highest quality results.

Our first commitment is to environment, health, and safety. And thanks to standardized training and processes you enjoy the same GE quality irrespective of your plant location. Thus, our highly qualified supervisors and site engineers are equipped with modern tools and conduct rigorous quality checks at every stage of the job.

Our offering:

- Maintenance services, e.g. minor and major overhauls
- Erection and commissioning
- Removal and Installation
- Condition assessment and non-destructive testing
- Site repairs

RECONDITIONING AND REPAIR

GE has developed an array of proven repair techniques for all parts of the industrial steam turbine.

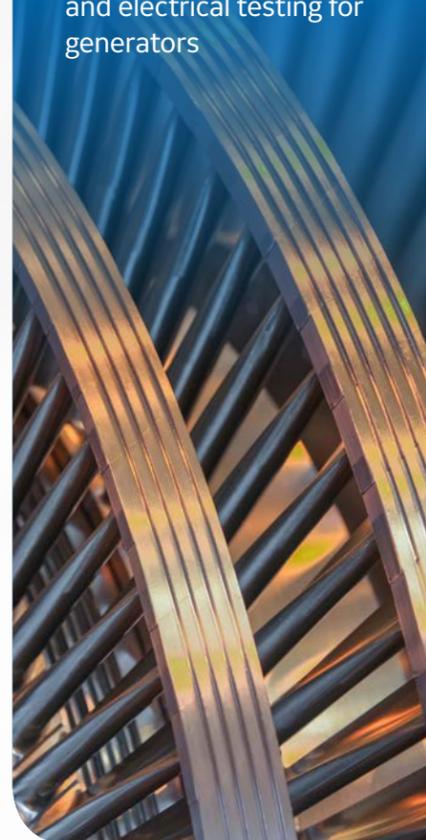
Our offering:

- Rotor repairs, straightening, balancing, weld repairs, disc head repairs, disassembly, and rebuild
- Casing repairs and re-rounding
- Guide blade carrier and diaphragm repairs
- Control stage and blading repairs
- Sealing re-alignment and replacement
- Bearing rebabbiting

The repairs are usually executed in our specialized repair workshops or even on-site with our mobile repair equipment.

MOBILE WORKSHOPS

- Full shaft-line machining of rotors
- Balancing of rotors
- On-site machining for turbine and generator components, including casings, shafts, and valves
- Specialized mechanical and electrical testing for generators



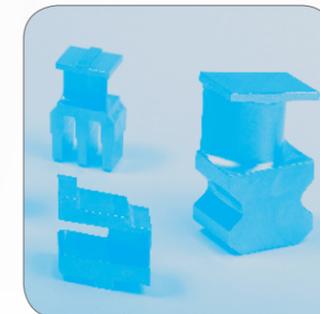
PARTS OFFERINGS

GE provides spare parts for its legacy machines and for a large number of non-GE industrial steam turbines. GE's extensive expertise in reverse engineering enables us to support our customers with standard and complex industrial steam turbine parts during ongoing overhauls.

Our pre-defined spare parts catalogs for standard spares and the GE rapid reverse engineering process ensure that necessary parts are delivered to site whenever they are needed. All of our reverse engineering parts are modified, manufactured, and tested according to GE's OEM quality process to ensure the highest quality and reliability for our customers.

Our offering:

- Steam turbine blading
- Bladed or unbladed rotors
- Guide blade carriers
- Diaphragms
- Gland segments
- Bearings
- Valve internals and actuators
- Fasteners
- Gaskets and seals
- Filters
- Consumables



ENGINEERING CAPABILITIES

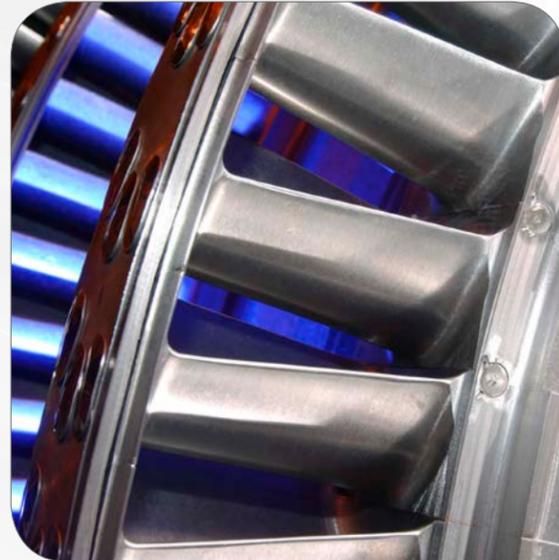
REVERSE ENGINEERING

GE's reverse engineering methodology builds on solid multi-year experience, both on our own as well as on third-party industrial turbine fleets. We understand the original design intent of any steam turbine or steam path component. An integrated process approach to outage execution and reverse engineering allows procurement of high-quality parts during an outage, with minimum measurement requirements.

Building on this experience, GE has developed a seamless process which integrates capabilities in turbine assessment, engineering, supply chain management, and field service. Starting with the condition assessment of the affected turbine components, parts are dispositioned for replacement, refurbishment, or continued use.

GE's reverse engineering and outage services contribute to the overall unit profitability in terms of availability and reliability, as parts are delivered only if and when required.

- The ability to provide just-in-time spare parts during a major outage avoids the need for continuous investment in stock parts, thus reduces warehouse costs
- Plant availability is kept high, as procurement and installation of spare parts will be completed during major outages
- Improved spare parts (using the latest design) can further increase flexibility and reliability of the steam turbine unit



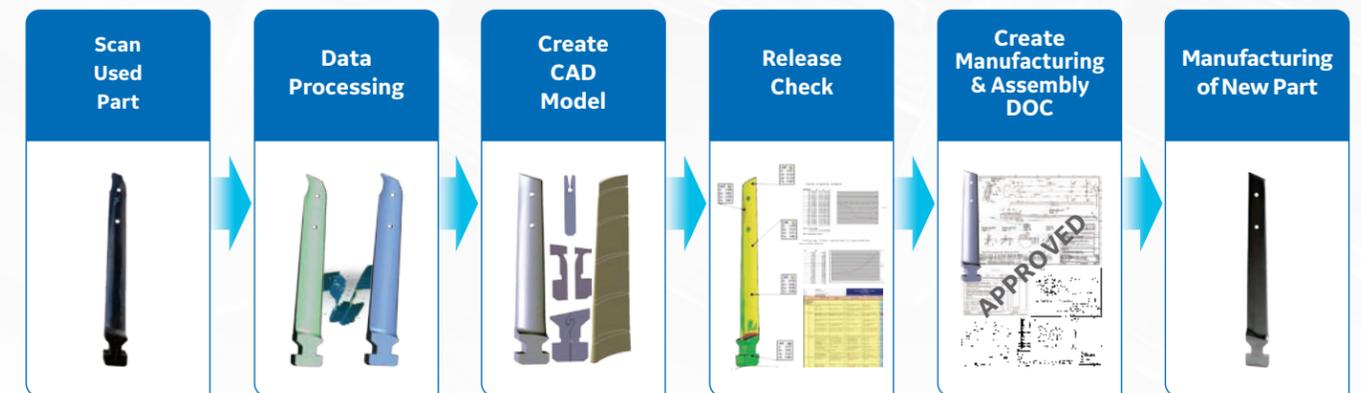
REVERSE ENGINEERING PROCESS

GE's reverse engineering process ensures a fast and safe spare parts supply for a large number of industrial steam turbines. The integration of the reverse engineering parts process into the steam turbine outage planning and execution ensures that parts can be supplied during ongoing overhauls.

Reverse engineering process steps include:

- Parts data capture either in workshop or on-site
- Data processing and creation of surface models
- Generation of 3D model of component and design of accessories
- Component re-design for improved operation and to address generic component deteriorations
- Dimensional, lifetime analysis, and design release
- Manufacturing and assembly drawing creation
- Production release

FROM USED TO NEW PART



PERFORMANCE IMPROVEMENT OFFERINGS

UPGRADES

Our upgrade offering is designed to boost the turbine's reliability and efficiency and can even reduce CO₂ emissions by replacing individual parts with improved components.

An upgrade can be the answer to many issues that our customers are facing:

- Generic technical issues
- Parts lifetime
- Performance and efficiency degradation
- Parts obsolescence

GE offers a large upgrade portfolio, ranging from improved sealings, bearings, valve components, and steam path blading to improvements for control systems, hydraulic systems, and generator parts.

Upgrades are usually designed in a way that they can be installed during a standard overhaul without delaying the outage schedule.



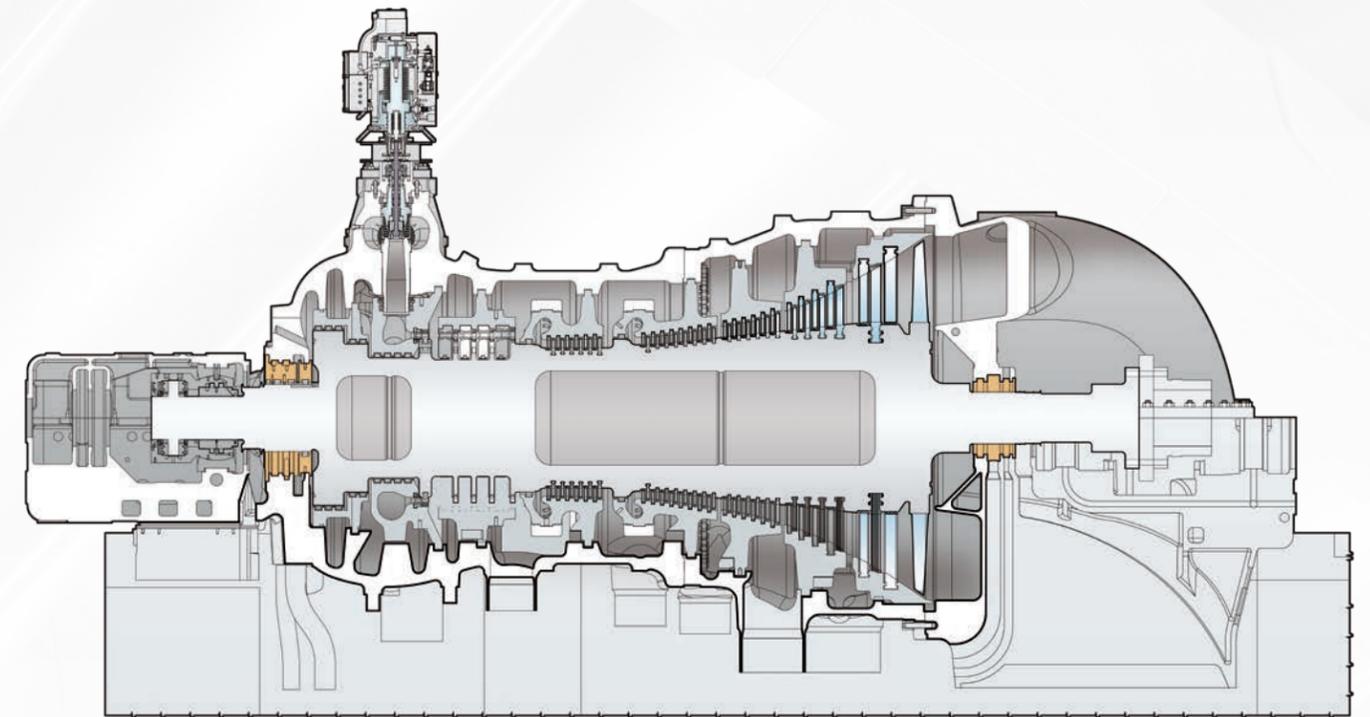
RETROFITS

Retrofits are modifications wherein major internals are replaced (e.g. rotor, blading, stator). This can be required when revised operating conditions lead to different output requirements, poor operating efficiency, and/or increased risk of age-related failure.

GE offers solutions ranging from partial retrofit (inner cylinder and partial blading replacement) to full retrofit (completely new steam path).

Main benefits include:

- Increased lifetime
- Improved efficiency and performance
- Expanded capacity adjustment
- Faster installation



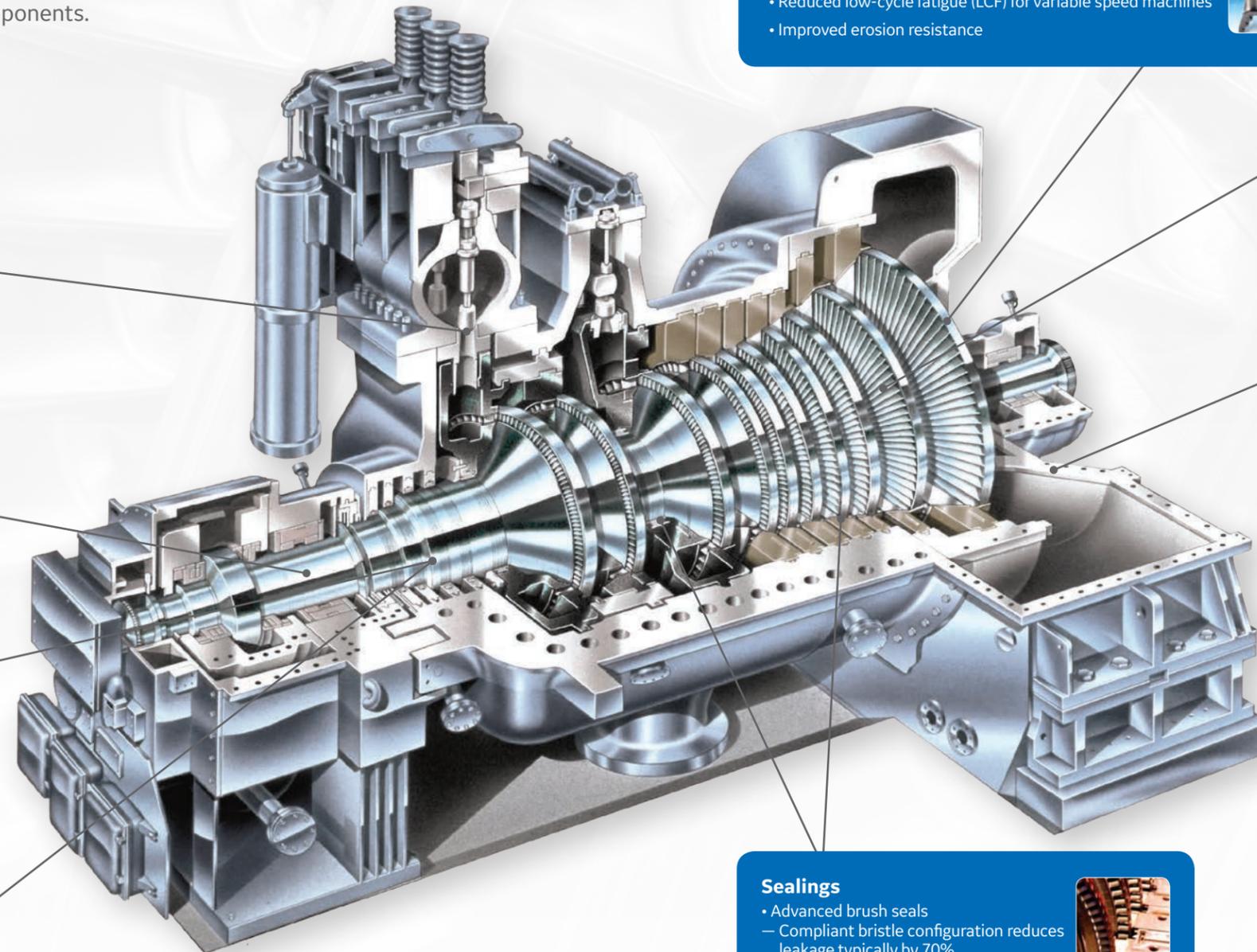
Over 1,260 turbine cylinders retrofitted, 25% of which were non-GE turbines

- Impulse and reaction turbines in all classes
- Industrial, fossil, combined cycle, and nuclear applications
- More than 300 retrofits of third-party cylinders, including Siemens, Westinghouse, MHI, Toshiba, Hitachi, Fuji, LMZ, Franco Tosi, Ansaldo & Skoda

IMPROVE THE VALUE OF YOUR STEAM TURBINE

Advanced Technology Component Packages for Enhanced Performance and Reliability

GE's Industrial Steam Turbines team has engineered Advanced Technology Packages to restore aging machines to modern standards (even after 20+ years of operation). These packages can be tailored to your specific needs. From individual components to turbine sub-systems or total machine modifications, GE can provide you with reliable and efficient components.



Control Valves

- High-efficiency valve conversions
- Upgraded layouts for valve seat, disk, bushing, cam shaft, stem, sector gear, etc.
- Maintenance-free DU bearing replacements
- High-efficiency actuator modification

Bearing Modification

- Journal and thrust bearing modification
- Tilting pad or shell design
- Journal area polishing

Rotor Maintenance

- Factory inspection
- Rotor welding:
 - dovetail, wheel, shaft end, fine-line welding
- Shrink wheel refurbishment
- Low- and high-speed balancing



Rotor Replacement

- Staging with modern blading technology
- Forged rotor construction eliminates shrink wheels, thrust collar, and coupling hubs
- Modern materials and NDT standards

Last Stage Blades

- High-performance last stage blade design
- Reduced low-cycle fatigue (LCF) for variable speed machines
- Improved erosion resistance



Steam Path

- Modern configurations with advanced blading profiles and improved structural layout
- Enhanced reliability and performance
- Welded nozzle plate replacements
- Hard facing nozzle protection against Solid Particle Erosion (SPE)

Casing Modifications

- Add borescope ports for easy inspection
- Add or modify extraction openings
- Convert condensing to back pressure unit
- Casing and diaphragm inlays for erosion repair
- Replace diaphragms or blade carriers



Auxiliary Turbine Systems

- Nozzle spray chamber replaces gland leakage condenser
- Gland exhaust vacuum pump replaces steam ejector
- Mechanical-hydraulic to pneumatic steam seal operator
- Convert NRVs to pneumatic operation

Sealings

- Advanced brush seals
 - Compliant bristle configuration reduces leakage typically by 70%
- Improved HP nozzle box packing for higher reliability
- Advanced labyrinth seals
 - Improved efficiency



Control System Upgrade

- Conversion of mechanical-hydraulic controls (MHC) or electro-hydraulic controls (EHC) to modern microprocessor-based controls
- Electronic controllers and hydraulic interfaces available for significant performance and reliability benefits
- Conversion of mechanical bolt overspeed protection to high-reliability electronic overspeed protection

DIGITAL SOLUTIONS

Our mission is simple: get faster, get smarter, get ahead.

Digital is disrupting and transforming the industry, challenging old models and creating unprecedented opportunities (~\$1.3 trillion of value over the next decade). With software and data analytics, combined with advanced hardware, new digitally-enhanced power generation will deliver greater reliability, affordability, and sustainability, helping lower costs, improve efficiencies, create growth opportunities, and lower carbon output.

Digital Power Plant is the ideal synergy of machinery and software, combining the diverse needs of power assets with high-speed, intelligent digital infrastructure built for the Industrial Internet. With the support of Predix, a cloud-based platform, our comprehensive suite of customizable services and solutions makes improving your unique operations simple and impactful. We make your machines smarter, leading to better business decisions, enhanced performance, and bigger results. Plant/Farm Optimization and Performance Metrics are part of the operation optimization. Portfolio Optimization and Market Intelligence and Forecasting are part of business optimization.

Software Defined Flexibility

Unlike traditional operations machines, where applications for that equipment were built into firmware and notoriously difficult to connect to the Industrial Internet, new breeds of assets autonomously connect to the Industrial Internet, execute native or cloud-based machine applications, analyze collected data, and respond to changes in that data.

Predix

GE's platform for the Industrial Internet combines best of breed technologies for massive data ingestion, analytic modeling, and execution, asset libraries, and a sophisticated User Interface (UI). Predix machine is an on-site gateway for data cleansing and communications and for executing analytics at the edge, required for near real-time response. This environment was industrial built to manage the data and analytics required for power companies to gain operational benefits and action based recommendations.

Digital Twin

An organized collection of physics-based methods and advanced analytics used to model the present state of every asset in a Digital Power Plant. GE applications use the Digital Twin to model solutions, execute "what if" scenarios, and to drive outcomes based on analytic models that mirror and predict the functions of the physical assets.

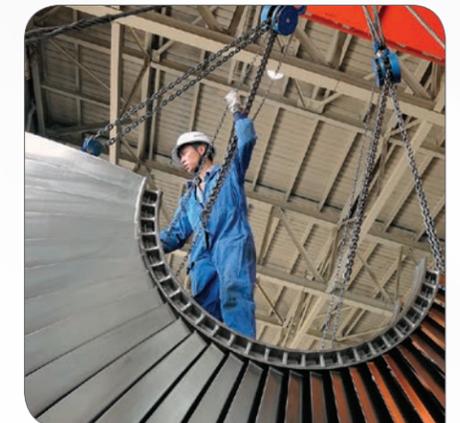
Suite of Applications

Leveraging data from software defined machines and the GE Digital Twin, a complete set of applications designed to improve asset performance and reliability, to increase operation efficiency, and to give power business leaders insights that allow them to make more profitable decisions.

GLOBAL REPAIRS SERVICES (GRS)

GE has a powerful and effective global supply chain and the largest global field service organization in the power industry. This world-wide presence ensures high quality and timely responses from dedicated, trained, and experienced service managers, engineers, and technicians.

The Industrial Steam Turbine Services organization can draw on the whole GE network to support customers with powerful technology, expert engineering, and quick access to the solutions that they need.



TRAINING FOR YOU

WE PARTNER WITH YOU

MEETING YOUR CONTINUOUS LEARNING NEEDS

A continuous path of learning helps plant personnel gain the knowledge and skills needed to run an efficient, successful plant. GE's Customer Training can suggest the right mix of training options to align with your plant configuration, equipment technology, employee audience, and time constraints.

- **Site-Specific Courses:** Our high-value training service offers a variety of 200 courses that are tailored to your specific site by your assigned GE instructor and dedicated training project manager. Courses are delivered either at your site or at one of our global learning centers in the language of your choice, and on a schedule that works for you. Courses may contain a mix of classroom learning, site walkdowns, and hands-on training.
- **Open Enrollment Courses:** With technology-specific content, our Open Enrollment training offers a comprehensive selection of more than 75 English-language courses for small staff or new team member training, or to expand the skills of select employees. Your employees train at one of our learning centers with students from around the world. Courses offer a mix of classroom learning techniques, and may contain walkdowns and/or hands-on training.
- **Online Courses:** A cost-effective solution for a broad range of employees, our 25-plus Online English-language courses let you train your personnel anytime, anywhere, and at their own pace. Each course ranges in duration from one to four consecutive hours, and can be started and stopped at the student's discretion.
- **Multi-Year Training Agreements:** Simplify your training, budgeting, and planning efforts with our long-term flexible training offering. This agreement entitles you to a fixed number of annual training days for GE's Site-Specific and/or Open Enrollment courses, unlimited use of all our available Online courses, plus exclusive access to our Remote Turbine Operations Simulator. We partner with you throughout your plant's lifecycle to help you select the training solutions that best meet your evolving needs.

SERVICE CONTRACTS

GE service contracts are win-win arrangements to increase operative efficiency and eliminate availability risks for parts and resources in the face of both planned or unplanned outages. GE's Long-Term Service Agreements and Emergency Response Plans can be tailored to perfectly fit your scope, duration, and risk-sharing requirements.

Multi-Year Agreement

A Multi-Year Agreement is one umbrella agreement for partial or complete industrial power plants covering on-site advisors, engineering support, and planned maintenance/parts support. This helps you to maximize generation and minimize downtime over the whole lifetime.



Fleet-Wide Maintenance Agreement

GE can offer international fleet-wide maintenance agreements to cover all your plant service, parts, stock management, and emergency response needs. Agreeing on the commercial conditions only once, rather than for each site, cuts your costs and saves time for everyone.



FLEETS & APPLICATIONS

Building on our global fleet and project execution experience, we partner with owners of GE and any other non-GE equipment to help maximize performance and lifetime profitability while keeping safety, reliability, and environmental compatibility as top priorities.

GE Fleet:

- GE
- BBC
- ABB
- Alstom
- Jugoturbina
- GEC, AEI, EE, MV
- Lang
- Zamech, LMZ
- ACEC

Other OEM Fleets:

- Siemens
- MHI
- MAN
- Toshiba

Applications:

- Chemical
- Petrochemical
- Waste to Energy
- Pulp & Paper
- Solar
- Geothermal
- Metals
- Marine/Transportation
- Utility
- Combined Cycle

Comprehensive Flexible Training Solutions to Meet Your Total Plant Needs

Steam Turbines | Controls | Generators | Boilers



Plan & Install



Operate & Maintain



Upgrade



Improve

Technology-Specific Online
eLearning Self-Paced

Technology-Specific Open
Enrollment at PS Learning Center

Site-Specific at Customer
Site or PS Learning Center



Leadership



Supervisors



Operators



Mechanical
Maintenance Engineers



Electrical
Maintenance Engineers



Instrumentation &
Controls Specialists

SUCCESS STORIES

OEM



MAJOR OVERHAULS + SPARE PARTS PACKAGE

Chemical Plant in France
10 - 21 MW GE ISTs

SCOPE OF WORK:

Major overhaul on three steam turbines + supply of spare parts including one steam turbine casing and diaphragms

MAIN EVALUATION CRITERIA:

Technical capabilities

MAIN WINNING REASON:

Steam turbine pre-assembly in factory for new casing to mitigate site erection risk and to keep outage duration short

Customer was very satisfied with the execution team, reinforcing the long-term partnership.



DERATE

Paper Mill in United States
60 MW GE IST

SCOPE OF WORK:

Major overhaul with new high-pressure section steam path components to derate turbine from 60 to 28 MW

MAIN EVALUATION CRITERIA:

Performance improvement

MAIN WINNING REASON:

Customer gained ~6 MW in their main operating point on same steam supply and significantly reduced its water treatment due to reduced de-superheating

Customer was very satisfied. Performance was better than expected, and the execution team performed up to expectations.

OTHER OEM



STEAM PATH REPLACEMENT + ASSEMBLY

Waste to Energy Plant in the Netherlands
24 MW Siemens IST

SCOPE OF WORK:

Complete steam path replacement + repairs

MAIN EVALUATION CRITERIA:

Lead time (significant loss due to stop of production), price

MAIN WINNING REASON:

GE offered a competitive price

As the customer was very pleased with the overall execution, they strengthened the partnership with GE on other on-site assets as well.



MAJOR OVERHAUL + EMERGENT WORK

Paper Mill in Sweden
26 MW Siemens IST

SCOPE OF WORK:

Major overhaul plus factory repair of turbine, new nozzle blades, new and modified ventilation protection ring

LEAD TIME:

Five weeks for factory scope plus two weeks for assembly and commissioning on-site

MAIN EVALUATION CRITERIA:

Lead time

MAIN WINNING REASON:

GE was able to react very quickly in offering the overhaul, which combined competitive pricing with a short delivery time

Customer was very happy with the professional execution of the overhaul and the fast delivery of needed parts.

For more information, see your GE sales representative or contact us at:

<https://www.ge.com/power/services/steam-turbines/industrial>

