GE VERNOVA

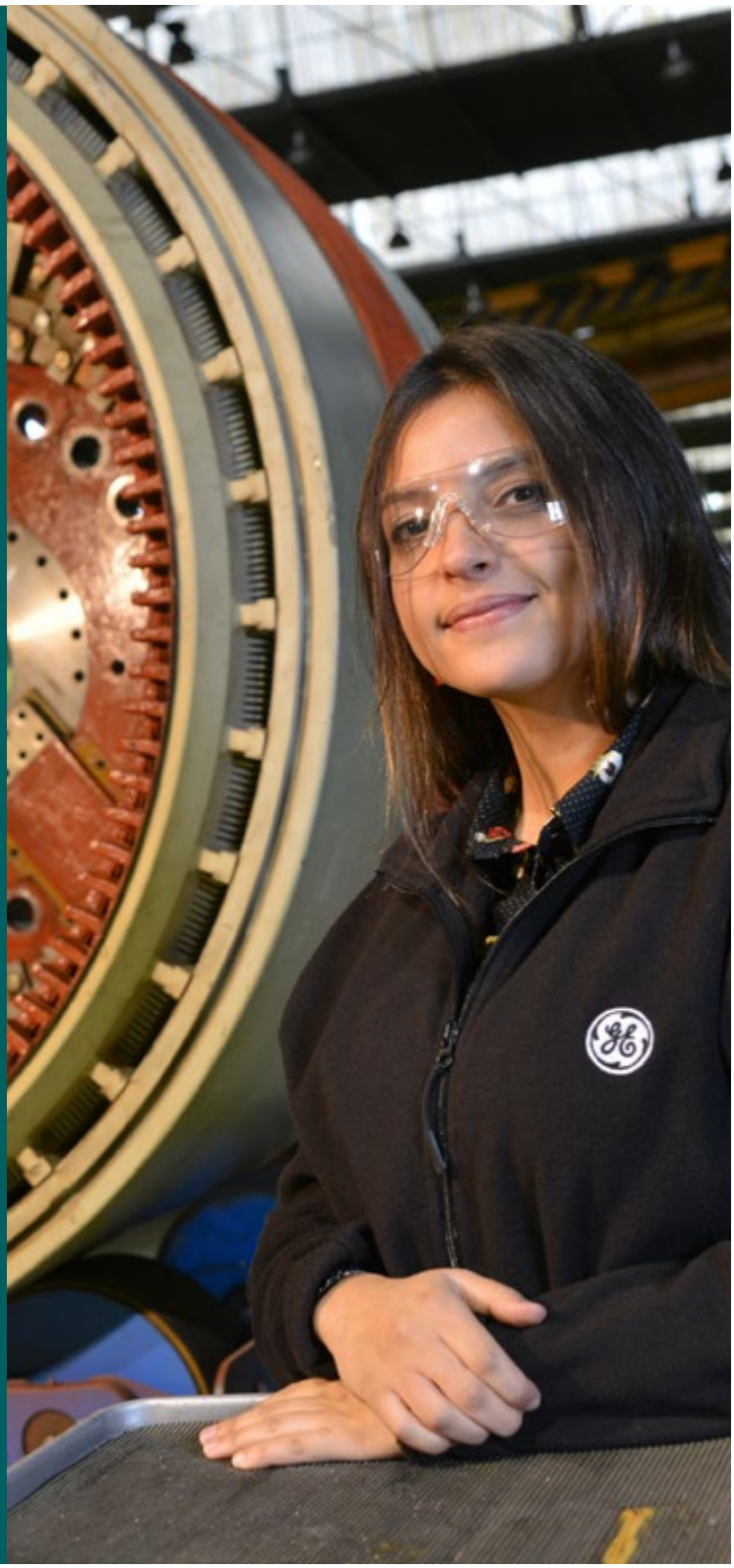
RUN TO RETIRE

ASSET MANAGEMENT

Are you seeking a cost-effective run-to-retire maintenance strategy?

Are you planning a post retirement strategy for your major rotating equipment?

GE Vernova's Steam Power team can help you get the most out of your retiring unit.



BACKGROUND

As your steam turbine/generator units age, you may decide to reduce capital investments in the maintenance and restoration of these power generating assets. This strategy may make economic sense in the final stages of operating life. However, trying to get final returns out of your investment also involves increasing risk levels. It's important to know the risks involved with this strategy, and then decide on a suitable approach to manage these risks. GE Vernova's Steam Power team has a number of offerings that can support you with decision making and risk management across your steam turbines, generators, and directly connected auxiliary equipment.

HEALTH ASSESSMENT

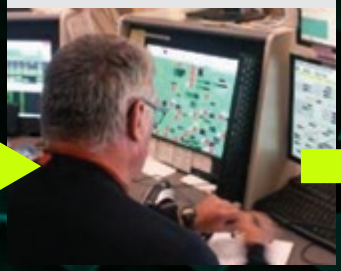
- Evaluation of current health status and risks for the planned remaining operating period
- Recommendations and options to cover remaining operation period

Run to Retire OUTAGE

- Component condition assessment for identified high-risk areas
- Life extension measures: repair or replace options
- Upgrades to adapt to changes in market conditions

RISK MANAGEMENT

- Continuous or periodic monitoring
- Support with operational issues or unexpected outages
- Spare parts strategy support



ASSET CONVERSION

- Re-purpose of Equipment
- Consulting studies

HEALTH ASSESSMENT

As a starting point to define a strategy, it is important to develop a good understanding of the unit's present condition, its expected remaining life, and the ways to manage the remaining expected operating period. Steam Power has a number of options to support you in this process.

Risk-based Health Assessment

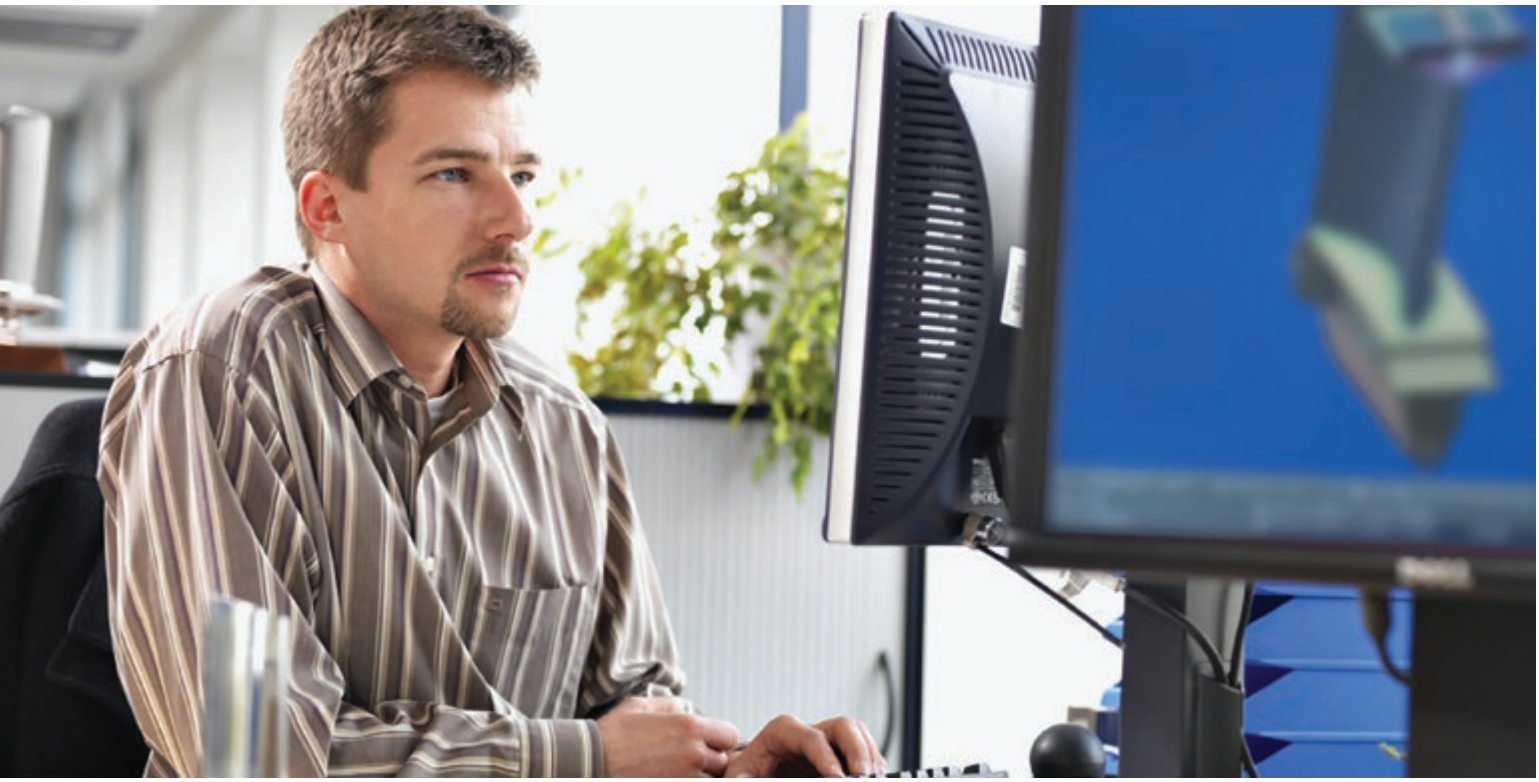
This offering is based on Risk-based Inspection (RBI) methodology, which is gaining popularity in many industries. RBI is a consistent decision-making technique, that uses risk as a proxy for "asset condition," to define the details of the different activities in an asset management plan.

The assessment combines fleet expertise in the form of proprietary risk models with a systematic, unit-specific review of historic operational data, findings from inspections, and feedback from the O&M team. The analysis reviews the drivers and presence of known degradation mechanisms and then proceeds to use these insights to identify solutions to manage lifetime-related and operational risks. The result is an overview of the unit-specific risks with recommendations to manage them.

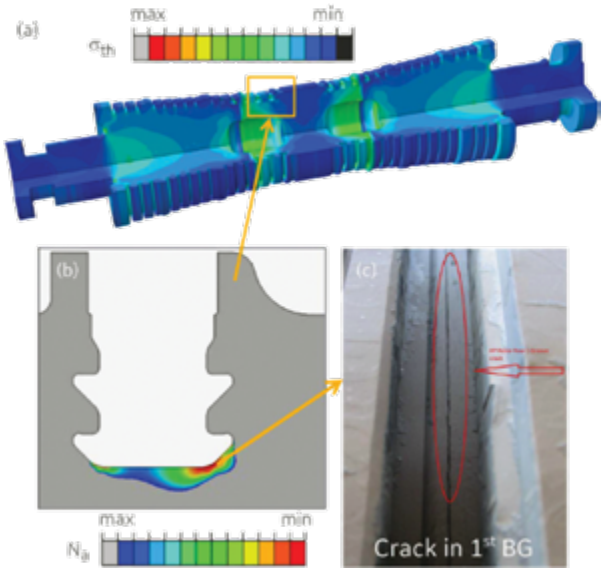
Engineering Studies

Some cases may require performing additional, more detailed engineering studies to gain the insights needed to decide on the preferred asset life strategy. Examples include:

- **Steam turbine residual lifetime calculation:** Creep and fatigue life assessment for high-temperature turbine components
- **Root cause analysis:** Engineering study to investigate the cause of unit-specific issues



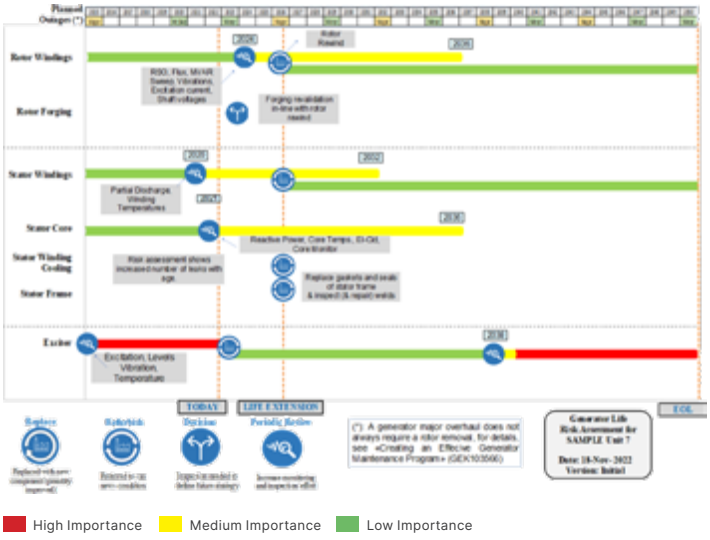
EXAMPLE: ST Rotor Residual Lifetime Calculation Assessment



Changes to the operating profile often lead to an increase in life consumption. It is therefore important to assess the actual steam turbine rotor life consumption in a remaining lifetime assessment (RLA). This will help ensure safe operation and improvement of the the maintenance program's effectiveness. The RLA is recommended to be performed every 100,000 EOH (equivalent operating hours). At left is an example depicting the location of the crack in a blade groove that was predicted by an assessment.

Finite Element Analysis- Impact of transient operation on the first blade groove

EXAMPLE: Risk-based Health Assessment



Lifetime planning overview

What can you do if a unit is more than 50 years old, planned for retirement, and the load dispatcher requests an operating extension of another 5-10 years? Steam Power recently performed a risk-based health assessment for a generator in this scenario.

The assessment started with a systematic review of historic operational data, information from inspection reports, and experience of the on-site operations team. The insights generated from this analysis, combined with the quantitative risk models derived from Steam Power-installed base experience, then are used to perform a lifetime risk analysis for the extended life period. This analysis shows the evolution of the risk levels for the main subsystems over time, which helps to define where and when component repairs or replacements are needed to cover the required operation period. Examples of such activities are generator stator rewinds, exciter slip ring machining, or inspections of the rotor forging.

RUN TO RETIRE OUTAGE

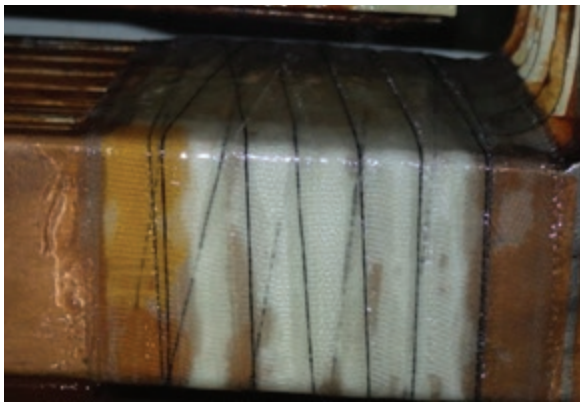
Once the asset management strategy is defined, an Run to Retire outage may be required.

In addition to the standard core services where parts can be replaced or reconditioned, this last major planned outage may include:

- **Component condition assessments for identified high risk areas:** Some high-risk areas may require additional information from a specific inspection or test with the unit off-line to finalize the asset risk management strategy. Examples include electrical tests on the generator and specific non-destructive testing (NDT) for the steam turbine.
- **Life extension or obsolescence management:** Where the health of the components is insufficient to reach the end of life, life extension measures will be required. In cases when it's not economical to replace the components with new ones, Steam Power can provide repair options that will restore the unit to a condition sufficient to reach the expected retirement date.
- **Upgrades:** Modifications may be required to benefit from new market conditions. For example, "Keep warm/ stress control of machining" for improved cycling capabilities when operational flexibility is needed.

EXAMPLE 1: Generator Rotor Winding Short

Deformation and reduced clearance, because of coil displacement, were observed between coil 2 and 3. To avoid an inter-turn fault, temporary repairs allowed for continued operation without the need for a complete rewind. This type of solution is not as extensive as a rewind, thus requiring some additional inspection.

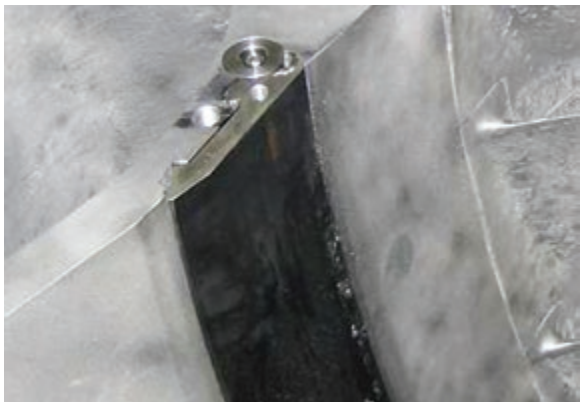


Glass tape painted with resin data pole

EXAMPLE 2: LP Turbine Diffusor Erosion Ring

A steam turbine unit suffered erosion in casing between L1 and L0. Instead of replacing the complete inner casing, an erosion ring was installed to fix the eroded area.

Steam Power offers a complete range of solutions, from a complete replacement, to the installation of a new ring, to a temporary repair of the eroded area.



New ring installed in existing casing

EXAMPLE 3: Auxiliaries

Older power plants' auxiliary systems may require a solution to ensure safe and reliable operation until the plant is retired. Challenges include lack of spare parts due to obsolescence and no immediate possible alternatives, lack of expertise to maintain these older systems, or EHS issues that were not considered at the time of the original design.

Steam Power has helped operators find a replacement for failed obsolete parts. Typical examples include: solenoid valves or EHC units for the operation and control of the steam inlet valves, lube oil extractor fans, gland steam system control valves, lube oil conditioner systems, and jacking oil pumps.

Although these older systems often no longer comply with today's EHS requirement, safety should remain a top priority, even during the final years of operation. A typical example is the implementation of a remote-controlled emergency release system for the generator's hydrogen gas system. This improvement will keep personnel away from the danger zone when hazardous situations arise.

Obsolete auxiliary skid

New and upgraded auxiliary skid

RISK MANAGEMENT

During the final operational phase, the asset management strategy may require specific risk management measures to address any remaining areas of increased risk. Our team has a number of offerings to support proactive or reactive risk management.

TEAMS Inspection

Periodic review by a Steam Power engineer with the unit in operation:

- Turbine evaluation, analysis, and maintenance scheduling program
- Includes a walk-down, a review of the operational data, and interviews with the site staff

Condition Monitoring

Proactive, continuous, or periodic monitoring of the operational parameters using software:

- **Monitoring and Diagnostics:** Review of operational data from standard instrumentation for anomalies and trends of leading indicators
- **Steam Turbine Health Monitoring:**
  - Valve and actuator monitoring system for turbine steam inlet valves
  - Turbine torsional vibration adviser
- **Generator Health Monitoring (GHM):**
  - Partial discharge
  - Rotor flux
  - End winding vibration
  - Rotor shaft voltage
  - Stator temperature
- **Stator Leak Monitoring System (SLMS)**

Spare Parts

We can provide spare part solutions to support the management of specific risks such as obsolescence.

Rapid Reactive Reliability Support

Agreement with GE to provide fast reactive support in case of operational issues or for rapid mobilization and recovery support during forced outages.

EXAMPLE 1: Generator Health Monitoring

A plant with three operating units was beyond the expected life of the winding but had only a few more years to go until retirement. Therefore, it was decided not to perform a rewind, but to purchase one spare rewind kit, and install generator health monitoring (GHM) software on all three units. The monitoring system would give advance warning, allowing for the preparation of a site rewind with existing copper, if required.

EXAMPLE 2: TEAMS

Customer Voices:

"Many owners have older units like we do, and the real value of a TEAMS inspection is that an outside set of eyes can look at the unit and find issues that can impact reliability."

— Turbine Technology Leader, U.S. plant

"Not only did uninterrupted TEAMS inspections provide valuable 'ammunition' in those annual 'battles', but they proved critical in several instances involving risk-based analysis and decision making and comprehensive major outage planning."

— Reliability Engineer, U.S. plant

EXAMPLE 3: Rapid Reactive Reliability Support: On-Site Minor Intervention

The customer called the hotline because of a sudden vibration increase at the IP turbine.

Our FAST team in Germany analyzed the vibration data, and a sudden mass loss was confirmed by the trend assessment. Based on the risk analysis, further operation could be ensured, while borescope inspection was prepared. During the borescope inspection, all blades were found in place, but after reviewing the latest balancing report a missing balancing weight could be detected. This weight had been unlocked by a third-party company during an outage. The same day a weight was provided, adapted, and installed by Steam Power.

The unit was back online the next morning.

ASSET CONVERSION

When approaching retirement, Steam Power can help you with the assessment and planning of the conversion of your assets.

Re-purpose of Equipment

We can provide solutions for repurposing of equipment through modifications or for using them as spares. We recently supported a coal operator in Germany to modify a decommissioned steam turbine low pressure rotor, repurposing it to be installed on their operating unit. Our team adapted the rotor to the new site's dimensions by removing its coupling and shaft end, and welding on a new stub shaft. This project enabled our customer to save time and a significant amount of investment in a new rotor to continue operating through the latter stage of their planned life cycle.

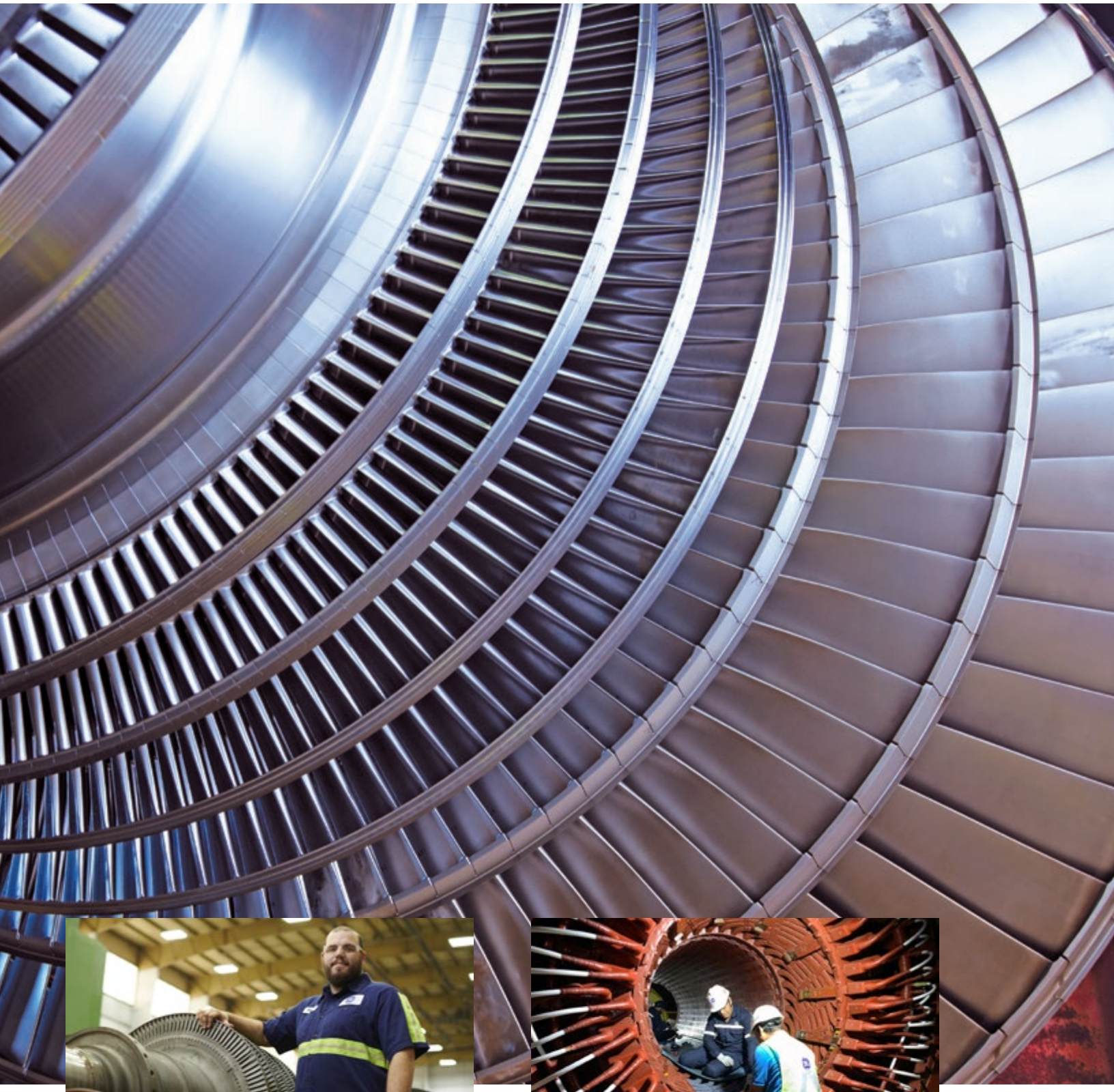
Consulting Studies

Our Consulting Services team delivers power systems engineering and economic consulting services, providing solutions to the electric power industry's most pressing challenges. Our services advance and enhance electric power systems so they perform with greater affordability, reliability, and efficiency while supporting you with the assessment of conversion plans.

Example of Consulting Studies

Consulting Services has experience in delivering studies and assessment such as:

- Investment plans for coal plant generators in retirement, upgrades, and new builds
- Economic evaluations for investments in existing and new renewable and thermal power plants across Europe
- Techno-economic studies for an integrated wind, solar, and energy storage project
- Validation of wind project system design, reliability, and compliance with the applicable grid codes
- System studies for condensers



For more information, contact your Steam Power sales representative at:
https://www.ge.com/power/services/steam-power-plants

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