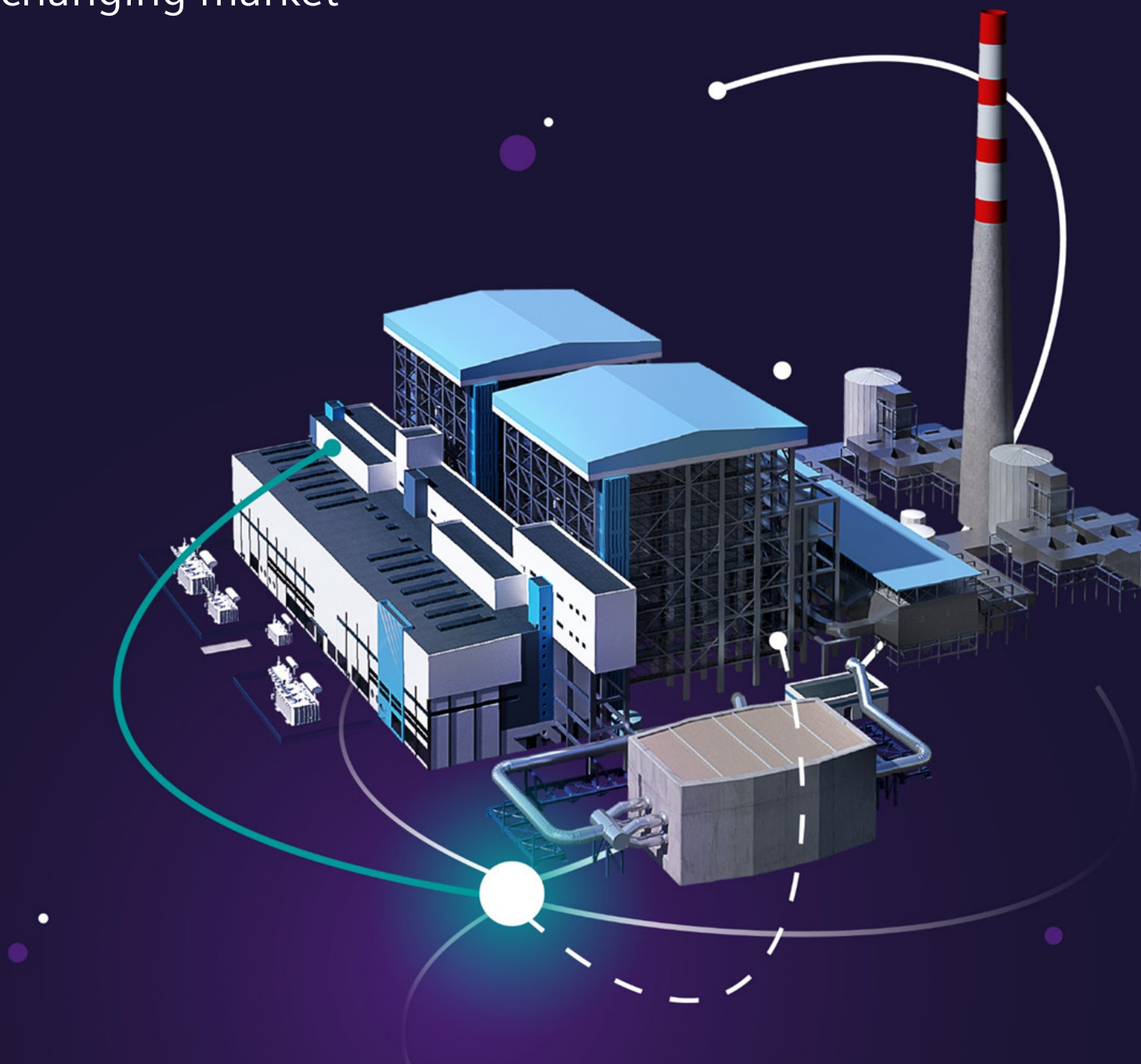
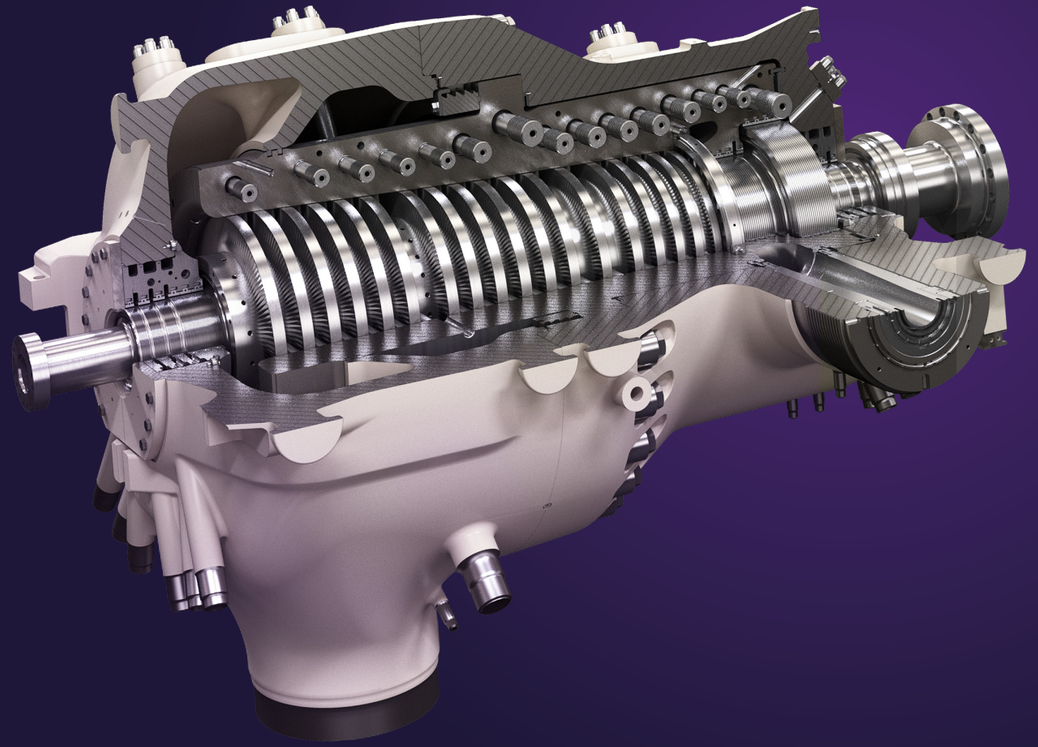
SIEMENS energy

Steam plant modernization

Options for mature power plants in a changing market



Make your steam plant as clean and profitable as possible.



The energy market is transforming with more and more renewable energy sources entering the power generation landscape such as wind, water and solar power. This more diverse power generation mix combined with ageing equipment can lead to some SPPs (Steam Power Plant) not being properly matched with current or upcoming market demands.

For example, several mature SPPs were originally planned to operate in base load while they now need – or will have to – operate in part load.

- Lifetime extension up to 30 years
- Highest attainable availability and reliability
- Plant output improvement up to 10%
- Optimization of part load efficiency
- Carbon footprint reduction up to 1.5Mio tons CO_2 per year in combination with boiler and steam turbine modernization
- Improved flexibility such as capability for low load operation (<30% load) and up to three times faster ramp rates
- Additional efficiency boosting by steam admission and reheat temperatures up to 610 °C
- Turbo set efficiency improvement up to 4% points (up to 5% points with balance of plant optimization)

Carbon footprint reduction

How to adapt in a changing energy market?

Modernization solutions may help not only extend the lifespan of SPPs but also strengthen competitiveness by addressing new requirements from the changing energy market, like enhanced power plant flexibility, improved heat rate and reduced CO_2 emissions.

We can perform a technical plant assessment to evaluate the current demands on your plant and develop specific solutions tailored to your needs.

The key components which contribute the most to reliability, availability, performance, and efficiency, such as heating surfaces of the boiler and the blade path of the steam turbine, are evaluated and, where possible, optimized. In addition, digital solutions to improve plant performance and availability can be applied.

These solutions are based on extensive OEM (Original Equipment Manufacturer) domain knowledge and decades of O&M (Operation and Maintenance) experience.





Modernization of steam power plants

Solutions tailored to your needs.

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Steam turbine modernization and upgrade

We typically recommend performing a LTE (Lifetime Extension) as a starting point for mature units. A LTE study requires specific knowledge about the unit such as operating regime and service history.

Our specialists perform various investigations such as advanced NDT (Non-Destructive Testing) and FEM (Finite Element Analysis) based on their domain know-how.

The LTE study then provides recommendations for repair and replacement to extend the lifetime of an unit or specific components and helps in developing tailor-made and economic upgrade solutions such as modernization. A steam turbine modernization typically includes the replacement of key components of mature units with state-of-the-art design enhanced components such as highly loaded rotors, casings, blades, seal elements and valves – see Figure 1.

Besides an efficiency and power increase, a steam turbine modernization can be a good opportunity for implementation of flexible operation solutions such as faster start-ups, fast load changes and economic part load operation during low load periods of SPPs. Unit specific optimizations, including steam turbine swallowing capacity adjustments because of BoP (Balance of Plant) optimizations, can also be implemented.

Dependent on customer requirements, a partial arc configuration based on operating mode and boiler capabilities can be implemented.

Exchange concepts such as HP (High Pressure) barrel turbine replacement can also be an option which may help to shorten the duration of the steam turbine major overhaul.

Being in the field of modernizing steam plants for decades has made our specialists experienced in knowing the essential requirements relating to clean and sustainable power generation.

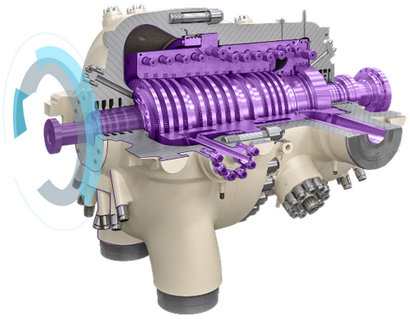


Figure 1: Typical overview of ST modernization

Benefits of advanced steam turbine technologies

- Optimized blade path efficiency through three-dimensionally designed blades with reduced secondary flow losses
- Application of modern computational fluid dynamics and FEM tools
- Partial arc configuration based on operating mode and boiler capabilities
- Implementation of flexibility solutions like faster start-ups
- Proven blade attachment techniques for both the rotating and stationary blade row can help to reduce vibratory stresses, high cycle fatigue and the stress concentrations
- Erosion mitigation features such as hardened leading edges of the LP (Low Pressure) turbine last stage moving blades, improved materials, and coatings
- Moisture removal features such as hollow last-stage stationary blades with either suction slots or a heating system to reduce water droplet erosion
- Advanced sealing technologies, to further improve blade path efficiency and reliability





02

Steam turbine full element replacement

The FER (Full Element Replacement) approach targets a steam turbine modernization by replacement of existing mature equipment with the current Siemens Energy steam turbine technology. Besides components such as the rotor and casing, which are replaced for a typical modernization, a FER includes turbine, valve and bearing outer casing. This eliminates the need for inspection of the outer casing and the effort associated with the integration of internal components to the existing outer casing. Additionally, there are no package space restrictions in designing the blade path. A FER concept may have advantages especially for the upgrade of other-OEM steam turbines.

03

BoP optimization for part- and low load operation

During periods of low electrical demand, the SPPs should have the capability to operate at their lowest load ranges to increase revenue potential and maintain or reduce the unit's carbon footprint.

The achievable lowest load ranges of coal fired SPPs can depend on several factors, such as fuel conditions, combustion system design and flue gas temperature restrictions.

If flue gas temperatures during part and low load are too low, unstable pulverized fuel combustion may occur, and the boiler may have to be switched from coal to oil or gas operation to achieve flame stability for proper catalyst system effectiveness to avoid exceeding any emissions restrictions.

A stabilization of the flue gas temperature can help to avoid such fuel changes of the boiler during low load periods. This can be achieved through implementation of an additional feed water preheater.

04

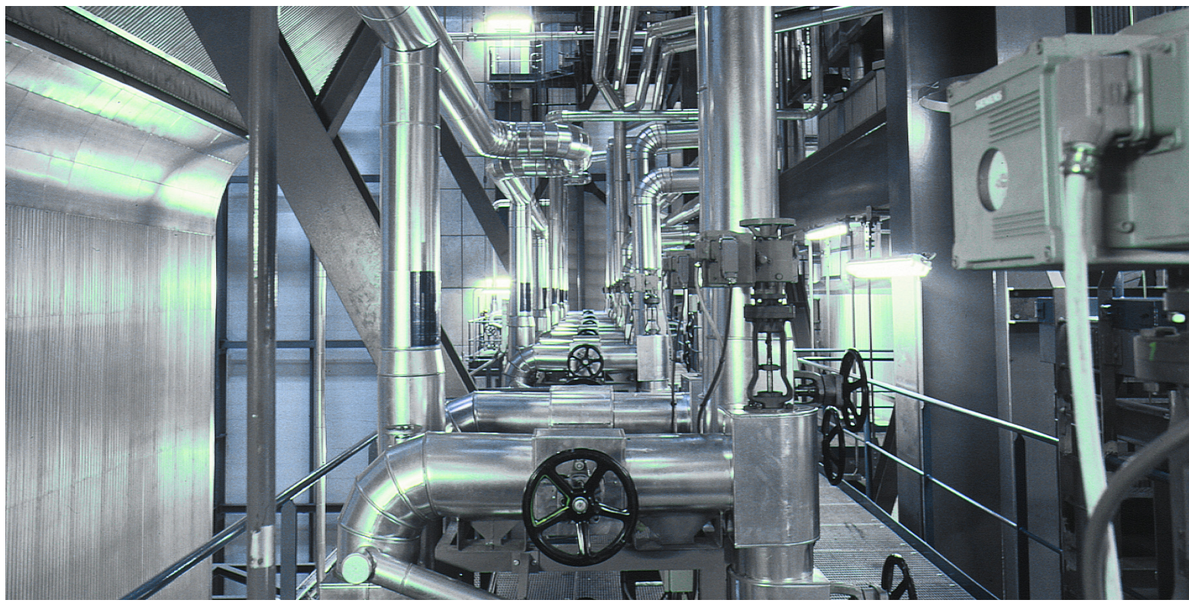
Boiler optimization

The boiler combustion system can be optimized to allow certain minimum loads with sufficient flame stability. Additional modifications can be performed to allow higher flexibility of the boiler operation (e.g. ramp rates). In order to address emission considerations, the economizer system has to stabilize flue gas exit temperature during part load operation with proper DeNOx (nitrogen oxide reduction) efficiency.

Further, restructuring and redesigning of the thermal profile of the heating surfaces can be performed to increase the main steam and hot reheat temperature. Finally, a fatigue stress analysis for relevant components is performed followed by a lifetime evaluation. Digital solutions using APC (Advanced Process Control) and AI (Artificial Intelligence) for example, a combustion optimizer or soot blower optimizer, can be added to help reduce NOx (Nitrogen Oxide) emissions or further increase plant efficiency.

Innovations that fit your needs!

Existing thermal storages, especially in the preheater part of the plants, can be used for further flexibility or efficiency increases, for example, through implementation of automatic "Condensate Throttling".





05

Generator modernization

We can provide several options to help increase your generator's reliability, availability, and flexibility. Our rotor modernization portfolio includes rotor rewinds, seed rotor concepts, replacement rotors, retaining ring replacement or rotor reliability and availability improvement packages. A potential modernization of the generator stator can include stator repair and partial refurbishment, stator rewind, stator core replacement, stator replacement or stator slot re-wedge. Diagnostics solutions for reliable online monitoring, predictive maintenance and digital data analysis for generators and high voltage equipment, such as the modular GenAdvisor™ system, can also be implemented. The modular products and services of our predictive maintenance or on-line monitoring systems can allow flexible configurations to provide tailored solutions.

06

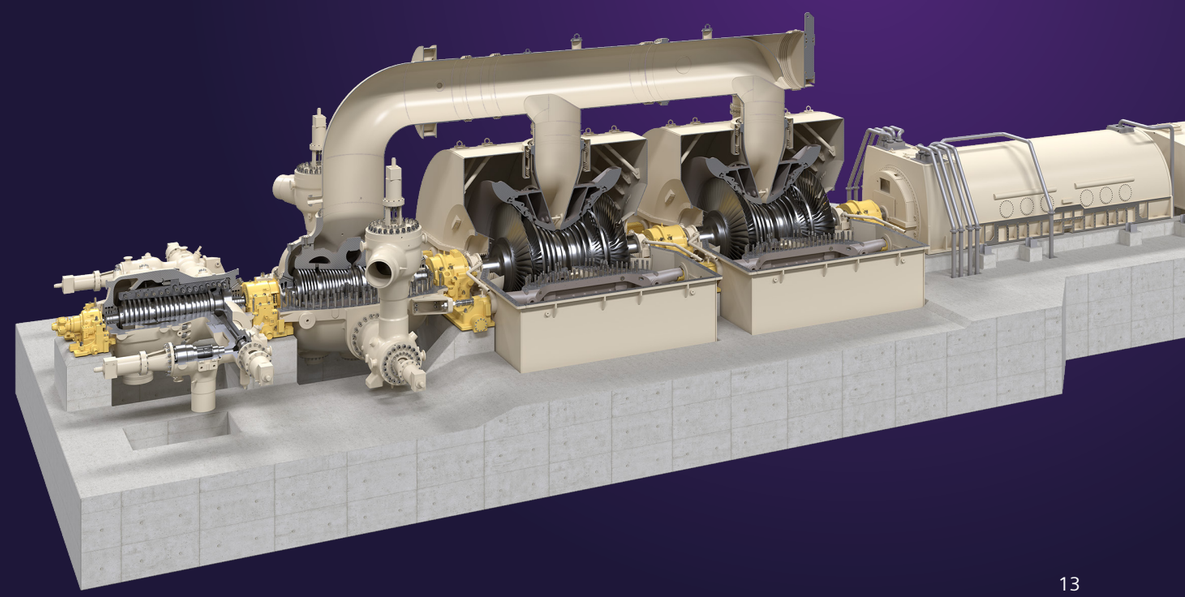
Steam turbine control upgrade

Most of the measures require changes in the automation system of a SPP. Depending on the age and compliance of the existing control systems with current standards, such as those for cyber security, these changes can be implemented as additions to the existing control system(s) or in a new state-of-the-art control system.
Various monitoring solutions and managed service options using digital twins are available to help customers retain achieved thermal performance and availability improvements and provide early warnings in case of deviations from the pre-defined expected behavior. As part of the plant modernization, steps towards autonomous operation and maintenance of the SPPs or integration into a virtual power plant can be implemented.

Your economic viability

Modernization of mature steam turbines may help to improve competitiveness by:

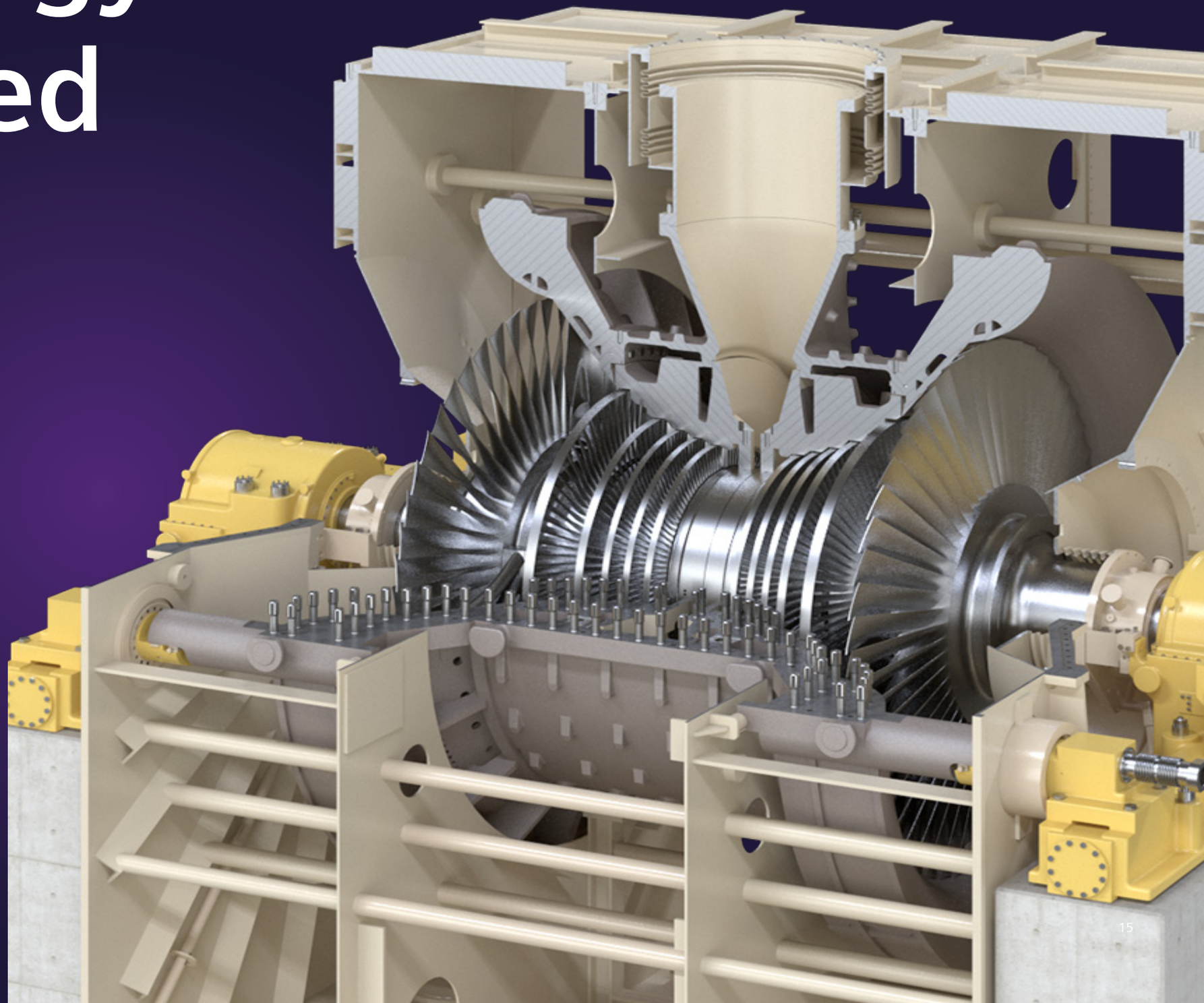
- Shortening outage duration of ST major overhaul
- Regaining efficiency losses due to degradation
- Plant output increases up to 10% in some cases through unit specific optimizations
- Reaching potential ROI (Return on Investment) for the modernization in a more rapid time frame
- Reduction of fuel consumption of the unit up to 4%. (up to 5% with BoP upgrade)



Technology developed for your needs

Designed and validated for high performance.

We have continued to invest in research and development for steam plant modernization technologies. We maintain a vast database of design knowledge and application information from our role as technology provider.





Quality assurance

With a proven track record.

We involve our customers in our quality assurance process which includes several customer witness points. These regularly scheduled witness points are conducted from an initial plant assessment study through project development and work at Siemens Energy plant until final implementation at site.
From the bid preparation phase until power plant commissioning, we have a strong project management competency with appropriate quality gates including readiness reviews.

Our project managers are also experienced in supplier selection, order and change management.

Plant assessment study → Project development and processing → Final implementation

Qualified field service competence

Our specialists are located in strategic hubs around the word and provide qualified and committed on-site competence for extensive projects.

Siemens Energy TMS (Total Maintenance Service) process provides assistance for optimized outage planning.

Our field service specialists work very closely with on-site staff in defining the project scope and operational assessments for implementing upgrades and product modifications.

Factory in the field – On-site machining

All field service activities are performed to the highest environmental, health and safety standards. Safeguarding employees and the environment at all times is an integral part of the Siemens Energy Zero Harm culture.

Our specialists can support field service requests worldwide as many Siemens Energy on-site machining services are practically like having a factory in the field.

Outage times can significantly be reduced with the help of the Siemens Energy portable equipment where our specialists can perform these tasks at site. In many cases, this can be much faster than shipping components to factory for repair. Our advanced on-site machining capabilities can also be used for the adaptation of the modernized components to the existing ones, such as final fixing of a new blade carrier into the existing outer casing.





Innovative on-site repair capabilities

On-site wire arc additive manufacturing

WAAM (Wire Arc Additive Manufacturing) is a wire based fusion manufacturing process. Instead of powder a wire is used melted by an electric arc. On-site WAAM includes layer by layer (metal) deposition and is particularly suited for larger components. Based on findings, it can be used for wall formation or for simultaneously cladding two materials in order to form a composite structure.

WAAM is a fast and cost-effective on-site repair method to avoid long lead times and high investments.

We have applied this repair method in numerous applications. This technique enables the cost-effective on-site repair of various steam turbine components.



Coal-to-gas shift

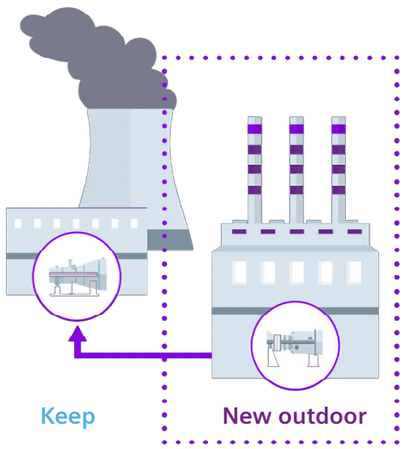
Repowering options for legacy power plants

Repowering an existing plant can range from a simple boiler conversion from coal-to-gas firing to so-called “topping”, “booster”, “parallel repowering” and finally “full repowering”, whereby not only fuel is changed from coal to gas, but a power plant is converted into a highly efficient combined cycle power plant.

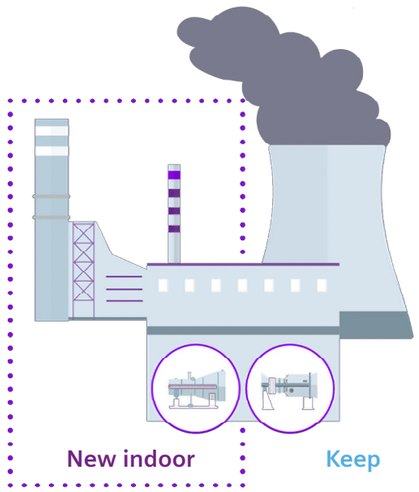
The potential business case could include lower investment cost, reduced permits, shorter implementation time, and reusing existing grid connections and other physical and social infrastructure already in place. Moreover, these repowering transformations can be designed to incorporate technologies, such as energy storage, energy conversion or carbon capture, all of which are intended to help achieve zero carbon emissions at the end of the transformation journey.

Over the past 20 years, several large-scale projects around the globe have proven to be technically and commercially sound.
We can offer guidance and expertise to help you make an informed decision on the future of your assets.

Brownfield repowering by **supplemental outdoor** approach



Brownfield repowering by **integrative indoor** approach



Our references

We have decades of fleet experience and a proven track record in successfully performing modernization projects for OEM and other-OEM power plants. More than 300 steam turbines have been successfully modernized worldwide. In addition to our own steam turbine fleet (e.g. KWU, Westinghouse and Parsons), we conducted modernizations on other-OEM steam turbine frames such as those manufactured by GE, MHI and LMZ.

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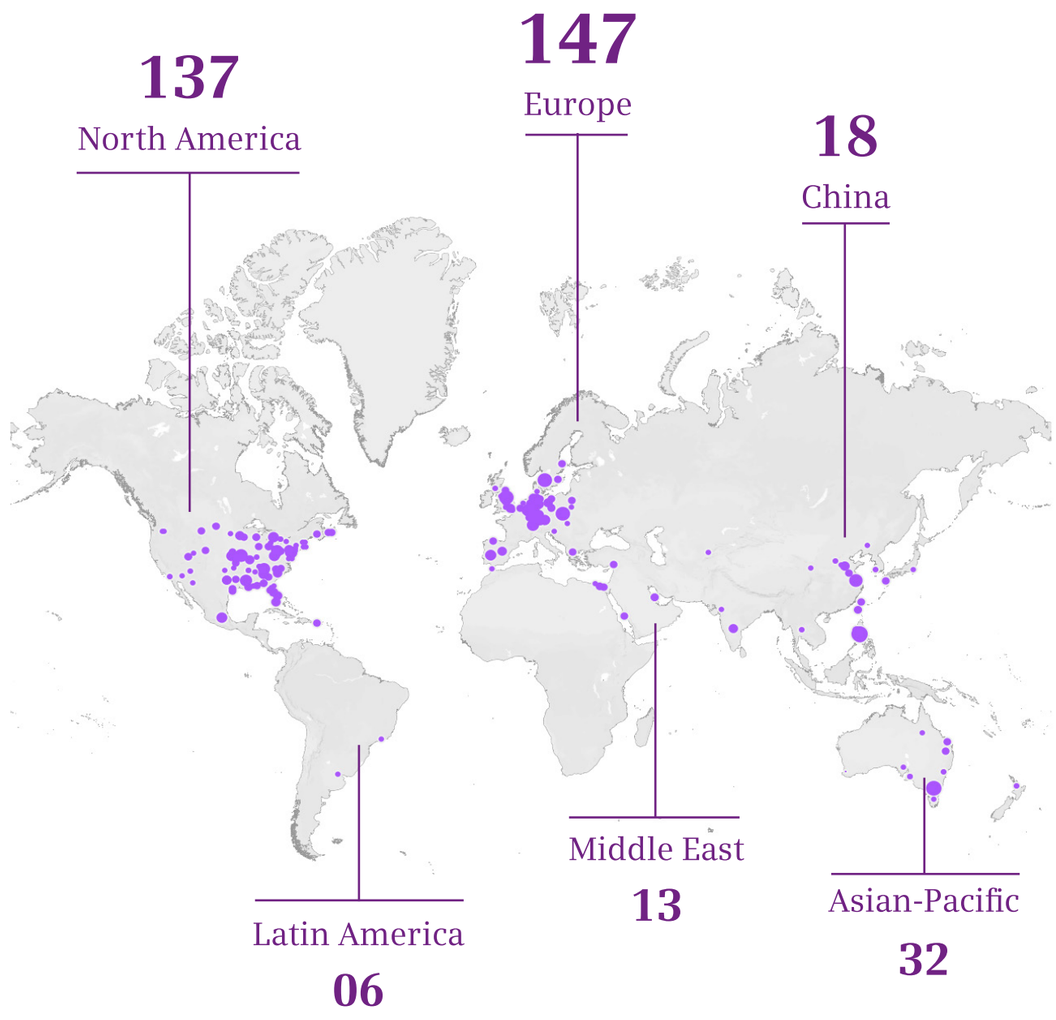
"A recent outage at one of our facilities resulted in significant expanded scope based on identification of fatigue cracking on our LP rotor L-0 blades as well as relatively significant damage to our stator core as a result of core-looseness. The support provided by Siemens Energy to diagnose our issues, evaluate potential causes and operational impacts, as well as developing and implementing repairs exceeded my expectations. As a result of the performance of Siemens Energy, we were able to execute the repair plan and safely return the unit to service in a reasonable amount of time restoring much needed power to the local grid. The unit has been operating since with no issues identified related to our findings."

Waterford 3 Steam Electric Station, Entergy Louisiana, Inc.

agl

„The AGL Loy Yang A power plant has achieved significant increases in performance (MW output and efficiency) by implementing a series of advanced modernization solutions developed by Siemens Energy.These performance improvements were achieved through innovative equipment exchange concepts, which enabled minimization of outage duration, and since implementation, have provided extremely reliable operation. The performance outcomes have exceeded our expectations. Our view is that Siemens Energy is a trusted supplier of service and modernization solutions for steam turbines and generators."

CEO, Loy Yang Power



Are you ready to start?

Our experienced service team is ready to assist you in deciding which solution is the right one for you. With our specialists in engineering, manufacturing, project management and field service in close collaboration, we can offer optimum service solutions for your power plant to match your specific requirements.Please do not hesitate to contact your local Siemens Energy representative for further information.

Visit our Customer Energy Portal cep.siemens-energy.com or our webpage siemens-energy.com.

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