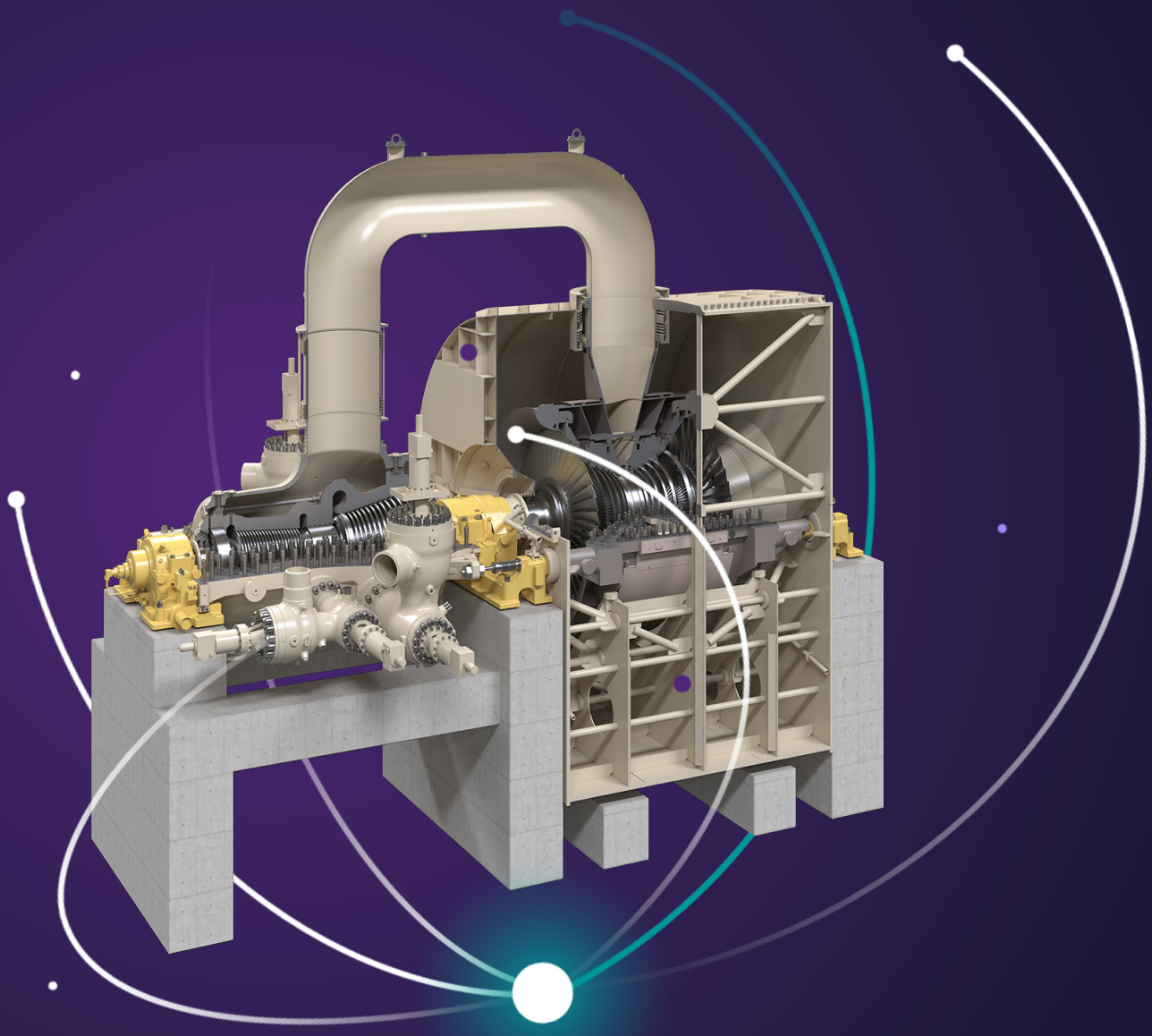
SIEMENS energy

Steam turbine modernization options for CCPP I SST-5000

Your success is our top priority



Optimize your assets and maintain sustainable power plant operation.

The reliability of a ST (Steam Turbine) depends to a large extent on the operational regime of a power plant. The increasing number of renewable energy sources with discontinuous, fluctuating power demand may result in increasing requirements for more flexible power plant operation.

Changes to operating profiles such frequent start-ups and part load operation may lead to increased degradation mechanisms of steam turbines which often have been intended for operation in base-load mode.

Issues affecting major components may occur with increasing operation time and may require extensive repair and/or replacement measures.

Eventually, some mature steam turbines which are intended for longer operation may have to implement major lifetime extension measures such as extensive repairs or in-kind component replacements.

In those cases, the implementation of modernization solutions can often be beneficial as this may also be a good opportunity to improve revenue generation by addressing new requirements from the changing energy market, like enhanced unit flexibility, economic part load operation and transient full load operation.

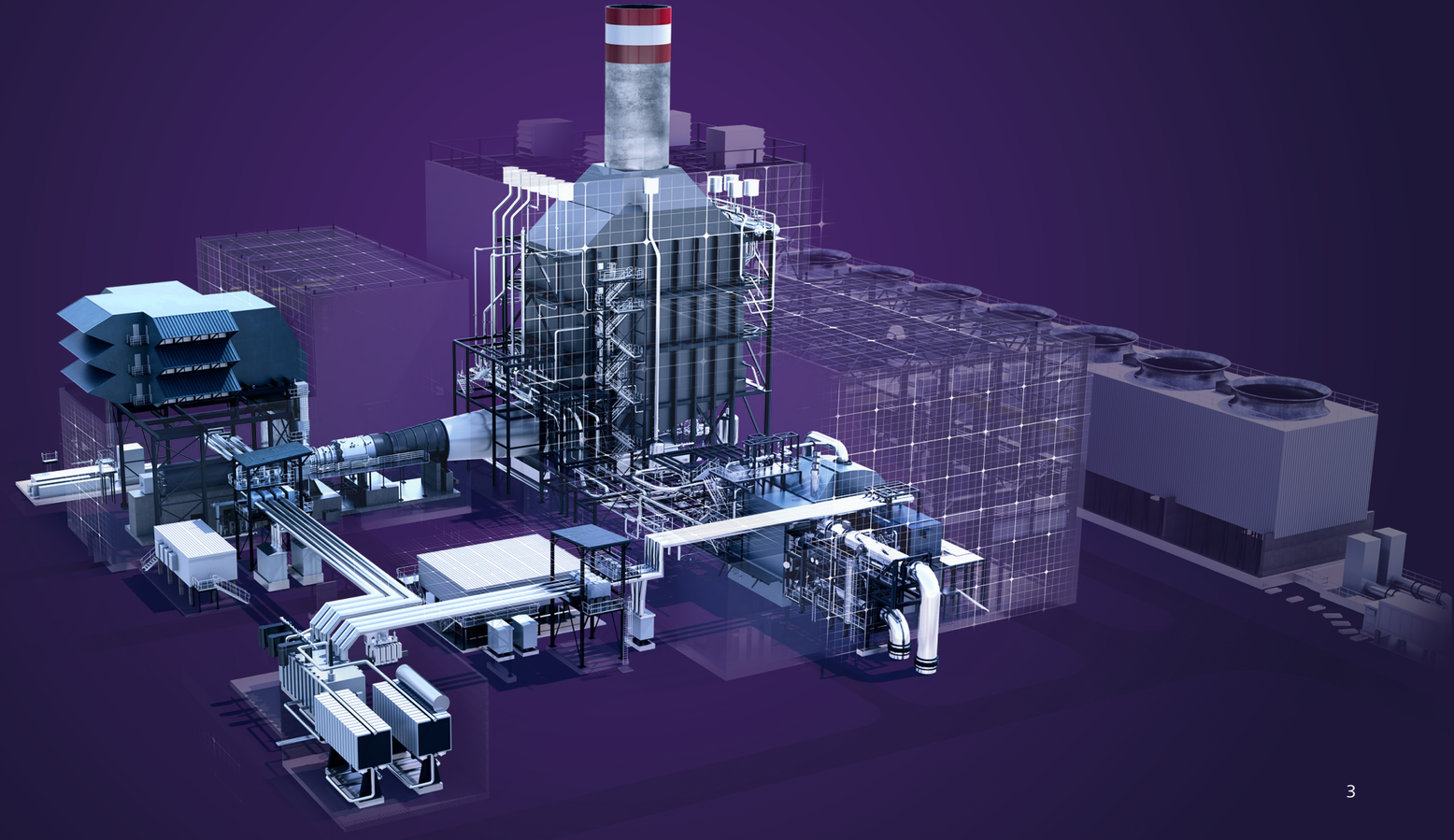
Boosting CCPPs (Combined Cycle Power Plant) power output through GT (Gas Turbine) upgrades may lead to changed thermodynamically conditions such as increased exhaust temperature and pressure. This may present another opportunity for an additional power output increase through steam turbine modernization.

Some power plants were erected several years or even decades ago – and were planned / designed even longer before that according to the market requirements of that time.

Market conditions have changed in many cases and over time we have developed several options to help power plants to better cope with today's requirements in order to help improve competitiveness.

Benefits of a steam turbine modernization:

- Efficiency & performance increase
- Improved flexibility
- Reliability & availability increase
- Emission reduction
- ST adaptation after GT upgrade
- Lifetime extension





Steam turbine modernization

More decades of reliable service.

Modernization measures can be tailored to the individual requirements of CCPPs. We can apply a technical plant evaluation process, including steam and gas turbine, heat recovery steam generator and condenser, to help maximize profitability potential through unit specific optimizations.

Lifetime extension up to 30 years

Highest attainable availability and reliability

Flexible intervals for improved availability

Optimization of part load efficiency

Potential carbon footprint reduction up to 32,000 tons CO_2 per year through GT and ST upgrade*

Improved flexibility such as capability for faster start-ups and increased start-up cycles

Potential plant output improvement up to 12% with both GT and ST upgrade

Overload steam admission for transient base load operation

Regain of losses caused by degradation due to long term operation and related aging effects

Potential ST train efficiency improvement up to 2% points

Service interval alignment GT/ST/Generator

*Calculation based on certain assumptions and conditions which may not be applicable.

Modernization of combined cycle power plants

Custom options to improve profitability.

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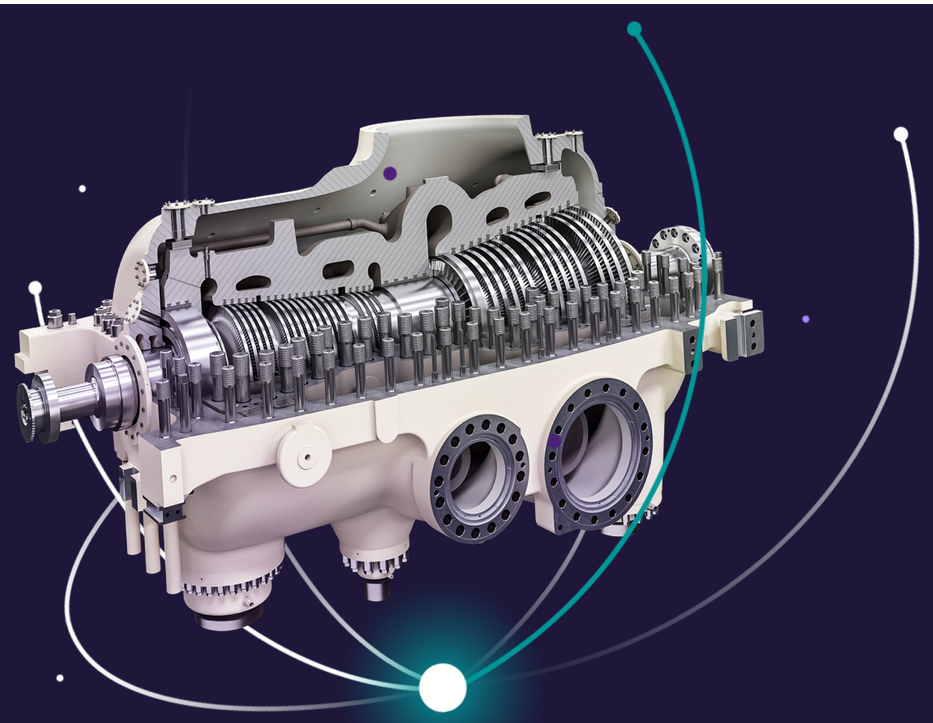
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Expertise you can rely on!

Our specialists can customize concepts to help increase your reliability, availability and flexibility.



01

Steam turbine modernization and upgrade

As a first step, we recommend performing a LTA (Lifetime Assessment) to estimate remaining lifetime and to assess the current condition of the steam turbine.

A LTA may include lifetime extension studies which help provide recommendations for repair and replacement to extend the lifetime of a unit or specific components and helps in developing tailor-made and economic upgrade solutions. This typically considers particular knowledge about the unit such as detailed design features (production documentation), operating regime and service history.

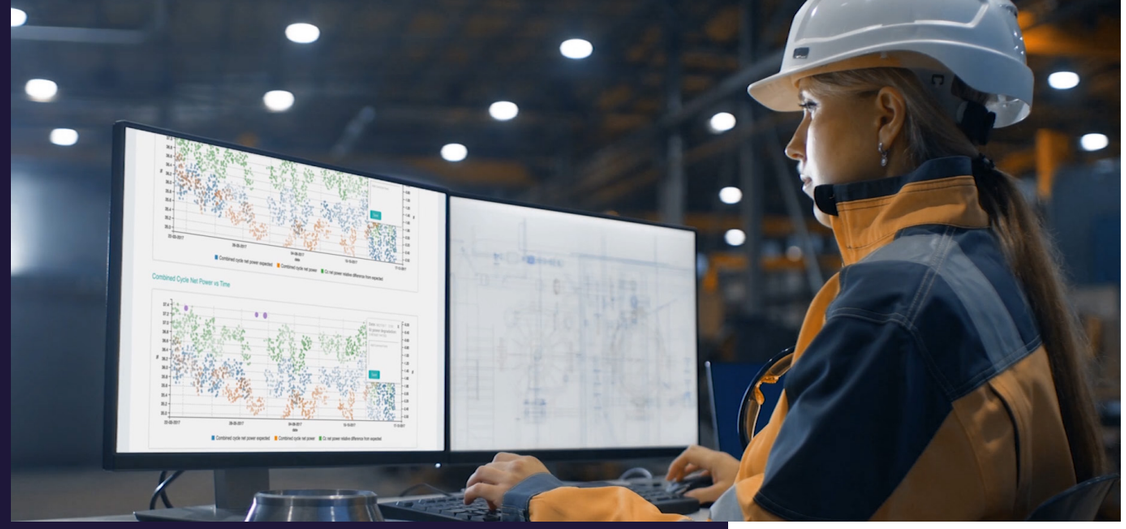
As part of the study, our trained professionals perform advanced NDT (Non-Destructive Testing) and finite element analysis based on their

Designed and validated for high performance.

domain know-how. A steam turbine modernization may typically include the replacement of existing key components of mature units with state-of-the-art design enhanced components, such as highly loaded rotors, casings, blades, seal elements and valves. Those key components help to substantially contribute to steam turbine reliability, availability, performance, efficiency and flexibility.

Flexibility solutions that may often be implemented together with a steam turbine modernization typically include faster start-ups, fast load changes, economic part load operation and steam admission for transient base load operation.

- Optimized blade path efficiency through three-dimensionally designed blades with reduced secondary flow losses
- Implementation of flexibility solutions such as faster start-ups
- Blade fixations for both the rotating and stationary blade row to help reduce vibratory stress, high cycle fatigue and stress concentrations
- Advanced sealing technologies such as abradable seals at balance pistons to help further improve the efficiency and reliability
- Erosion resistance features such as hardened LP (Low Pressure) turbine last stage moving blades, moisture removal features, improved materials and coatings
- Application of modern computational fluid dynamics and finite element method tools
- Optionally, application of shot peening with glass beads to increase blade path efficiency
- Hollow last-stage stationary blades with either suction slots or a heating system to help reduce water droplet erosion



02

Long-term service program

Our FlexLTP (Long-Term Service Program) offers a maintenance program which is based on unit specific requirements.

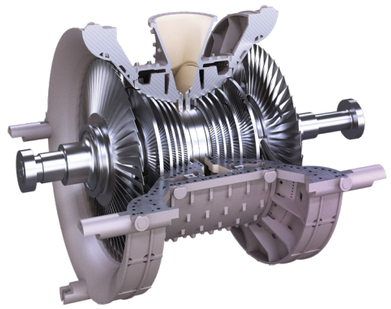
The program may be applicable whether you want to maximize production by extending the duration between periodic scheduled inspections, choose to have your inspections at a time when your plant is already shut down, optimize life-cycle costs by equipment condition-based replacements, or operate without predetermined inspections.

We also offer a CBM (Condition Based Maintenance) program. The CBM approach is intended to trigger maintenance actions on the basis of information from monitoring of the physical condition of components and helps in estimating the remaining useful lifetime of components that are monitored.*

Depending on plant configuration and operational profile, the steam turbine equivalent operating hours may accumulate at a different rate than the gas turbine equivalent base load hours.

We offer flexible outage concepts that may help improve plant availability by aligning steam and gas turbine service intervals.

*May not be applicable for all regions



Cost effective solutions combining modernization and other LTE measures.

This concept typically combines modernization, in-kind replacement, and innovative repair solutions. The current condition, operational outlook, and future operation mode of the equipment all play an important role in this.

Advantages of FlexLTP

Creating solutions that work for you.



03

Technical plant assessment

Our trained professionals conduct an in-depth analysis based on their domain know-how. With the technical plant assessment, we aim to provide a tailored solution for optimization of the operation of your power plant.

According to your specific objectives, recommendations can be provided to help you exploit your plant's future potential and realize your vision.

In general, the technical plant assessment is conducted in three key phases with the support of the global network of our key specialists in engineering, process and plant operations:

Identify.
Evaluate.
Adapt.

Innovative solutions to meet new market requirements.

Identify and define objectives

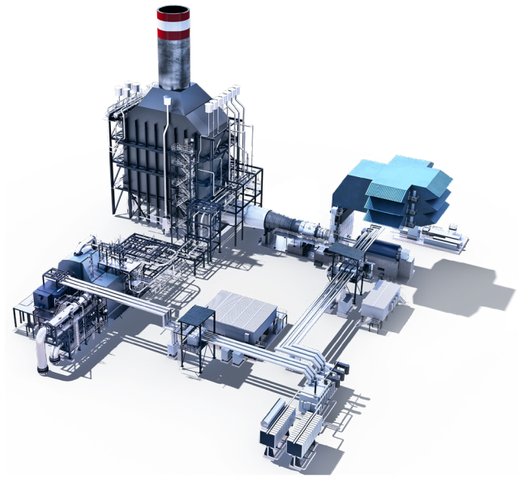
- Development of operational goals, based on your stated value drivers and specific site conditions

Technical evaluation and engineering analysis:

- Remote data collection and site visit
- Analysis of plant baseline condition and assessment of potential operational risks and opportunities

Tailored solution

- Comprehensive final report with optimization recommendations based on the assessed equipment condition and potential for improvements





Boost your plant's output.

up to 12%

CCPP power increase

up to 1.5% points

CCPP efficiency increase

04

Performance upgrades together with gas turbine modifications

Our gas turbine upgrades are intended to improve performance parameters of CCPPs such as power output, efficiency, and operational flexibility. Depending on the gas turbine frame, the CCPP efficiency may be increased by up to 1.5% points and the power output may be increased up to 12%.

As very often gas turbine upgrades lead to changed thermodynamical conditions in the exhaust area, it is beneficial to assess the possible addition of a steam turbine upgrade to help maximize the benefit.

We can perform an in-depth evaluation as to whether a modernization of the steam turbine may facilitate an overall improvement of the CCPP.

05

Care about flexibility upgrades?

The Flex-Power Services™ portfolio includes products and solutions as well as studies and assessments to help adapt to changing operational requirements. We develop solutions to help enhance operational flexibility of power plants and its key components.

Flex-Power Services™ may in many cases be provided as a retrofit for our service fleet and may often be combined with other modernizations. Implementation of these state-of-the-art features may help to increase power plant flexibility and retain or improve the competitiveness of the plant in the changing energy market.

Aspects of Flex-Power Services ™

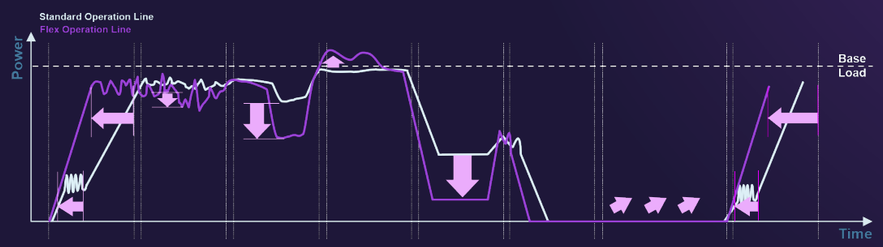
Grid services & Peak power

While on load, upgrades to enhance flexibility can include:

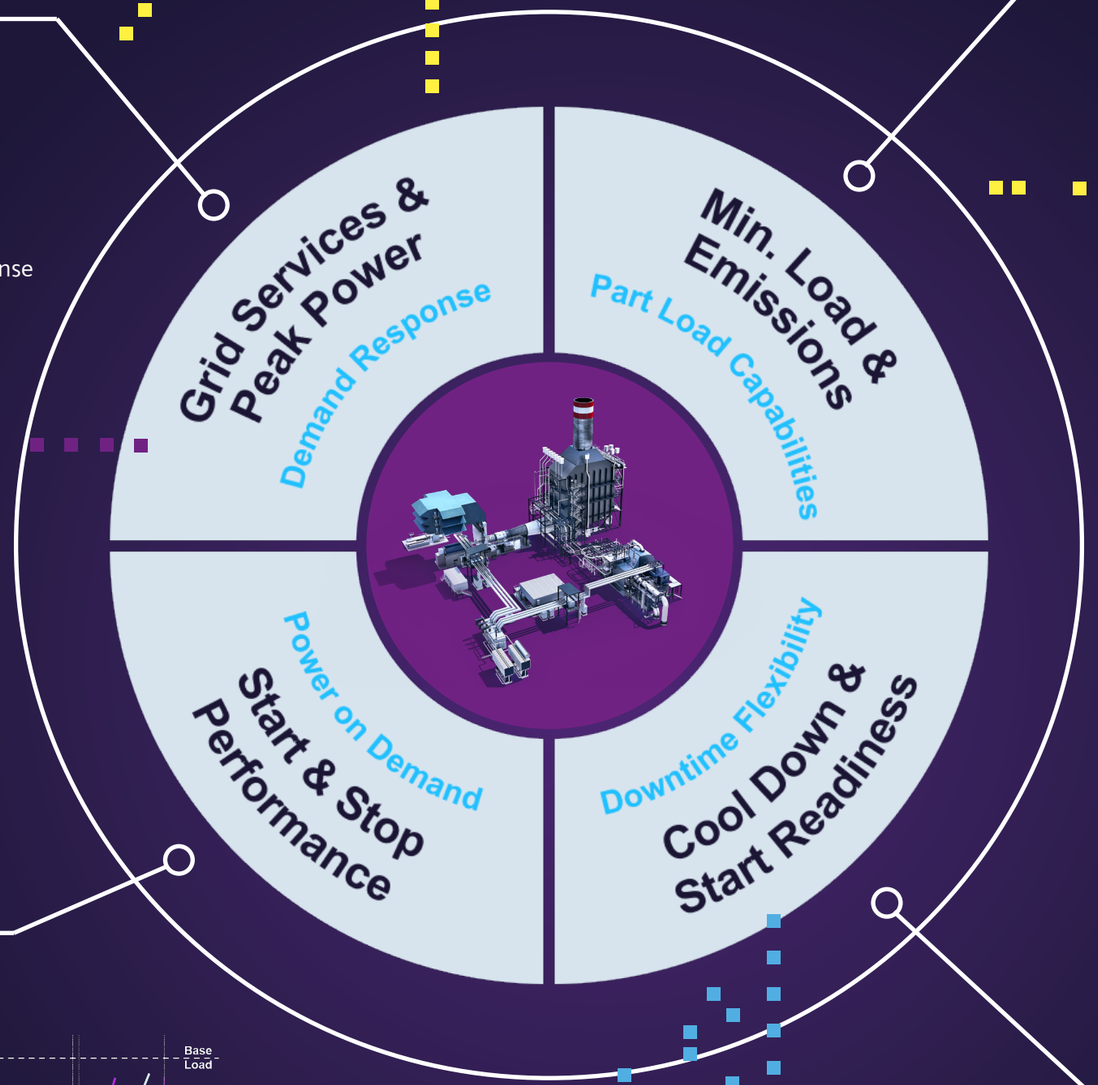
- Grid code studies
- Load following capabilities (e.g. enhanced ramp rates)
- Grid services, e.g. primary and secondary frequency response
- Peak power capabilities

Part- and low load optimization with thermal upgrade

Unit specific optimizations like turbine swallowing capacity adjustments which may be required due to boiler and / or BoP (Balance of Plant) upgrades may also be implemented. The steam temperature level is decisive for the efficiency and fuel consumption of a steam power plant.



Flex Power Services



Minimum part load & emissions

In energy markets with a volatile infeed from various generation sources, power plant operators may find themselves in part load situations for higher shares of their uptime than originally intended.

Enhanced part load capabilities may make a difference in the ability to successfully participate in such generation environment.
Upgrades to enhance part load capabilities may include:

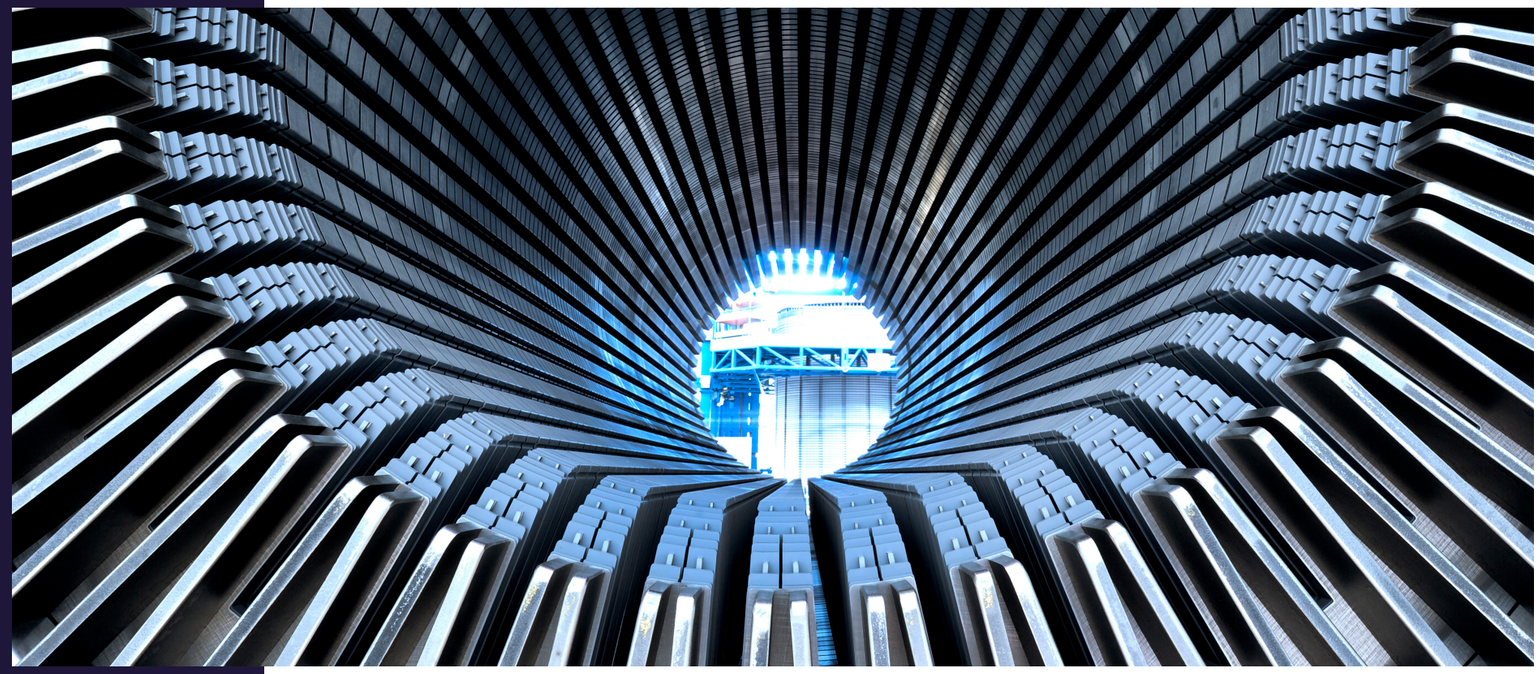
- Reduction of minimum load for gas turbine and/or power plant
- Measures to enhance part load efficiency
- Measures to address / enhance part load emissions

Cool down and start readiness

Advanced preservation concepts and the ability to maintain a plant in a status which allows fast re-start even after multiple days of shutdown may greatly enhance flexibility and support better dispatch success.

Reduced cool-down times may support faster access to components for inspections and repairs, thus supporting shorter outages.

Advanced inspection and interval concepts may help to enhance availability.



Our rotor modernization portfolio includes rotor rewinds, seed rotor concepts, replacement rotors and retaining ring replacement concepts.

Our trained professionals can customize concepts to help increase your generators reliability, availability and flexibility.

06

What about the generator?

A potential modernization of the generator stator may include stator repair and partial refurbishment, stator rewind, stator core replacement, stator replacement or stator slot re-wedge.

We can perform advanced inspection methods for exciter components. Diagnostics solutions for reliable online monitoring, predictive maintenance and digital data analysis for generators and high voltage equipment, such as the modular GenAdvisor™ system which may also be implemented. The modular products and services of our predictive maintenance and online monitoring systems allow flexible configurations to provide tailored solutions.





07

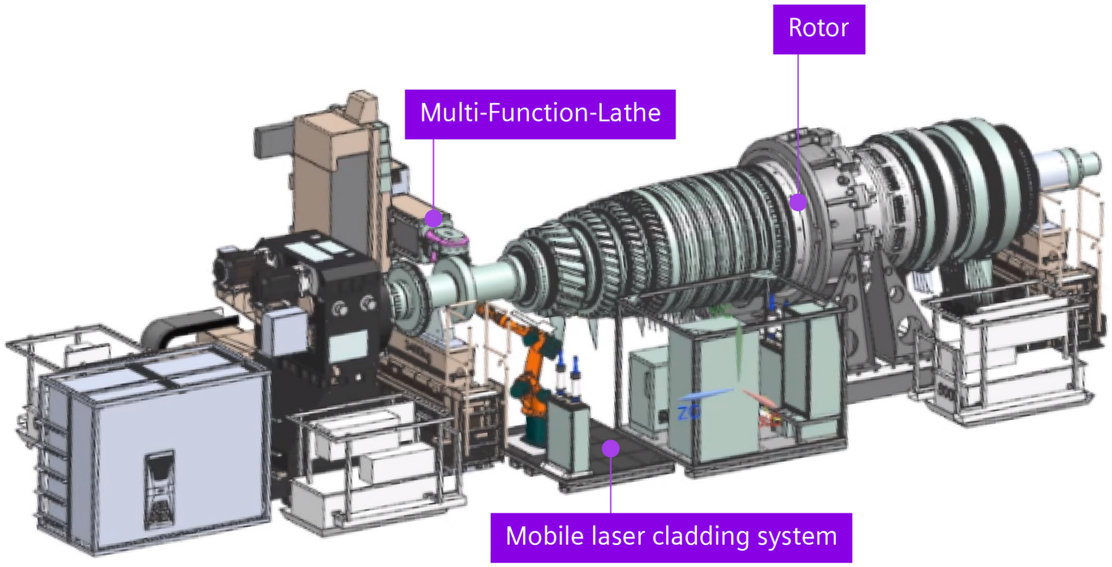
Field service competence

Our trained professionals are located in strategic hubs around the world and provide qualified and committed on-site competence for extensive modernization projects.

Our TMS (Total Maintenance Service) process is intended to provide assistance for optimized outage planning. Our field service professionals work closely with on-site staff in defining the project scope and operational assessments to help implement upgrades and product modifications.

Factory in the field

On-site machining



Besides repair capabilities, our advanced on-site machining capabilities can be used for adaptation of modernized components to existing components, such as assembly of a new blade carrier into the existing casing.

With a proven track record.

Field service activities are performed to 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 trained professionals can support field service requests after appropriate assessment is made.

Outage times may significantly be reduced as with the help of the Siemens Energy portable equipment, our trained professionals may perform machining processes directly at site.

This typically may be much faster than shipping components to factory for repair.

08

LMD – On-site Laser Metal Deposition

Printing out of the box

We can perform on-site repair and refurbishment of turbine components with the help of our innovative LMD (Laser Metal Deposition) equipment.*

LMD is an advanced additive manufacturing technique and involves the use of high-energy laser beams as the heat source for cladding powder materials on the surface of worn-out parts. The coating is metallurgically bonded with the substrate, able to create optimized metallurgical properties.

Siemens Energy has applied this verified repair method several times. This technique enables the repair of various turbine components.

*May not be applicable for all regions



Your economic viability

Modernization of mature steam turbines may help to improve the competitive position of your power plant.

We continue to invest in research and development for steam turbine technology aimed towards improvement of your position in a changing market.

Modernization can be an economically attractive approach as the benefits may be translated to positive monetary values.

Implementation of our modernization solutions such as the HP barrel turbine exchange concept may shorten outage duration up to 30 days compared to a typical steam turbine major overhaul of the same scope.

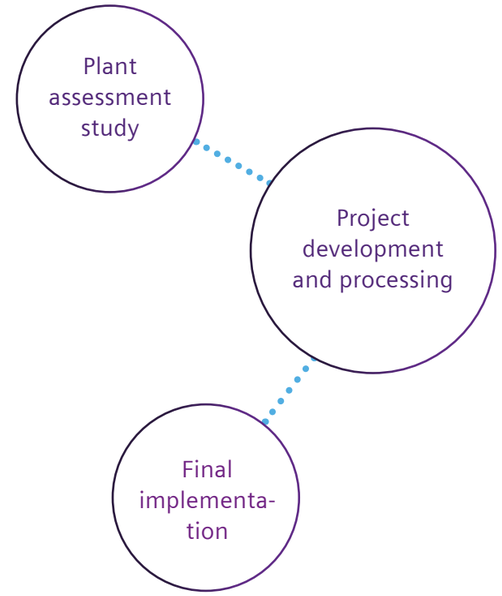
CCPP power output increases up to 12% may be achieved by unit specific optimizations such as adjustment of turbine swallowing capacity in combination with a gas turbine upgrade.

A reduction of fuel consumption may be achieved by an increase of thermal performance and a regaining of thermal efficiency losses due to degradation. Steam turbine train efficiency increases up to 2% points may be reached with the help of modernization solutions.

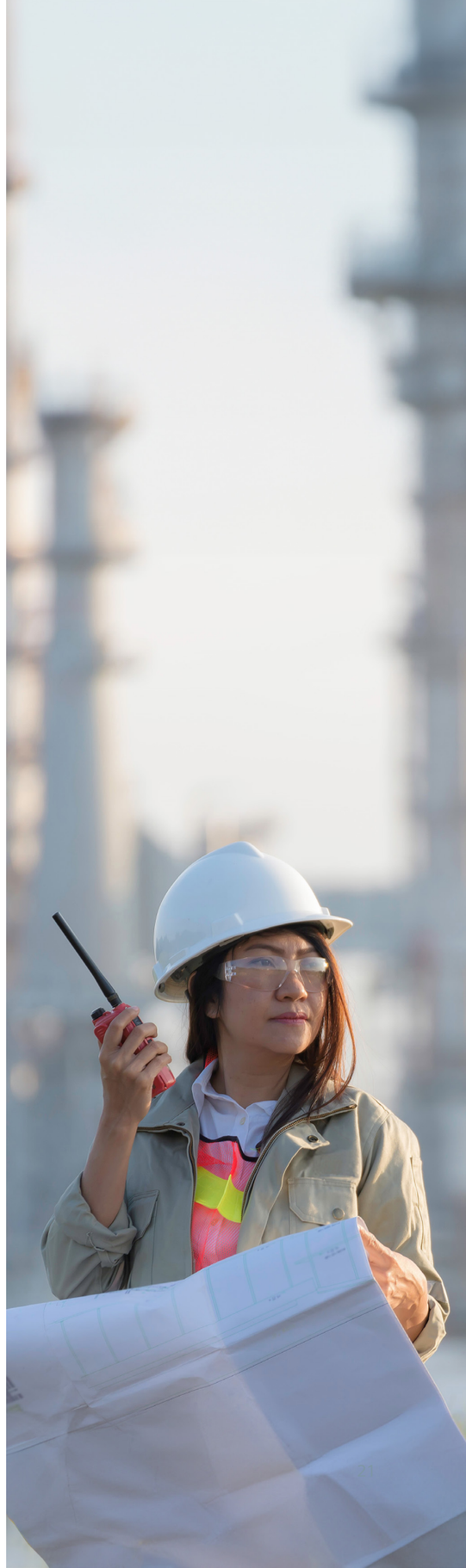
Quality assurance – that's our job!

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.



We are ready for complex challenges.

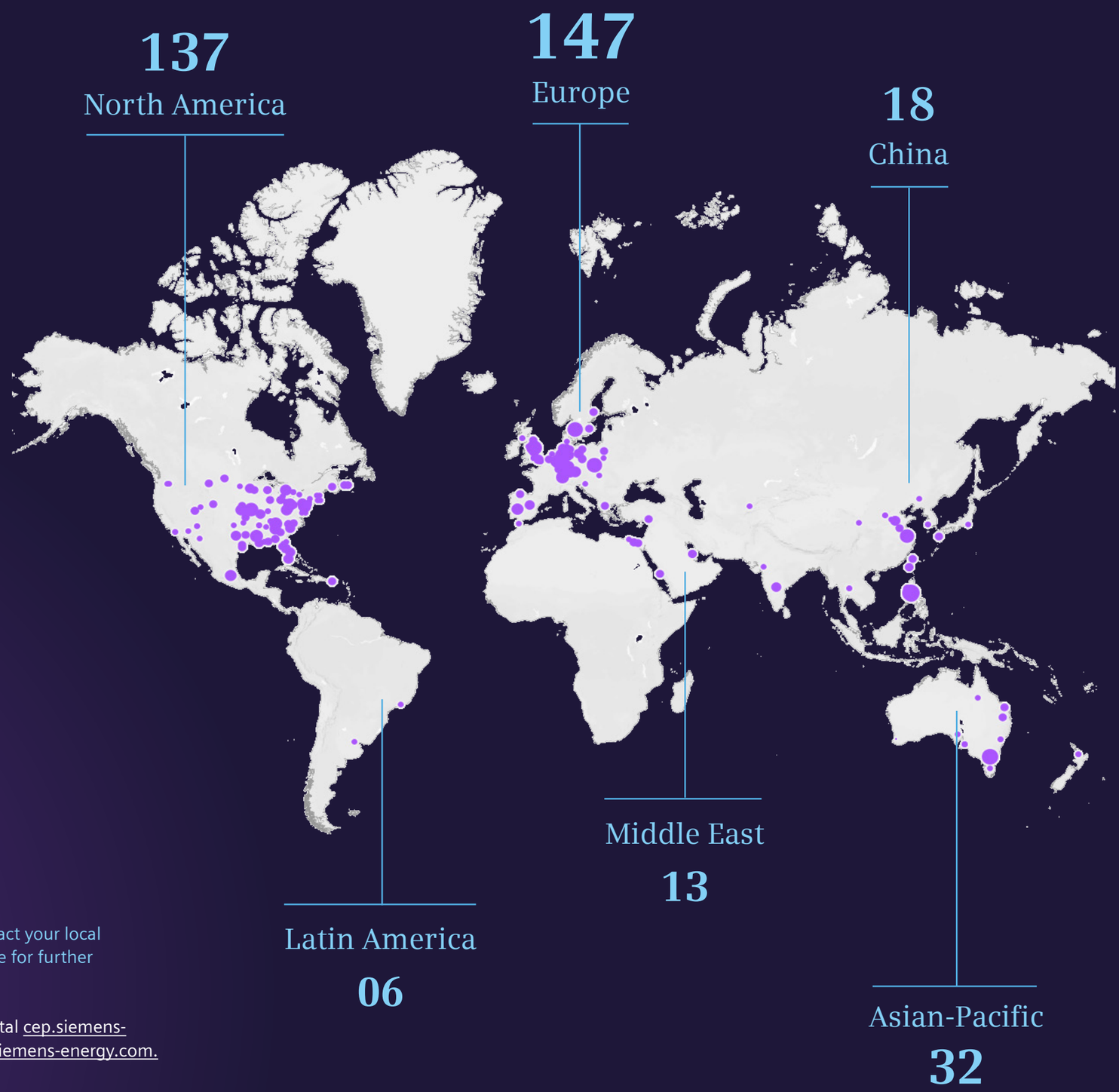


Our References

More than 300 steam turbines have been successfully modernized by Siemens Energy worldwide infusing new technologies intended to improve performance and reducing outage durations.

We have decades of fleet experience and a proven track record in successfully performing modernization projects tailored to the needs of our customer for OEM and other-OEM power plants.

More than 300 steam turbine modernizations



Ready to start?

Our experienced service team is ready to assist you in deciding which solution is the right one for you. With our trained professionals in engineering, manufacturing and/or field service in close collaboration, we can offer optimum service solutions for your power plant to match your specific demands.

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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