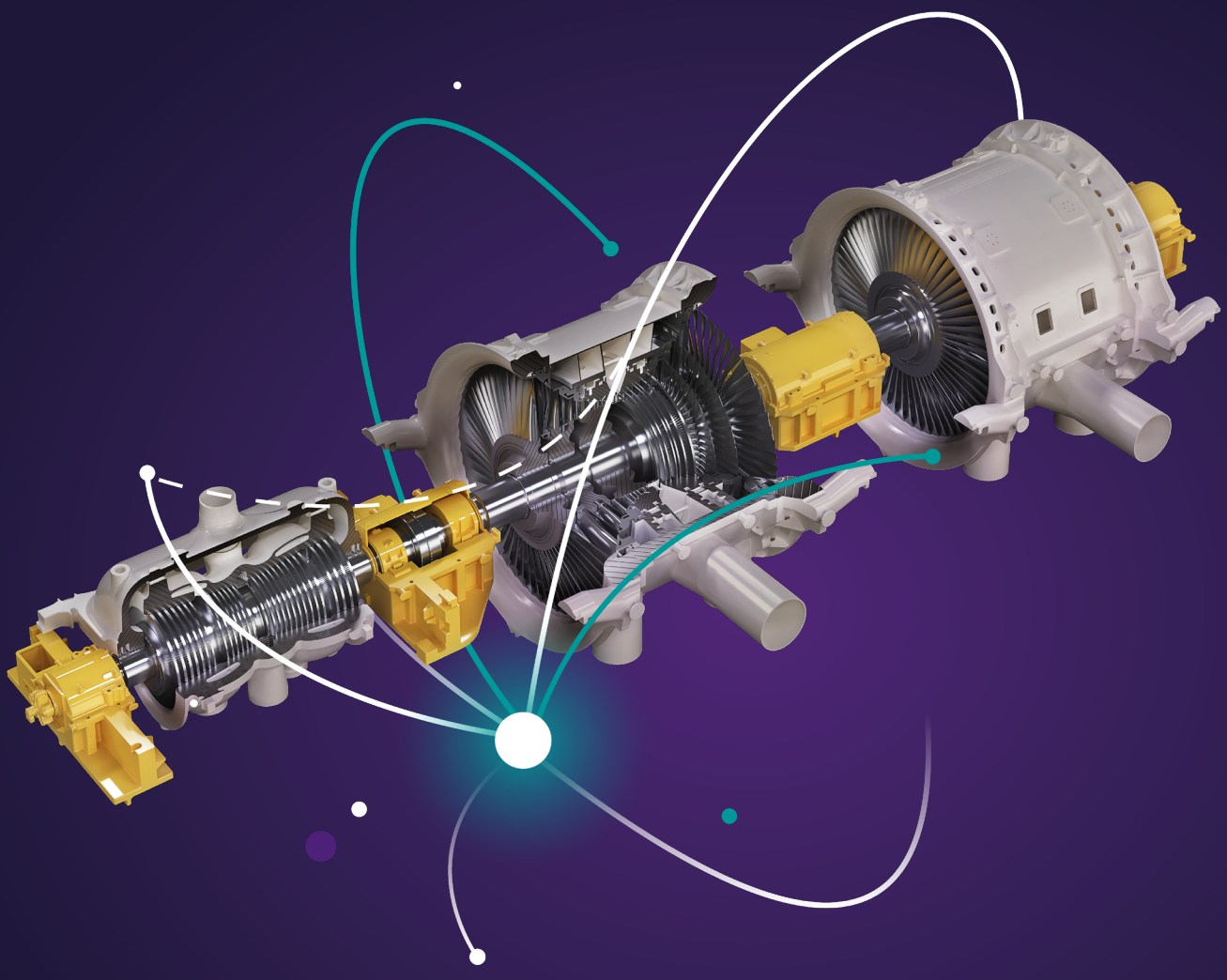
SIEMENS energy

Nuclear plant modernization

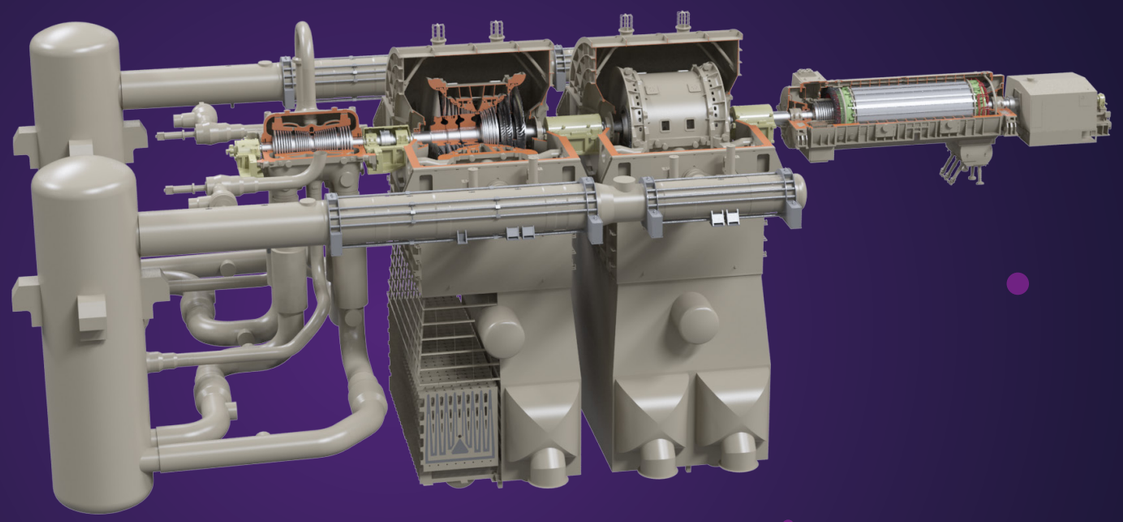
Options for mature power plants in a changing market



Modernize your nuclear plant

We start where you are.

Modernizing your nuclear power plant may help extend the life of the unit and help prepare it to operate reliably for the future. Siemens Energy can help update your steam turbine, generator, exciter, auxiliaries and control system.



Content

Your success is our top priority.

01 Steam turbine modernization
Page 05

02 Generator modernization
Page 12

03 Exciter maintenance
Page 15

04 Nuclear auxiliary systems
Page 16

05 Omnivise T3000 control system
Page 18

01

Steam turbine modernization

Precision engineering, reliable solutions.

Our goal is to provide you with modifications that are intended to help improve your mature generating equipment reliability. Modernization measures may help extend the lifespan of steam turbines and strengthen competitiveness by improving steam turbine efficiency and performance.

A steam turbine modernization typically includes the replacement of key components which contribute the most to reliability, availability and efficiency such as highly loaded rotors, casings, blades, seal elements and valves with improved components. A Lifetime Assessment (LTA) can be performed for mature units.

An LTA requires specific knowledge about the unit such as operating regime and service history. This helps provide repair and replacement recommendations to potentially extend the lifetime of a unit or specific components and helps in developing tailor-made and economic modernization measures.

Optimize your assets and maintain sustainable power plant operation.

Benefits

- Lifetime extension
- Highest attainable availability and reliability
- Turbine train efficiency improvement up to 3%*
- Longer inspection intervals
- Recover efficiency losses up to 2%* due to degradation
- Improved resistance to erosion
- Plant output improvement up to 10%*

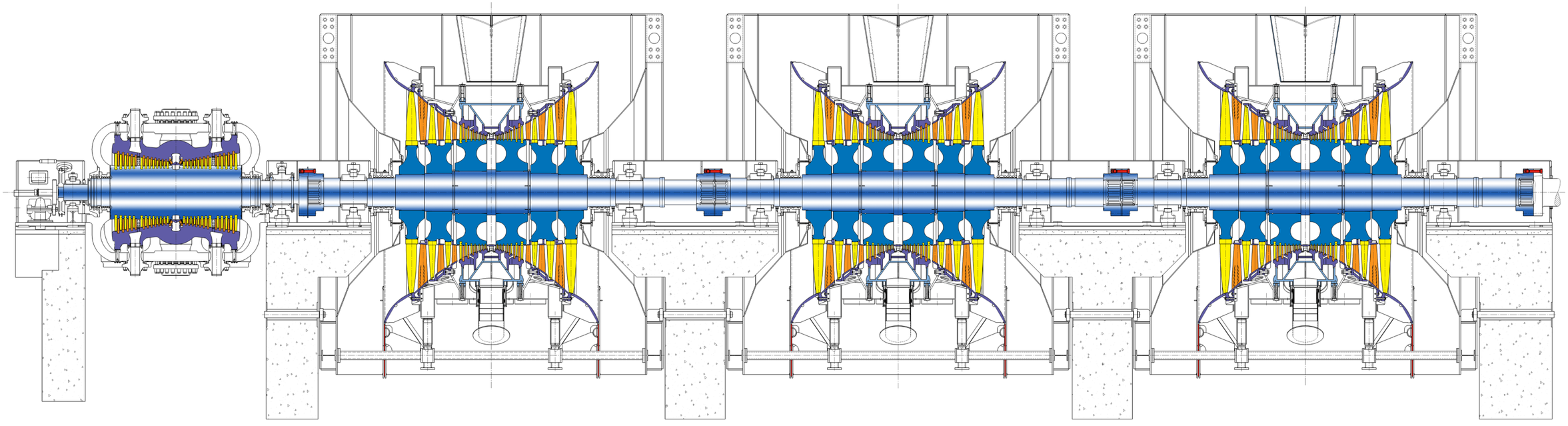


Figure 1: Section view of a typical modernization solution for nuclear steam turbines (modernized components are highlighted in different colours)

*Site specific results may vary

Three-dimensional blading

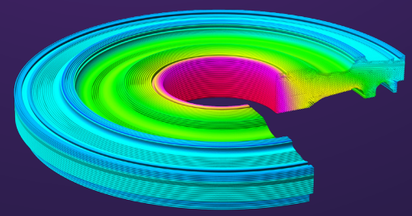
The latest blade path technology incorporates three-dimensional blading with variable degrees of reaction, also known as 3DV™. This technology is intended to optimize the blade path using automated computational methods and can potentially add 3%* in efficiency as compared to conventional blading.

Advanced low-pressure turbine shrink-fit disc

The Siemens Energy LP rotor incorporates high efficiency blading, a monobloc rotor and three shrunk-on discs per LP flow. The advanced shrink-fit disc design, material selection and manufacturing process may help to reduce the potential for stress-corrosion related cracks of LP rotor blade attachment areas.

Low operational stresses at rotor blade attachment areas may be achieved through:

- Optimized disc geometry
- Compressive stresses introduced by heat treatment during manufacturing of the discs
- Steel shot peening of disc surface and attachment areas
- Rolling of specialized areas



*Site specific results may vary



Optimization of swallowing capacity

Reactor and/or balance of plant (BoP) optimizations may help improve the performance and the overall efficiency of the entire steam turbine train.

Siemens Energy applies advanced tools such as computational fluid dynamic simulations to develop unit specific turbine design and blade path geometry to help achieve the maximum power plant output.

Steam turbine modernizations designed and validated to meet your targets.

High-pressure turbine full arc steam inlet ring design (diagonal stage)

This configuration is intended to help reduce inlet pressure losses and protects the rotor surface from moisture, washouts, and temperature changes.

The high precision of electrical discharge machining (EDM) helps maintain a high dimensional accuracy. This is a particularly important factor in the modernization of saturated steam turbines of nuclear units, where the possibilities of adjusting the steam flow rate or power by “adjusting“ the thermodynamic parameters of fresh steam are limited by safety systems.

*Site specific results may vary

The diagonal stage makes it possible to carry out further modernization of the HP turbine in the future while potentially increasing the thermal power of the reactor to the range of 105%* to 107%* of the rated power by only replacing one component, the steam inlet ring.

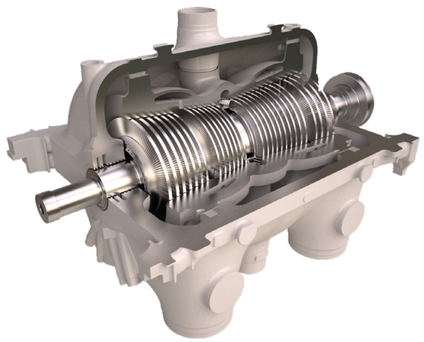


Figure 2: Siemens Energy nuclear high-pressure turbine

Damping elements for LP turbine last stage blade row

The use of damping elements to couple blades are integral to potentially reducing vibration and improving structural integrity of the LP turbine last blade row.

The damping elements are loosely assembled into pockets inside integral bosses on the blade airfoils. The blade pockets provide a dissipative mechanism and help increase the total amount of damping. These damping elements can potentially reduce the vibratory response of the blade row.

Operational experience has shown that this configuration helps improve the robustness of the last blade row.

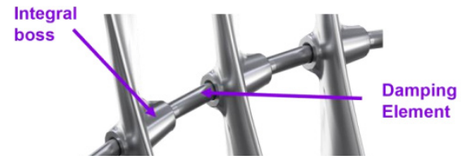


Figure 3: Damping elements

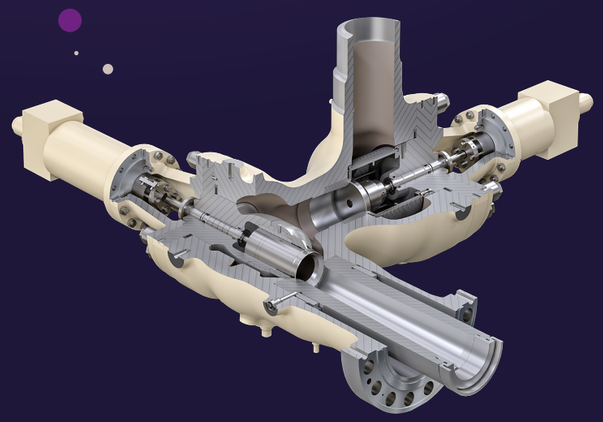


Measures to adress droplet erosion and corrosion

Where applicable, Siemens Energy hardens the leading edges of LP turbine last stage blades manufactured from steel by laser or flame hardening. This is intended to counteract droplet erosion. Where steam moisture content is high, stationary blades can be provided with suction slots or vane heating in the last stage to help reduce the effects of the droplets.

Modernization of high-pressure turbine main steam inlet valves

Siemens Energy can optimize valves to allow higher flow rates. A turbine main steam inlet valve modernization typically includes upgrading key components such as highly stressed valve cones, spindles and bushings.

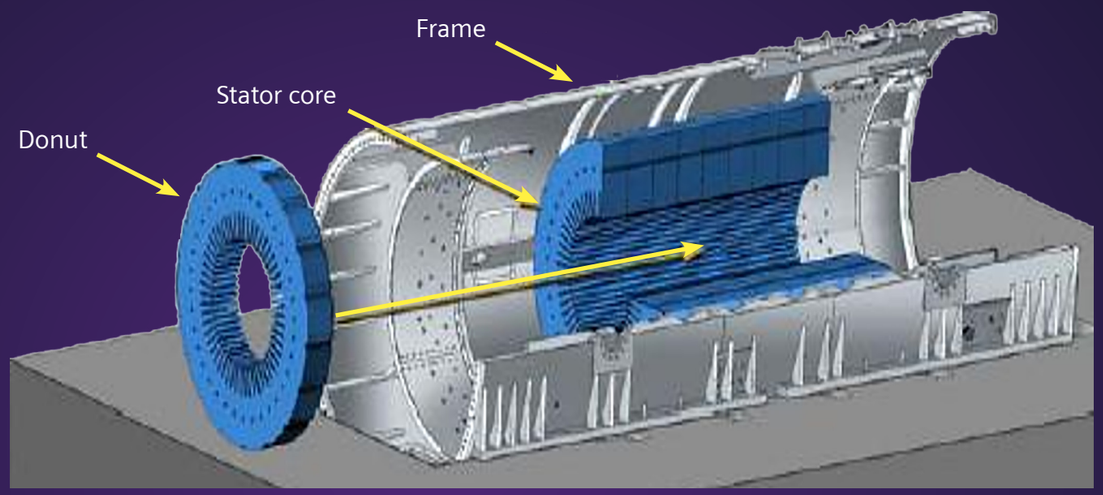


02

Generator modernization

Designed for maximum performance.

As a generator ages, conditions such as interlaminar shorts, hotspots, and looseness have been reported on some units. These conditions can potentially damage the stator winding, which could result in an unplanned outage. For customers planning to extend the operation of their generators, replacing the core as part of a rewind can potentially restore the wound stator core. Planning for a core replacement with a stator rewinding can help extend the generators reliability and minimize the potential of an outage extension due to core findings.



Stator core donut technology

The Stator Core In-Situ Replacement technology replaces the stator core with the generator in the horizontal position by using bonded core packs (commonly called “donuts”). Replacing the core as part of a rewind can potentially restore the wound stator core assembly. This would replace the current hand stacked method. Intended benefits of replacing the stator core with donuts include:

- Reducing core replacement schedule time by up to 75%* as compared to hand stacking
- Less frequent retorquing of the stator core due to better retention of overall core tightness with potential associated cost reductions and increased availability
- Core geometry and ventilation changes which can potentially increase power output capability

*Site specific results may vary

RIGI-FLEX™ stator end-winding design

The Rigi-Flex™ support structure is axially free, flexible in the tangential direction, and rigid in the radial direction. The addition of both an inner ring and axially free support ring allow the Rigi-Flex™ to be decoupled from the parallel rings. This helps lower the natural frequency of the end-winding basket and provide a homogenous stiffness which is intended to prevent the generator end-winding from operating close to resonance. Intended benefits include:

- A more robust end-winding structure which is less sensitive to grid impacts
- Improvement of end-winding vibration behavior
- Reduction of maintenance efforts for stator winding
- Improved operational reliability

FAST Wedge™

Siemens Energy has developed and patented the FAST Wedge™ retightenable stator wedge system for generators with SVPI (Single Vacuum Pressure Impregnanted) coils. Implementing FAST Wedge™ allows for stator wedge retightening with the rotor in place. Intended benefits include:

- Up to 15 days reduction in outage duration
- Eliminate the need to remove the rotor to retighten slot wedges
- Improved availability and increase generation capacity by reducing outage time over the life of the unit
- Potentially prolong life of the stator winding with the capability to tighten wedges more frequently

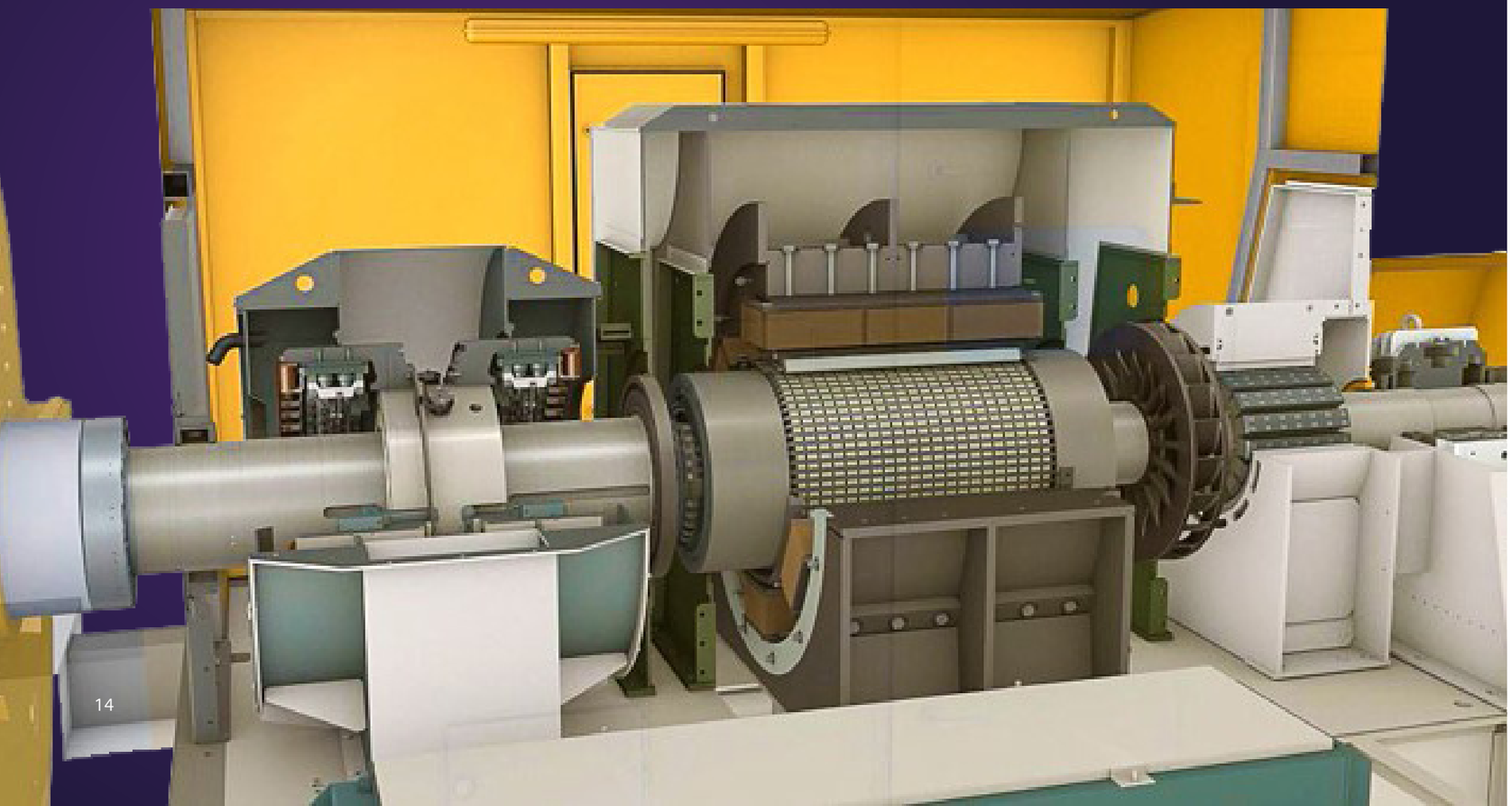
Uprates

Plant upgrades often result in more output from the steam turbine. Often times this requires modernization to the generator and auxiliaries to generate additional power.

Due to the effects of renewable energy on the power grid, large generators are sometimes asked to alternate between producing and absorbing reactive power, as well as operating at significantly different load levels.

The electrical and cooling capabilities of the stator core, stator windings and rotor can normally be modernized to help meet the new power output and operational flexibility demands on the plant. The applicable auxiliary systems can also be upgraded to help meet the new demands.

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



03

Exciter maintenance

Cost effective solutions.

Over time, brushless exciters are subject to thermal, electrical, and mechanical stresses, as well as contamination issues. Siemens Energy can test and refurbish brushless exciters and their related components.

For operators requiring faster generator response times to grid disturbances, it may be possible to upgrade their existing brushless exciter to a High Initial Response (HIR) system. This enhancement is intended to retain the beneficial features of a brushless excitation, while potentially achieving faster response times similar to those of the static type.

- Improve reliability of the exciter
- Potentially reduce future maintenance efforts
- Reduce potential for unscheduled outages related to the exciter
- Help avoid the potential for exciter replacement and associated costs

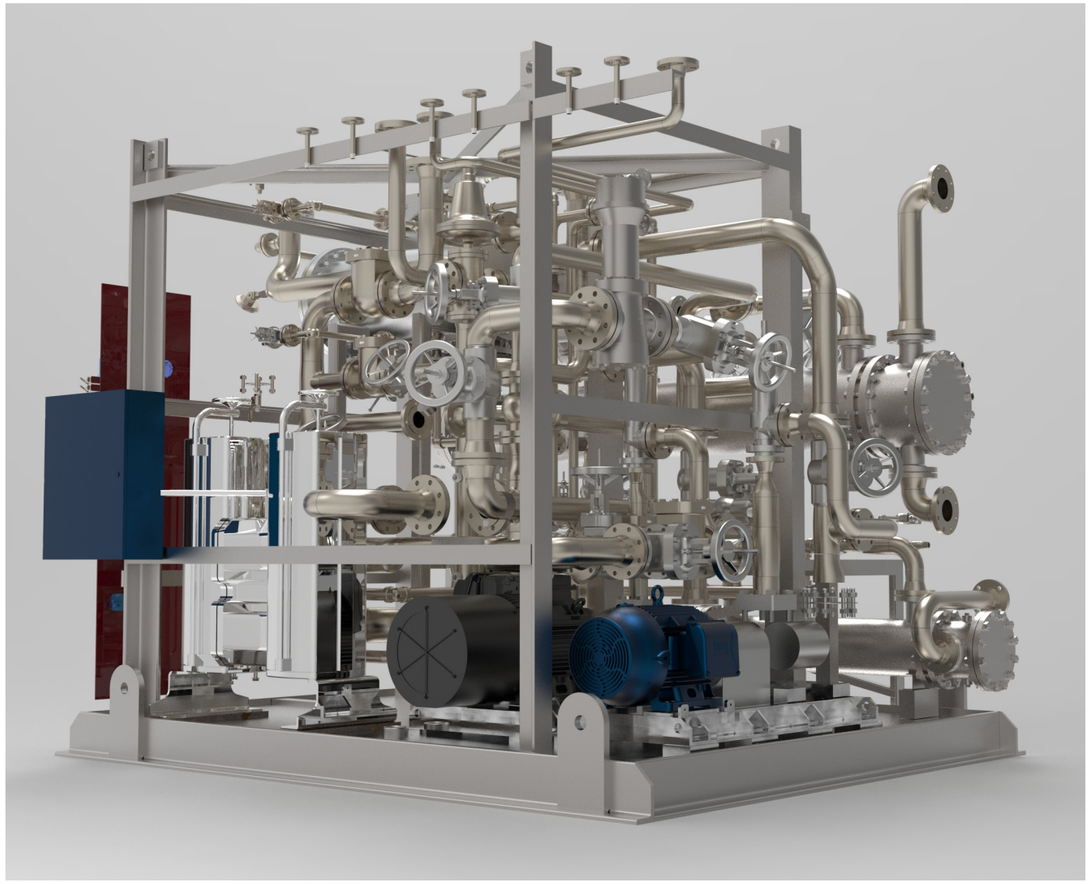
04

Nuclear auxiliary systems

Technology developed for your needs.

Auxiliaries play a crucial role in plant operation. Maintaining and upgrading plant auxiliaries may increase plant reliability plant help reduce the potential of an unplanned outage.

Siemens Energy now offers a unit specific Auxiliary Systems assessment intended to provide tailored products and solutions aimed at addressing customer feedback/concerns and obsolescence to support lifetime extension.



Valve condition assessments

The focus of the nuclear valve condition assessment are units that have been in service 40 years or longer that could potentially experience degradation of components listed below.

- ✔ Steam chest & supports
- ✔ Piping
- ✔ Actuator Support Towers
- ✔ Valve Internals and Actuators

Non-Destructive Evaluation (NDE) should be performed after 40 years of service and then at 10-year intervals.

New auxiliary systems

Siemens Energy has developed a package intended to extend the life expectancy of your unit's auxiliaries.

Steam turbine:

- Electrohydraulic (EH) System
- Lube Oil System
- Gland Steam System
- Drain System

Generator:

- Seal Oil System (Double Flow)
- Stator Cooling Water System
- Hydrogen Gas System

Brief overview

EH system

- Variable displacement pumps
- Higher filtration

Lube oil system

- Pump redundancy
- Temperature control valves
- Higher filtration

Gland seal oil system

- Valve upgrade and replacement

Gas skids

- Fully automated fast degas system
- Integrated hydrogen purity monitor
- Dual tower gas dryer

Stator water skid

- Alkalizer for maintaining PH
- Oxygen analyzer
- High-capacity coolers

Seal oil skid

- Seal oil temperature control valve
- Localized control monitoring

05

Omnivise T3000 Control System

We are ready for complex challanges.

As energy markets change, your I&C system needs to do more and may be required to handle distributed sites as well as large centralized power plants. The innovations in Omnivise T3000 (formally known as the SPPA-T3000 system) are aimed at making improvements that impact the market quickly.



T3000 SCADA

SCADA provides control and efficient management of distributed, decentralized power generation in large-scale distribution grids. Intended benefits include:

- Import data from remote units, at every production location
- Enable central management of remote units
- Perform root cause analysis to pinpoint issues

T3000 Cybersecurity

We have developed a comprehensive strategy, which is intended to identify vulnerabilities and misconfigurations, and remediates them, specifically for standard T3000 plants. Intended benefits include:

- Built-in cybersecurity to protect your plant
- Defense-in-depth concept to withstand external attacks
- IEC-certified system

T3000 Simulator

Simulator is our fully integrated digital process and automation twin of Omnivise T3000 and all kinds of generation units that rely on T3000. Intended benefits include:

- Simulates real plant behavior before any change is made
- Enables detailed testing of the effects of changes or adjustments in T3000

T3000 Virtual

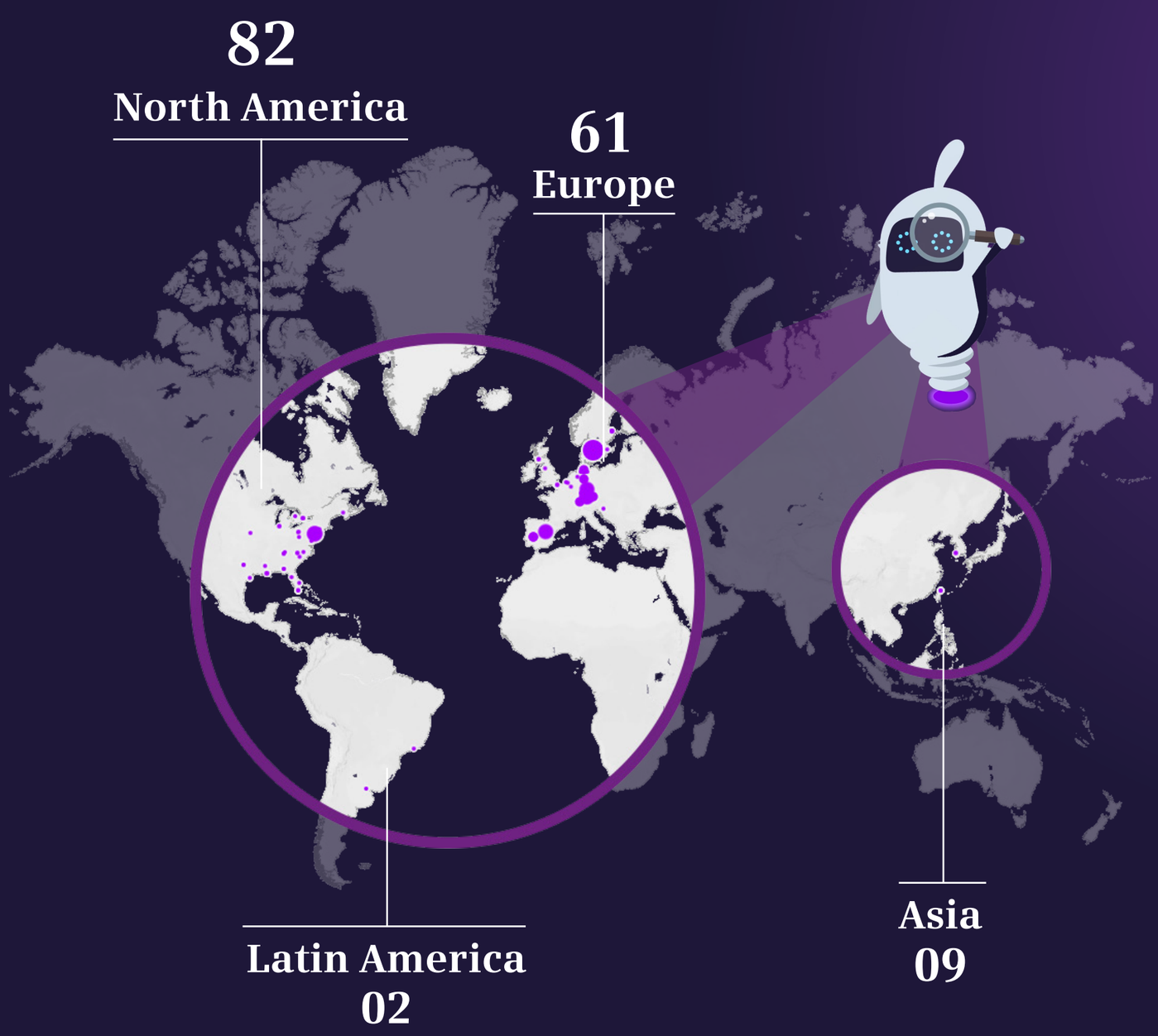
Through innovative virtualization techniques, T3000 can be offered virtually. Intended benefits include:

- Improved availability
- Lower life cycle costs
- Decoupling of hardware and software for simplified spare part handling and lifecycle management

Our References

Trusted expertise and global reach

We have decades of fleet experience and a proven track record in successfully performing modernization projects for nuclear power plants. More than 150 nuclear steam turbine building blocks have been successfully modernized worldwide. In addition to our own steam turbine fleet, we have also conducted modernizations on other-OEM steam turbine frames.



At Siemens Energy, we prioritize a collaborative partnership with our customers to tackle maintenance challenges head-on.

By proactively engaging with us, we can jointly develop tailored solutions that align with your unique circumstances and requirements.

Related products

To potentially improve the reliability of the generator, Siemens Energy offers the GenAdvisor™ system.

To potentially improve the reliability of the steam turbine, Siemens Energy offers the Blade Health Monitoring System.

For more details please visit our web page: Home | Global | Siemens Energy Global (siemens-energy.com).

Ready to start?

Modernize your nuclear power plant to prepare for the increase in nuclear energy demand and help minimize unexpected downtime.

Please do not hesitate to contact your local Siemens Energy representative for further information and visit our Customer Energy Portal: cep.siemens-energy.com or our webpage siemens-energy.com.

Published by

Siemens Energy Global GmbH & Co. KG
Otto-Hahn-Ring 6
81739 München, Germany

For the US published by

Siemens Energy, Inc.
4400 N Alafaya Trail
Orlando, FL 32826, USA

For more information, please visit our website:
siemens-energy.com/website

Article No. CB3-24-0007-GN-EN-01

© Siemens Energy, 2024

Siemens Energy is a trademark licensed by Siemens AG.

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract. All product designations may be trademarks or product names of Siemens Energy Global GmbH & Co. KG or other companies whose use by third parties for their own purposes could violate the rights of the owners.