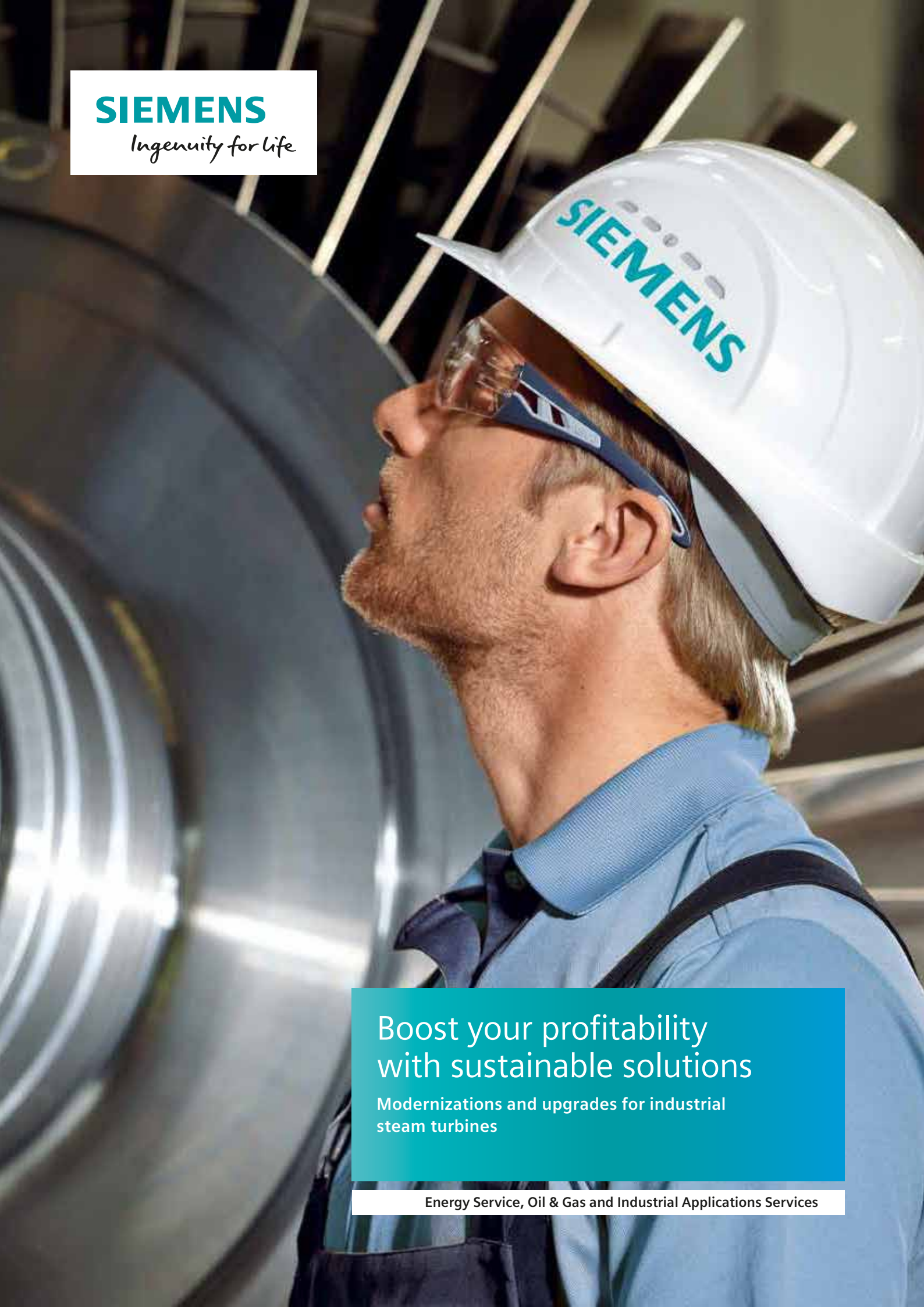



SIEMENS
Ingenuity for life

# Boost your profitability with sustainable solutions

## Modernizations and upgrades for industrial steam turbines

Energy Service, Oil & Gas and Industrial Applications Services

# Competitive solutions to meet new requirements

*Industrial steam turbines can have service lives of 30 or more years and are important components in many industrial processes, the oil and gas industry, and power generation. It is very likely that the operating parameters of turbines will change along with market conditions over such long periods, as well as when new processes and laws, such as environmental standards, come along.*

Modernization programs by Siemens help operators conserve precious resources while always keeping their systems at peak levels of efficiency, reliability, and availability – with OEM-quality services.

**Operational and economic benefits**
Thoroughly planned modernizations and upgrades help you to keep downtime and production losses to a minimum. At the same time, your turbine can be optimized in terms of efficiency or steam consumption by implementing state-of-the-art technology and innovative solutions. Apart from this, modernizations and upgrades are cost-effective, since:

- Existing parts, systems, and components can be reused, reducing investment costs
- Retrofitting or upgrading a machine requires less downtime than installing a new turbine
- You continue to work with familiar equipment and may even have relevant spare parts in store

What is more, Siemens' stringent analysis of your plant's operation allows to implement tailored solutions for specific operational conditions.

**Staying competitive**
No operator can allow its competitive position to be weakened in an era of global competition. That's the reason for constant investments in new technology and optimization of processes – and conditions on the market keep changing, too. Industrial steam turbines offer a great opportunity to reduce costs and boost the performance of your plants. If the original requirements change due to differences in operating parameters or other constraints, it will be worthwhile to modernize steam turbines and adapt them to new conditions. Especially since upgrades can do more than simply optimize processes and can also extend the life of the turbines themselves. Moreover, it usually takes less time to modernize than to manufacture a new steam turbine.

**A partner with a thorough knowledge of turbines**
Siemens has been developing, building, and servicing steam turbines for extremely diverse applications for over a century now. As it developed into one of the world's leading suppliers of industrial steam turbines, Siemens acquired many other manufacturers and integrated their equipment into its portfolio. As a result, Siemens can now offer OEM services for turbines manufactured under another brand name. You can directly profit from Siemens' knowledge of multiple manufacturers and industries, as well as its all-round experience in developing and implementing innovative solutions.

**OEM service provider for:**

- ABB/Alstom Industrial Steam Turbines
- ABB První brněnská strojírna
- AEG Kanis
- AEG/KWU
- ASEA STAL
- Austrian Energy
- BBC Industrial Steam Turbines
- Coppus
- Delaval
- Dresser-Rand
- Gimpel
- GMB Görlitzer Maschinenbau
- Hamburger Turbinenfabrik
- Kanis Turbinenbau
- MAN Industrial
- Moore
- Murray
- Nadrowski
- STAL LAVAL
- Terry
- Turbodyne
- Westinghouse
- Worthington

**A reliable partner, anywhere in the world**
Siemens' globally integrated service organization is available 24/7 around the clock. With corresponding Centers of Competence, Siemens is fully capable of reviewing all inquiries related to steam turbine modifications on very short notice, and then developing the most suitable recommendations for the application.

# Custom steam turbine service

*No two plants are alike – their components are just as individualized – so Siemens offers tailor-made services of the highest quality.*


## From a thorough analysis to a tailored solution

### Analysis comes first

When a plant is to be re-engineered, Siemens starts with a comprehensive analysis of the condition of both the turbine and the entire system. A look at current and future requirements will quickly show which systems, components, and parts can still be used and which will have to be adapted and replaced. Siemens proposes solutions to fulfill your requirements based on that analysis. The last step is a feasibility analysis that lets you evaluate the costs of retrofits or upgrades for your existing turbines and the system. Whenever possible, modernization is scheduled so that all work can be done during planned downtime without additional shutdowns of production.

### More power pays off

Modernizations and upgrades by Siemens will quickly pay off. Your specific requirements are taken into account, so you get a steam turbine that is precisely customized for maximum efficiency.

### Footprint solutions

A footprint turbine is a replacement turbine that may have slight changes to the base frame or foundation. At the same time, the existing oil system, the driven machine, and/or the gear unit can be adapted according to new operating parameters or be used without any changes.

A footprint turbine is especially appropriate when modifications must be made for new operating data or when the service life of highly stressed components has been exhausted.

One argument for using a footprint turbine is the increase in plant availability resulting from minimized production downtimes. The components in the new turbine are designed and manufactured according to the latest state-of-the-art technology.

As existing components can still be used, the investment expense is lower than for the purchase of a completely new turbine system.

# A comprehensive portfolio of services

*Siemens' modernizations and upgrades for steam turbines have been specially developed to meet the requirements for all different types of steam turbines and their applications.*

## Decisive improvements for more efficient and cost-effective operation

**State-of-the-art blade design and seal technologies**
Siemens offers ultramodern blade technology that combines robustness and the highest efficiency.

Brush seals on the balance piston labyrinth and improved thermodynamic configuration of the blades improve efficiency, reduce fuel consumption, and lower emissions.

**Improved turbine operation under high exhaust wetness conditions**
Waste incineration and biomass plants may operate with relatively low live-steam parameters to protect the boiler against high-temperature corrosion. That results in high exhaust wetness conditions for the turbine, which increases erosion of the low pressure portion, including the end-stage blades. This can be addressed by resistant materials and changes in geometry of the end-stage blades to reduce erosion protection. Hollow guide vanes to suction away excess moisture from the exhaust steam are also available for certain types of blades.

**Adaptation to more flexible operating parameters / optimization of the turbine low pressure (LP parts)**
For operators of condensing steam turbines it may become uneconomical to produce electricity due to changes in the market. A reduction in power output or an increase in process steam are ways to restore profitability. Options range from cutting back/optimizing the quantity of low pressure steam to a complete conversion of a condensing turbine into a back-pressure turbine.

It may be necessary to make turbosets flexible enough to be able to respond to changes in loads on the power grid. Siemens offers solutions for improving fast start capability, reducing temperature-related voltage peaks in turbine components, and optimizing the steam channel.

**Retrofitting control systems to enable remote monitoring and diagnostic services (RDS)**
Many steam turbines are still operated using mechanical-hydraulic or older electronic controls. Wear and tear on components and an uncertain supply of spare parts for older electronic systems can impair smooth operation. And it isn't always possible to integrate into a higher-ranking modern process control system.

Siemens offers a modular approach to modernizing turbine controls – from simple, cost-effective retrofitting to comprehensive full-scope turbine control systems. Disregarding low-cost or high-end solutions API conformity can be realized. In addition, remote diagnostic services (RDS) can be offered provided that corresponding components are installed.

The positive effects of modernizing turbine controls include greater availability, a longer service life, shorter startup and shutdown times, and lower maintenance costs.

**System-related view of steam turbine auxiliary systems**
Thanks to decades of experience with turbine production and plant construction, Siemens is also an expert at optimizing steam turbine auxiliary systems. That includes optimum adjustment and integration of turbine-related systems, reducing the use of fuels and operating materials, lower consumption of onsite power, and enhanced plant efficiency and availability.

Some practical examples of Siemens' comprehensive portfolio of modernization solutions are shown on the next few pages.

# Case studies for increased efficiency

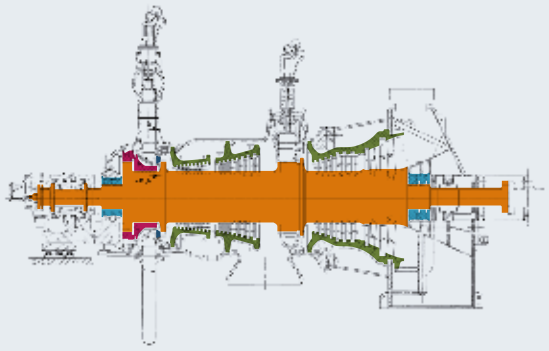
## Higher efficiency in a very short time

### The challenge

A customer in the paper industry had to modernize the rotor of a BBC steam turbine and turned to Siemens. The aim of the modernization was to restore the technical performance of the turbine during an upcoming complete overhaul while strictly limiting down time.

BBC steam turbine after retrofitting. The following components were modernized:

- High-pressure nozzles
- Guide blade carrier
- Shaft labyrinth bushing
- Rotor
- Balance piston bushing



### The solution

A complete damage and error analysis was done after taking stock. The analysis showed that over the years the rotor blades and guide vanes had eroded and sheet metal seals had been destroyed with corresponding losses in efficiency. In addition to conventional repair, the alternative of a completely new rotor was suggested. After evaluating all of the options, the customer chose the new rotor. Siemens supplied a new rotor with three guide blade carriers and gland bushings. The overhaul was completed within the agreed time frame of no more than three weeks, and the system was online again as scheduled.

### The benefits

This modernization project offered numerous advantages to the customer. Using an experienced partner for overhauling the turbine helped reduce the length of the project. At the same time, the customer was able to choose the best solution based on specific cost and process parameters. Finally, within the shortest possible time the customer had a turbine with new internals that was well equipped for the challenges of the future. That includes the fact that today it is again operating at its original very high level of efficiency, an improvement of 7 to 10 percent compared with the old rotor that was damaged by erosion.

## Regaining state-of-the-art efficiency

### The challenge

A BBC steam turbine in a waste incineration plant had been in use for almost 40 years when a fatal defect occurred at start-up. Although the unit was tripped immediately, a root cause analysis revealed severe damage that called for an overhaul of the turbine. The biggest demand was for short-term repairs, preferably with state-of-the-art design and improved efficiency. The unit in question is a back-pressure industrial steam turbine with low live steam parameters, driving a generator with maximum performance of 14 MW.

### The solution

Dismantling the turbine revealed that the entire turbine was severely corroded and a suspected rotating blade failure in one row had damaged all subsequent stationary and rotating blades. To repair the turbine, Siemens developed a modernization concept with two options for the exchange of turbine blading:

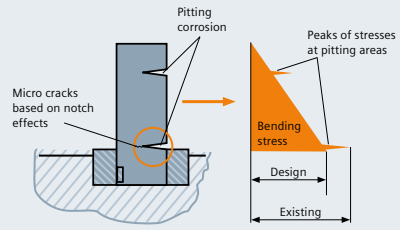
- **Option 1**: using the original free-standing blading design
- **Option 2:** using state-of-the-art shrouded blading

The costs for repair, the improved reliability, better efficiency, shorter delivery time, and the expected return on investment led the customer to select the state-of-the-art blading (option 2).

### The benefits

After the modernization project was completed, turbine performance increased by 880 kW (or 6.3 percent), leading to additional profit for the customer. At the same time, the customer benefited from improved availability and reliability of the plant, thanks to the application of highly reliable, advanced turbine components. In addition, the outage period for the modernization was much shorter than it would have been for the installation of a new turbine, and existing components could be reused.

Dominant consequences of pitting corrosion




Heavy corrosion of rotor

# Case studies for increased efficiency

## Retrofitting for higher earnings

### The challenge

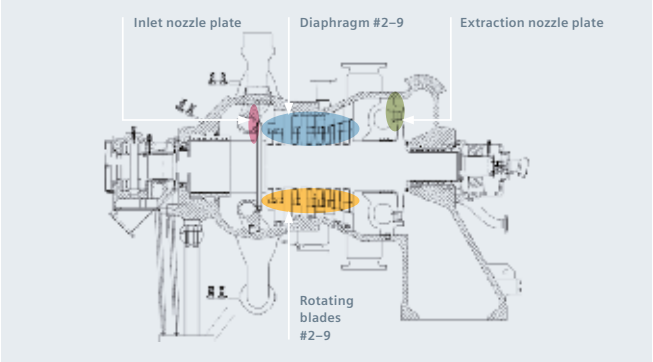
Siemens installed an SST-900 steam turbine at a paper mill. Its main purpose is to provide steam for the pulp and paper process, and electricity through a generator. After a process update, the flow through the turbine changed because less steam was required by the process. As a consequence, the turbine operated off its original design point resulting in lower efficiency and a loss of power. Siemens focused on redesigning the steam path to the new process/boiler conditions in order to increase turbine efficiency and the total number of MWh produced annually.

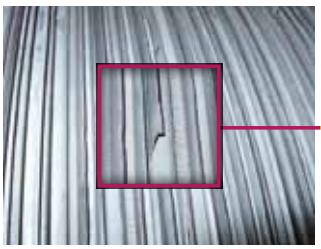
### The solution

An assessment of the actual process parameters showed that the inlet flow had decreased by about 20 percent compared to the design data, whereas inlet pressure and temperature remained more or less constant. As a result, Siemens optimized the steam path for the new site conditions and upgraded the sealing design along with adopting other new features that have been developed since the turbine was built. For stages #2 to #9 this meant using new state-of-the-art diaphragms and blading in order to give the customer the best possible output for the new steam conditions.

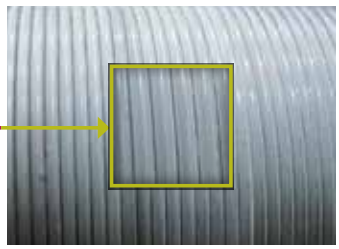
### The benefits

The pulp and paper plant profits from a number of benefits realized in their retrofit project. First of all, the power output for the new steam conditions was increased by six percent compared with the original steam path. Secondly, the retrofit was cost-efficient because the existing rotor could be used for the optimized blading. And most importantly, Siemens knew the turbine inside and out because they were the original manufacturer – and this significantly speeded up the entire process.



Before overhaul: Broken sealing strip due to wear and tear

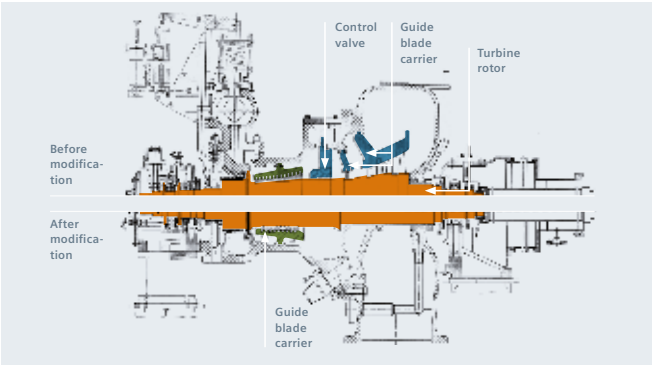


After overhaul: Remake sealing strips

## Engineering for lasting improvements

### The challenge

A chemical company uses a Siemens steam turbine to generate electricity. Following a change in process steam parameters, the turbine had to be operated under partial load, which markedly worsened its efficiency and was also unprofitable. The customer asked Siemens to modernize its plant with a footprint turbine. At the same time, exhaust steam from the turbine of a waste incineration plant located four kilometers away would be used to supply additional steam for the customer's process. That required converting the condensing turbine at the incineration plant into a back-pressure turbine.




**The retrofit in detail**

The condensing turbine was extensively modified and successfully adapted to the new steam parameters.

The split view shows the turbine before and after modification.

### The solution

Siemens developed a footprint turbine with modern shrouded rotors that was an excellent fit with the new process steam parameters. The turbine control uses the Turloop system, while brush seals increase the efficiency. The only work that had to be done on site was to adapt the internal steam and oil pipelines to the new turbine. The use of a double-extraction system in place of the previous bleed extraction system means the turbine can handle the customer's steam requirements at all times throughout the entire operating range. At the incineration plant, Siemens converted the existing condensing turbine to a back-pressure turbine and adapted the gears, turbine control, and monitoring system to the new speeds and performance data in order to optimize efficiency. Both machines were successfully started up in October 2010.

### The benefits

The customer benefits from significantly higher power output, because the footprint turbine is optimally adapted to the new process steam parameters. With the double-extraction system precisely modified for the new process, the machine works much more efficiently. Thanks to the injection of backpressure steam from the incineration plant, the customer was also able to stop purchasing primary fuel, greatly reducing its $CO_2$ emissions.

# Case studies for lifetime extensions

## More decades of profitable operation

**The challenge**
The high investment cost and long delivery time of new equipment make it worth considering the alternative of lifetime extension for existing turbine parts. For that reason, a utility company in Sweden asked Siemens to conduct a Life Time Extension (LTE) analysis on a district-heating turbine. By that time, the turbine had accumulated about 70,000 operating hours. The challenge was to ensure the turbine's ongoing operation beyond the end of its normal design lifetime.

**The solution**
Before the planned overhaul, Siemens performed a theoretical study with the goal of identifying critical components for which a reduced operating lifetime could be projected. The turbine's history, original design calculations, and Siemens' unique experience with similar units were all part of the evaluation. For some components, further analysis was recommended to reduce uncertainty and limit the number of replacements. Finite element (FE) calculations were made and an extended nondestructive testing process (NDT) based on the theoretical study was performed during the overhaul. The LTE study resulted in a recommendation to replace some components during the next planned overhaul and to re-inspect the most critical parts in the hot areas more frequently in a systematic way.

By the time of the next major overhaul, the turbine had been running with no operational disturbances. The detailed knowledge of the condition of specific components from the LTE study made it easy to establish the scope of the overhaul in advance. All recommendations presented in the first LTE analysis were implemented. The NDT activities were repeated at the same locations and using the same methods, and then compared with the previous results in order to keep track on the turbine aging process.

**The benefits**
After the second overhaul the turbine had fewer critical components than before the start of this LTE program, as well as detail knowledge of the components' condition. A customized maintenance plan based on all available information was also delivered by Siemens. The client is now able to plan future inspections and replacements in the most economical way. In addition, the customer can expect to benefit from reduced operating costs for a substantial period of time, thanks to the measures taken by Siemens.

## Tailored efficiency increase

**The challenge**
An ammonia plant operator had to upgrade his topping steam turbine. Because the ammonia market is particularly driven by gas prices, increasing the turbine's efficiency had top priority. After 25 years of service and countless operating hours, many improvements and upgrades had already been implemented. To achieve the best result possible, Siemens' designers started the upgrade process with an empty casing, incorporated the latest technical expertise, and came up with a step function improvement package.

**The solution**
Due to the focus on cost savings, this retrofit involved wholesale changes to an already mature design steam turbine. To improve the machine's efficiency and augment the reheat effect, Siemens added one stage – raising the number of stages to three – and also slightly raised reaction and velocity ratio. Also, further radial seals were added to control leakage losses in the steam path. Additionally, Siemens used a full arc of blading and axial entry blading to eliminate the losses for missing blades now found in the steam turbine. Valve pressure losses were reduced by removing the center pilot valve in the valve gear. Siemens also implemented a set of mechanical improvements, such as a larger exhaust end journal bearing, a heavier shaft, a larger exhaust end oil drain, and a double-acting Kingsbury thrust bearing in place of the existing single- acting one.

**The benefits**
Thanks to Siemens' upgrades, the turbine's steam rate improved by approximately six percent. As a result of design improvements and aging loss recovery, considerable energy savings were achieved. The upgrade also offers the possibility to reinstall the original internals as spares, using special adapters. In addition, the overall plant capacity was increased. Combined with equipment improvements, this provides an overall attractive payback.

# Case studies on controls upgrades & RDS (Remote Diagnostic Services)

## Fast, inexpensive remote support

**The challenge**
Following a fire, a textile finisher had to repair its industrial steam turbine and replace its control technology, including switchgear cabinets. All work had to be done in the shortest possible time to recommission the turbine as soon as possible. The customer also wanted to get quick, precise support in the future whenever questions arose about operation or fault management.

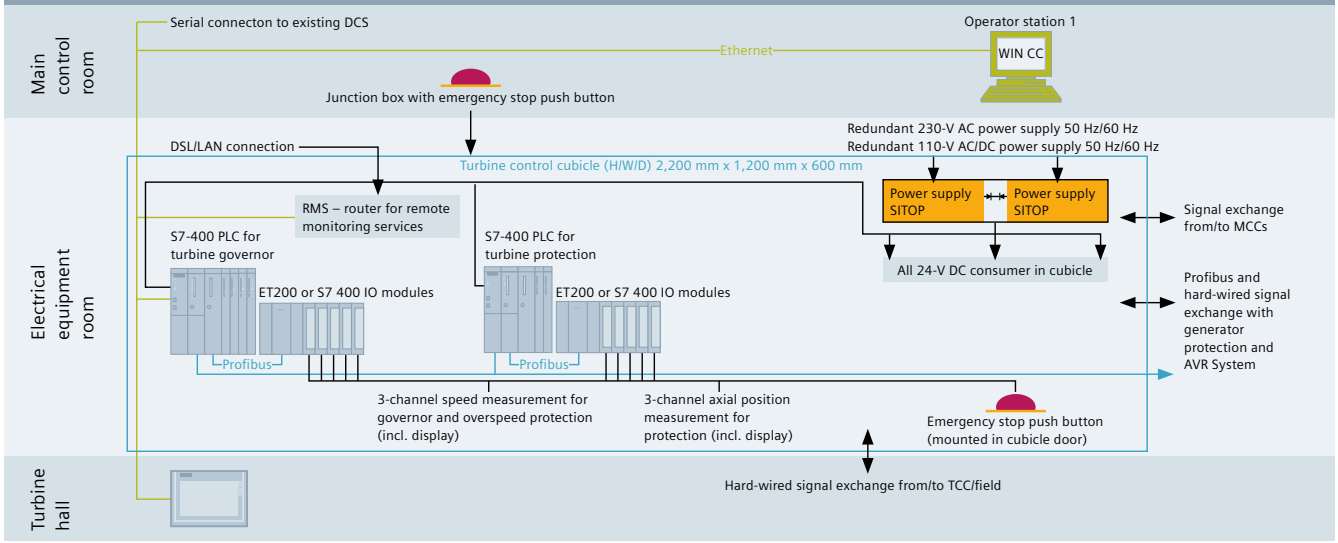
**The solution**
In addition to the mechanical repair work, components for remote support and a remote monitoring system (RMS) were installed during replacement of the control technology with the modular TURLOOP S7 control system. Some of the user stations were designed as engineering stations and linked to the OEM service using a highly secure connection via the common Remote Service Platform (cRSP) from Siemens. The system records all accessible process and operating data and transmits it daily for monitoring and diagnostics.

Twofold monitoring: The turboset at a textile processor

**The benefit**
Thanks to the cRSP connection, Siemens was able to provide support to the people working on the startup the first time the new control technology went online. This included simultaneous (online) work by the TURLOOP development engineer (at Siemens) during adjustment or expansion of the control technology to fulfill additional customer requirements. It offered superior support for the customer – and avoided needless coordination costs. In the future, Siemens will be able to advise the customer more quickly and less expensively on all issues and requested changes related to control technology, visualization, and operation. The online availability of all relevant operating data is vital for keeping response times as short as possible, since this allows remote error detection and increases the availability of the system.

## Better performance through optimized controls

### Control system topology




### The challenge

An Indonesian pulp mill customer relied on Siemens' expertise for implementing a turbine controls upgrade during a major overhaul of the entire plant. The controls upgrade was urgent due to availability issues, for example:

- the old programmable logic controllers (PLCs) have been phased out
- no spares and support available for the installed visualization system
- the old speed and axial displacement measuring system is no longer available

### The solution

Siemens installed the modular TURLOOP S7 turbine control system and Siemens S7 PLC hardware. Turbine and process control as well as protection functions were adapted to the existing plant process. A new process visualization allows the operators to analyze, control, and record all operating parameters. In addition, new hardware for speed/axial displacement and vibration and relative extension monitoring was installed for high operational safety and simplified troubleshooting. The connection to higher-level control systems is established via serial interfaces with Modbus and Ethernet protocol – and for optimum online support, a new Remote Monitoring System (RMS) was implemented.

### The benefits

Apart from the improved control functions, the customer also enjoys the peace of mind brought about by the availability of all relevant spares through the international Siemens service organization. In addition, easy implementation of new operating parameters and functions as well as easy adaptation to new processes was feasible. And, most importantly, the remote connection to the Siemens experts results in quick service support and the feasibility to plan proactive and preventive maintenance measures.

### Modernization measures

- Replacement of control technology with components for remote support and monitoring
- Some user stations were designed as engineering stations and connected to OEM service over a highly-secure cRSP connection
- Recording of all accessible process and operating data, daily monitoring and diagnostics

(TURLOOP) Turbine control cubicle

Touchscreen PC for operation and visualization

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