Leading Technology for Efficient, Reliable Generation

**Siemens Steam Turbines**
from 90 MW up to 1,900 MW
In order to guard against the impact of fuel price volatility and to provide long-term operating cost stability, you need a reasonable fuel mix for your fleet of power plants. That is why Siemens has continued to work aggressively on advanced steam turbine technology to provide a complete portfolio of 50 Hz and 60 Hz steam turbines ranging from 90 MW up to 1,900 MW for combined cycle, conventional steam and nuclear applications. In addition, we offer a full line of industrial steam turbines ranging from 1 MW to 150 MW.

With 8,000 steam turbine units in operation, the Siemens Steam Turbine (SST™) fleet contributes nearly 540 GW of power generation capacity and represents 21% of the world’s operating fleet in megawatts.

Proven modular design

The Siemens Steam Turbine product line incorporates pre-engineered modules to reduce technical risk, reduce assembly and commissioning times and lower initial costs to our customers. We offer preconfigured turbine modules of different sizes to provide a broad range of power ratings. Each specific module has different material options to meet specific steam conditions.

To meet the unique requirements of a project, Siemens selects the appropriate modules from our proven steam turbine-generator portfolio and then only needs to engineer the individual steam blade path. We offer the steam turbine-generator as an optimized package to ensure the best possible performance.
A turbine series to meet your application needs

<table>
<thead>
<tr>
<th>Turbine series</th>
<th>Turbine-generator arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST-6000 series</td>
<td>Separate high-pressure (H), intermediate-pressure (I) and low-pressure (L) cylinders</td>
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<tr>
<td>SST-5000 series</td>
<td>Combined high-pressure/intermediate-pressure (HI) cylinder and separate low-pressure (L) cylinder</td>
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<tr>
<td>SST-4000 series</td>
<td>Separate intermediate-pressure (I) and low-pressure (L) cylinders</td>
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<tr>
<td>SST-3000 series</td>
<td>Separate high-pressure (H), cylinder and combined intermediate-pressure/low-pressure (IL) cylinder</td>
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<tr>
<td>SST-1000 series</td>
<td>Combined intermediate-pressure/low-pressure (IL) cylinder</td>
</tr>
<tr>
<td>SST-8000/ SST-9000 series</td>
<td>High-pressure saturated steam (S) and two or three low-pressure (L) cylinders</td>
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</table>
Siemens turbines employ a design philosophy to help ensure long and reliable operation.

**HP and IP elements**

Our HP elements utilize a unique barrel design that does not require a massive horizontal joint flange. The circular cross-section of the inner and outer casings reduces stress risers to minimize joint maintenance issues. The barrel design uniformly controls thermal expansion, permitting rapid load changes. For our IP and combined HP/IP cylinders, we employ an advanced inner casing design with stiffening ribs on the top and bottom to balance the thermal stresses created by the horizontal joint. Thus, all of our designs follow the principle of circumferential symmetry for low stress and mechanical integrity. For high-temperature applications we employ a special vortex cooling arrangement in our HP and IP turbines, which can significantly lower rotor temperature and related material concerns.

We employ full-arc admission, which has proven to be the most efficient and reliable design by eliminating potential control stage problems and allowing for rapid and efficient load-follow. By incorporating full-arc admission into our design concept we are able to decrease the number of HP inlet valves, thus reducing both installation and maintenance costs.

All of our main steam and reheat valves are directly connected to our cylinders, eliminating separately mounted valves and the complex interconnect piping. Our HP, IP and HP/IP elements are factory assembled and can be shipped with the rotor installed for rapid and simple installation at the customer site.

**LP elements**

Our LP turbines also incorporate many advanced design features. We utilize a fully forged "mono-bloc" rotor for all of our double flow fossil units and use a patented welding technique for IP/LP rotors with combined high-temperature and high-stress requirements. For nuclear applications we have a unique disc-type design that has proven to be stress-corrosion free for over 30 years.

Siemens has a broad range of proven last row blades for both 50 Hz and 60 Hz applications. Our free-standing steel blades and interlocked shrouded titanium blades are ruggedly designed and suitable for both high flow and high back-pressure requirements.

**Turbine arrangement highlights**

The LP inner casing is directly supported on the bearing pedestals that are mounted on the foundation. This arrangement permits the inner casing to expand with the rotor, minimizing relative expansion and eliminating the need for differential expansion monitoring. This also separates the LP outer casing from the blade path, allowing it to be welded to the condenser and thus eliminating the air in-leakage problems associated with a typical flexible connection. Fixed bearing pedestals allow the use of single bearings between cylinders on our fossil units. This feature reduces overall turbine length, simplifies installation and results in smoother operation due to less sensitivity against unintended misalignment as well as significantly lower rotor bending stresses.
Elements and arrangements

**HP/IP elements**

- **H**: High-pressure, single flow, barrel-type turbine
- **HI**: Combined high- and intermediate-pressure, opposed flow, reheat turbine
- **S**: High-pressure, double flow, nuclear turbine (half or full speed)

**LP elements**

- **I**: Intermediate-pressure, single or double flow turbine
- **IL**: Combined intermediate- and low-pressure, reheat or non-reheat, single flow turbine
- **L**: Low-pressure, double flow turbine

*High-pressure rotor with blades*
Exclusive blade technology
for high efficiency

**HP and IP blading**

For over 100 years Siemens has been at the forefront of reaction blade technology. We have continuously improved and refined our blading, striving for the highest element efficiencies and operational reliability by incorporating the very latest developments in blade technology.

Our 3DSTM designs optimize the three-dimensional airfoil shape and the compound lean angle (bow). These designs lower the loading at the base and tip, reducing secondary flow losses. 3DSTM blade technology improves blade path efficiency by 2% over cylindrical designs.

For our advanced 3DVTM blading, we go beyond maximizing individual blade efficiencies. We numerically optimize load distribution across the entire blade path. Our 3DVTM designs provide an additional gain in element efficiency of up to 1%.

Using these advanced techniques, Siemens can now achieve element efficiencies of 92% in high-pressure and up to 96% in intermediate-pressure applications.

Throughout our entire design process we use advanced computer tools to reveal the secrets of fluid dynamics and mechanics for overall steam path optimization. We have automated data transfer to our blade machining tools for minimized tolerances and faster cycle times.

All Siemens drum-type reaction blading utilizes integral shrouds that are preloaded during installation to form a tight continuous ring.

This creates a consolidated unit with excellent vibration damping characteristics, flexibility to withstand thermal transients and no fretting between blades. The ‘best fit’ combination of blade roots, airfoils and integral shrouds allows Siemens to deliver top performance while maintaining the mechanical integrity needed for long-term reliability.

**Last stage blades**

Siemens has over 50 years of experience with the design, manufacture and operation of freestanding blades and has applied that experience to develop a comprehensive range of modern, freestanding and interlocking shroud last row blades. This full line of proven LP blading modules allows us to apply the appropriate blade to achieve efficient, reliable operation for nearly any site condition or customer need.

Our standard last stage blades incorporate conservative, yet sophisticated, designs that impart efficient operation even with high end loading. They are also sufficiently robust to permit operation at high back-pressures, making them ideal for air-cooled condenser applications.

**Erosion protection**

All of our steel last stage rotating blades have flame or laser-hardened leading edges for maximum erosion protection. Siemens also has the ability to apply advanced design techniques in its last row blades to control moisture before it can reach the rotating blades.

Hollow last stage vanes permit the use of a slot on the suction side of the vane, which also removes moisture before it can reach the rotating blades. This hollow profile can also be heated with steam from an upstream extraction to re-vaporize the moisture when conditions require additional measures.
A comprehensive line of LP blading modules to meet site conditions and customer needs.

### Siemens last stage blade lengths

<table>
<thead>
<tr>
<th>Blade family</th>
<th>Rated speed (rpm)</th>
<th>3600</th>
<th>1800</th>
<th>1500</th>
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<tr>
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<td>3000</td>
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<td>22.9</td>
<td>45.5</td>
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<td>26</td>
<td></td>
<td>26.2</td>
<td>52.4</td>
<td>17.5</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>30.2</td>
<td>60.4</td>
<td>20.8</td>
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<tr>
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<td>32</td>
<td>60.4</td>
<td>20.8</td>
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<td>37.6</td>
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<td>12.5</td>
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<td>47T</td>
<td></td>
<td>47</td>
<td>45.1</td>
<td>12.5</td>
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<td>47T</td>
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<td>11.1</td>
<td>12.5</td>
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Precision-forged, free-standing last stage steel blade.
We offer five steam turbine configurations that can be applied in combined cycle application.

Following is an example of a SST-5000 series turbine used in a combined cycle plant.

**Osprey, USA**

**Combined cycle – Reheat condensing turbine**

A SST6-5000 reheat condensing steam turbine is installed in the 540 MW Osprey 2x1 combined cycle plant in Auburndale, FL, USA. At a base rating of 196 MW, main steam and reheat steam conditions are 111 bar / 566°C / 566°C or 1,604 psia / 1,051°F / 1,051°F – yet this SST6-5000 turbine has 284 MW capability when duct fired.
Mainz-Wiesbaden, Germany
Combined heat and power – Reheat extraction condensing turbine

The 400 MW Mainz-Wiesbaden cogeneration power plant set a world record in plant efficiency, achieving over 58% with a SST5-6000 steam turbine rated at 142 MW. Main and reheat steam conditions are 105 bar / 556°C / 556°C or 1,517 psia / 1,032°F / 1,032°F.

Shuweihat, United Arab Emirates
Desalination – Back-Pressure Turbine

This 1,500 MW multi-shaft combined cycle power plant utilizes two single casing intermediate-pressure steam turbines from the SST5-6000 in back-pressure application for sea water desalination. Electrical output is rated at 254 MW each, with main steam conditions being 77 bar / 560°C or 1,110 psia / 1,040°F.
We recommend three of our steam turbine configurations for use in steam power plant applications. Below is an example of one of our supercritical steam power plant projects.

**Niederaussem, Germany**

**Fossil-fired steam – Reheat extraction condensing turbine**

Commissioned in 2002, we supplied the world’s largest supercritical, tandem-compound steam turbine-generator set with a power output of 1,025 MW, incorporating a SST5-6000 reheat extraction condensing steam turbine to realize main and reheat steam conditions of 265 bar / 576°C / 600°C or 3,845 psia / 1,069°F / 1,112°F.
Siemens Power Generation has a unique presence, with over 200 offices located around the world. As a part of one of the largest companies in the world, we leverage Siemens’ strength to better serve our customers. With 30,000 employees and a global engineering, manufacturing and service network, our field-based resources enable us to be a responsive, flexible and dependable “partner.” Through our investment in research and development, we are able to continuously improve our level of service support with new products, tooling, processes and technology. As part of our commitment to being customer-focused, we have established a powerful and responsive global service network with more than 3,000 highly trained field engineers and technicians in regional service offices ready to support power generation equipment and systems operating in over 100 countries. So wherever you are, wherever your plant is located, we speak the language and we are available to provide 24 hours a day, 7 days a week customer service and support.

At Siemens, we want to develop an ongoing partnership to ensure your project’s long-term success. We are committed to serving our customers well after plant commissioning. That is why we offer comprehensive service options ranging from Corrective Maintenance, Preventive Maintenance, Performance Enhancement Programs and Service Agreements to Consulting & Training.

With our extensive knowledge gained through supplying and servicing the power market, we offer an unparalleled level of comprehensive solutions that enable our customers to achieve and maintain competitiveness and profitability. Furthermore, our global diversity and financial strength ensures that we will be there when and where you need us.

### Steam turbine and generator: maintenance schedule

<table>
<thead>
<tr>
<th>Unit years</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
</tr>
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<tbody>
<tr>
<td>Turbine</td>
<td>25,000</td>
<td>50,000</td>
<td>75,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Operating hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator</td>
<td>25,000</td>
<td>50,000</td>
<td>75,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Our extended maintenance schedules on our steam turbines can be aligned with other key plant components, including the gas turbine, generator or boiler, to avoid additional downtime. The first major inspection is recommended at 100,000 equivalent operating hours (EOH) with minor inspections performed every 25,000 EOH.
With a network of more than 3,000 field engineers and technicians in regional service offices around the globe.....

....we are providing leading steam turbine technology for efficient, reliable generation.
Leading technology for competitive, reliable generation

The power generation industry is not a 100-meter dash. It is a marathon requiring the most reliable, most enduring technology. We have been manufacturing steam turbines for over 75 years and many of our steam turbines have been in operation for more than 40 years, demonstrating an outstanding fleet availability. And our track record validates high cycle efficiencies of over 48% with a steam turbine forced outage rate that is less than half of the North American Electric Reliability Council (NERC) average. Our steam turbine fleet is consistently meeting performance guarantees with over 90% of our operating units surpassing guaranteed efficiencies.

High reliability and availability
Our steam turbine forced outage rate is less than half of the NERC average for forced outages

- Forced outage rate: (10 years average through 2002)
- Based on fossil fleet data

0.37%
(Siemens Power Generation)

0.77%
(Industry average)