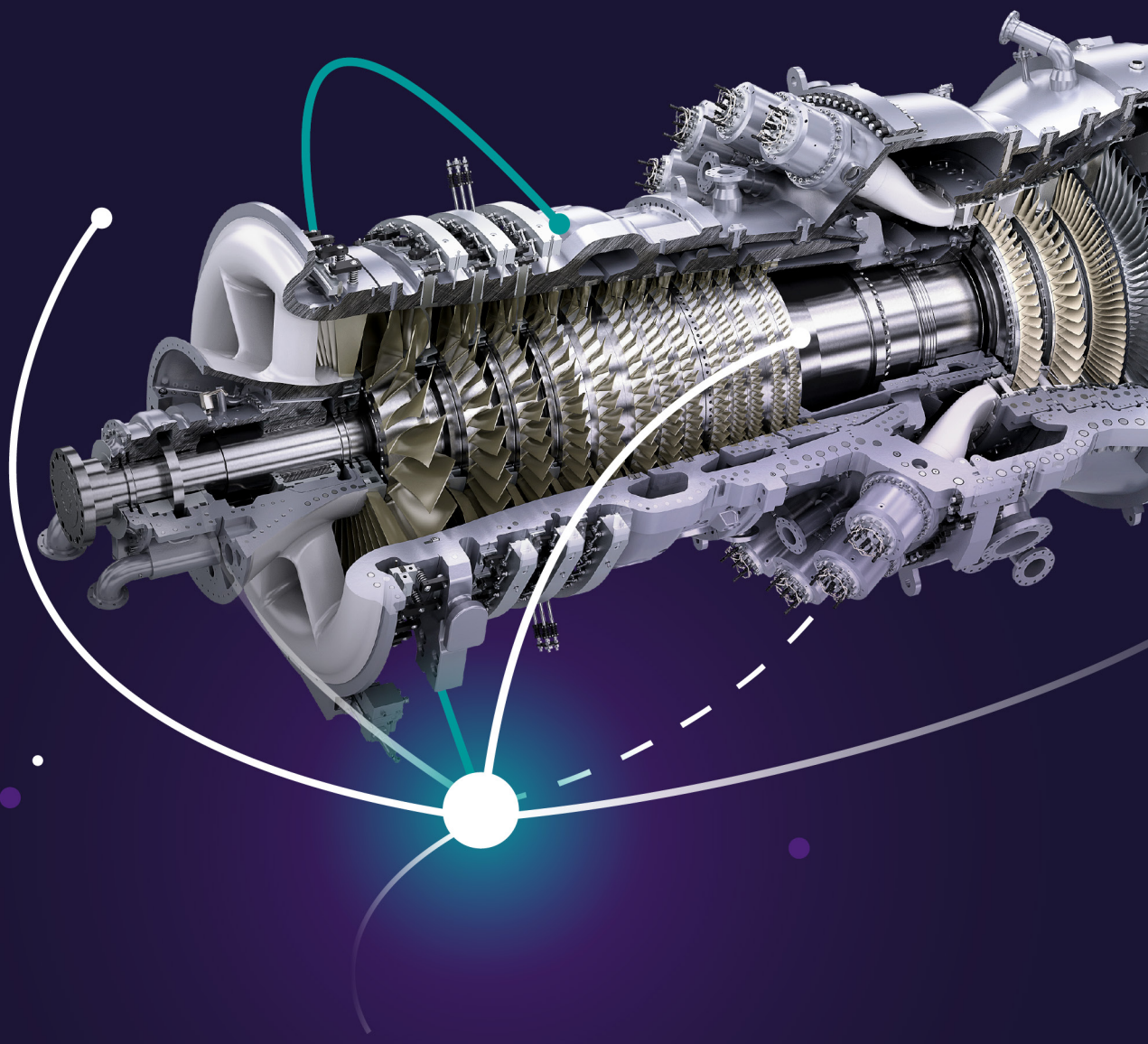
SIEMENS energy

SGT6-5000F modernization portfolio

Gas turbine modernization & upgrades



Revitalize your energy solutions with SGT6-5000F gas turbine modernization

Benefits of gas turbine modernization

24/7

Maintenance interval extension & outage optimization

Improved base load & transient efficiencies

Fuel mix & operational flexibility

Increased power output & revenue

Improved operational & Starting reliability

Improve possibilities by incorporating latest technologies in communication and data processing

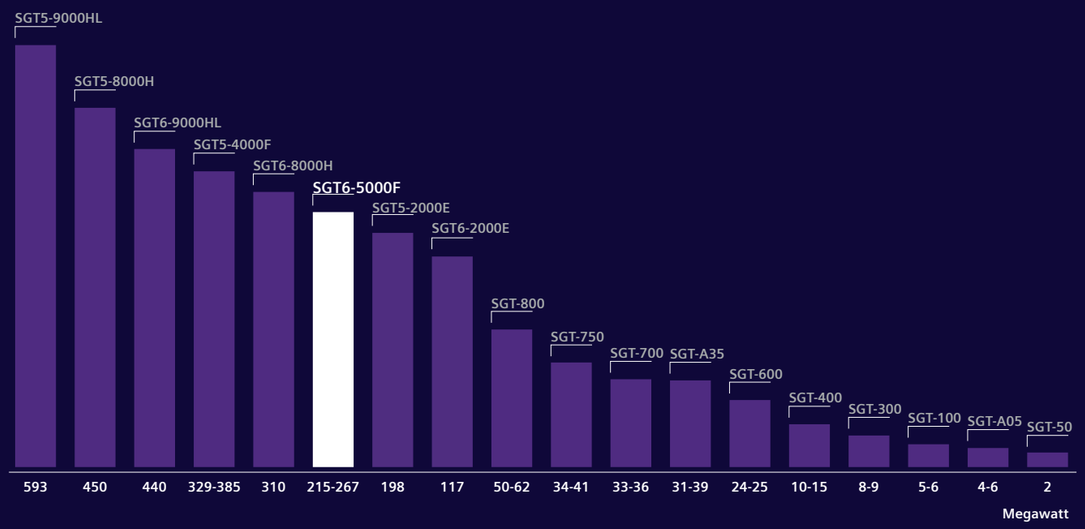


Table of Contents

01 Market and fleet overview
Page 4

02 Design evolution
Page 6

03 Technical features
Page 8

04 Experience
Page 11

05 Increased power and efficiency
Page 12

06 On demand power increases
Page 16

07 Hydrogen economy
Page 22

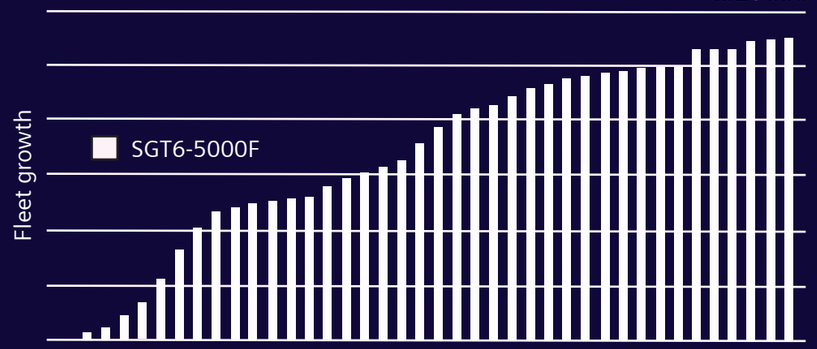
08 Solutions increasing reliability and availability
Page 24

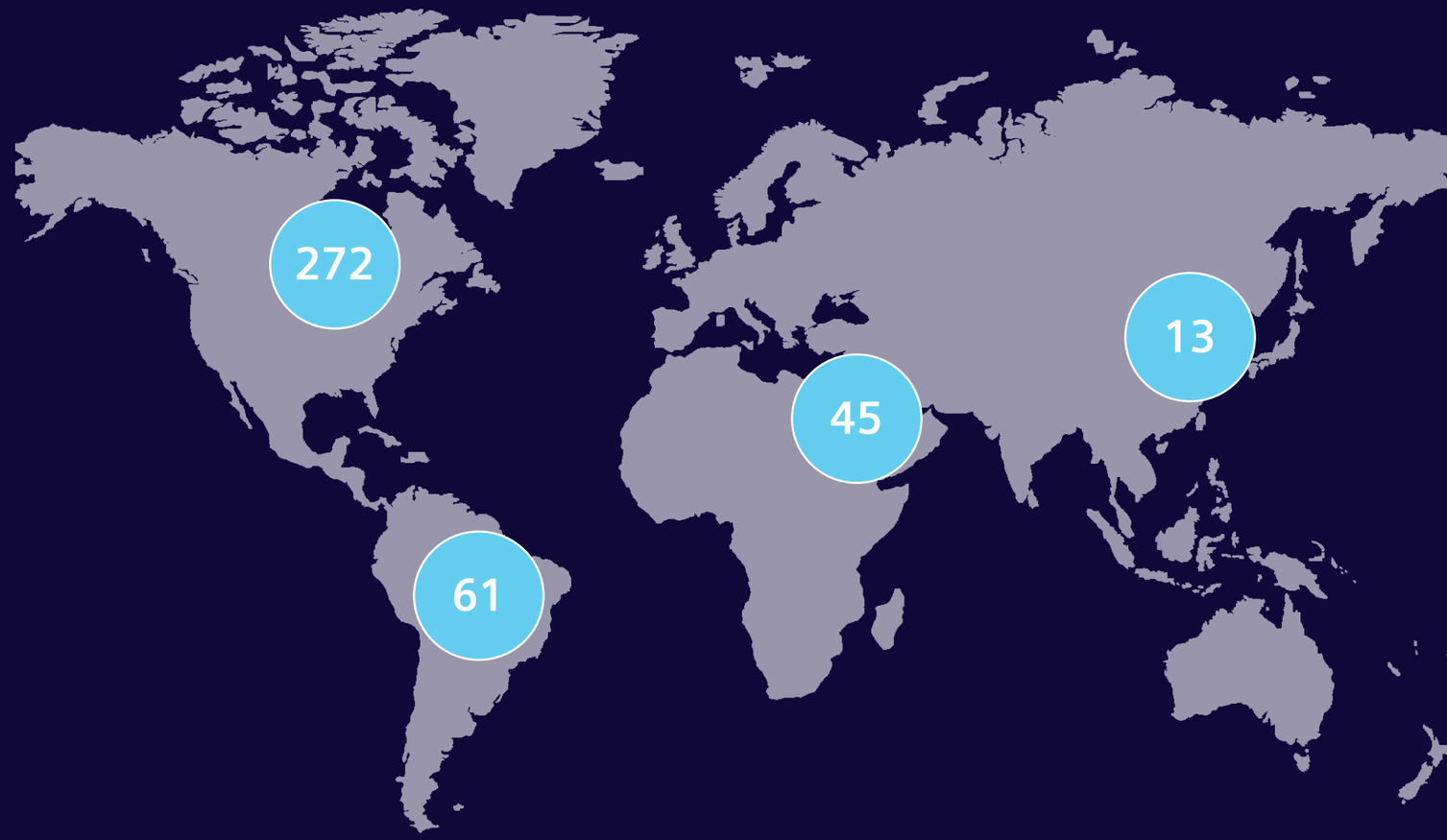
09 Digital offerings
Page 26

01 Market and fleet overview

SGT6-5000F
Global fleet: 350

Ordered / Operating
432 / 350





Siemens Energy fleet experience operating data

Frame (Hz)	kEOH		Starts	
	Total	Fleet leader	Total	Fleet leader
60 Hz	29,345	266	672,621	6,441

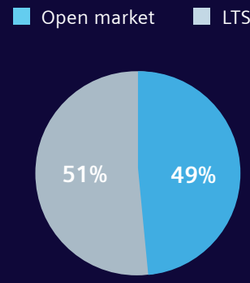
Siemens Energy fleet averages

(FDM: Last 12 months rolling average as of Dec. 2022)

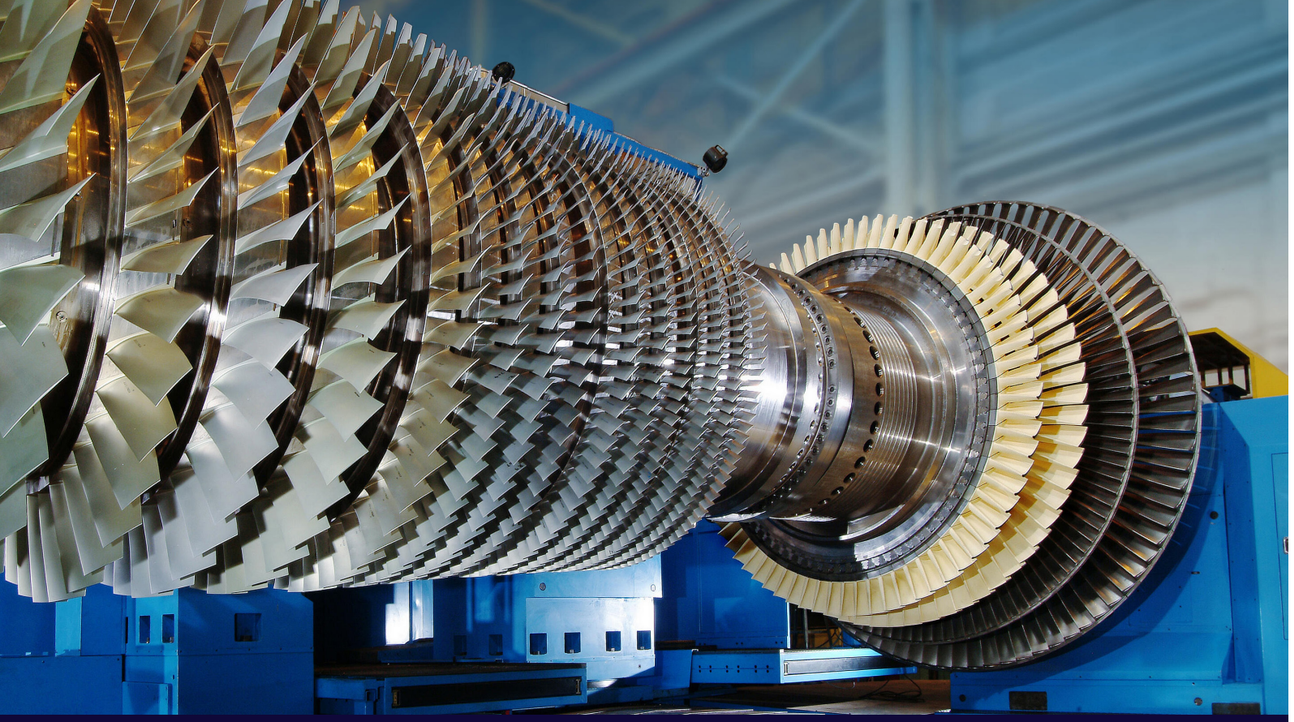
Availability	**96.3%**
Reliability	**99.7%**
Starting reliability	**98.0%**

Service program fleet

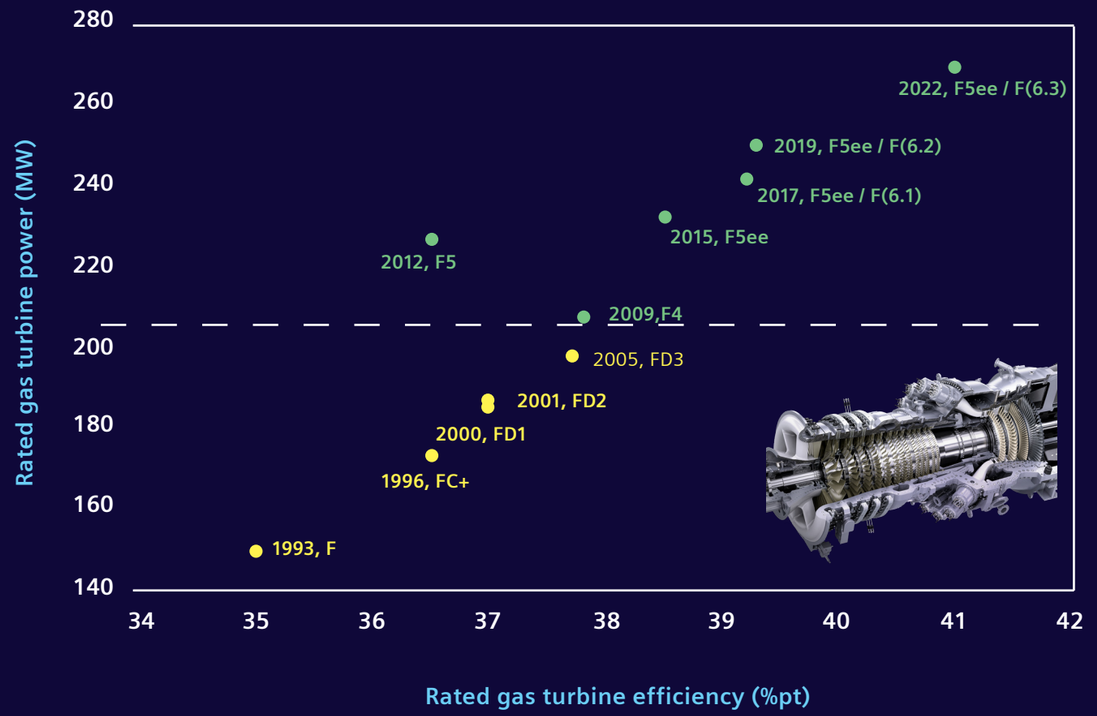
(Siemens Energy service fleet)



Fleet experience in more than 45 countries, across all climate conditions.



02 Design evolution SGT6-5000F



Technology developments to significantly improve performance of mature plants

The **SGT6-5000F** gas turbine offers economical power generation with fast start-up for peak, intermediate, or base load duty. It achieves peak values for reliability and continuous operation with highest performance values in its class.

Today, more than **430 turbines** have been sold. The installed fleet has accumulated more than **29 million** equivalent operating hours, with a fleet **reliability of over 99%.**

- Highest power output for 60 Hz F-class
- Fast start-up and load changing capabilities
- Low emissions with an NOx emissions of ≤9 ppmvd on gas and ≤25 ppmvd on oil

>430

Gas turbines sold

Fuel can contain up to

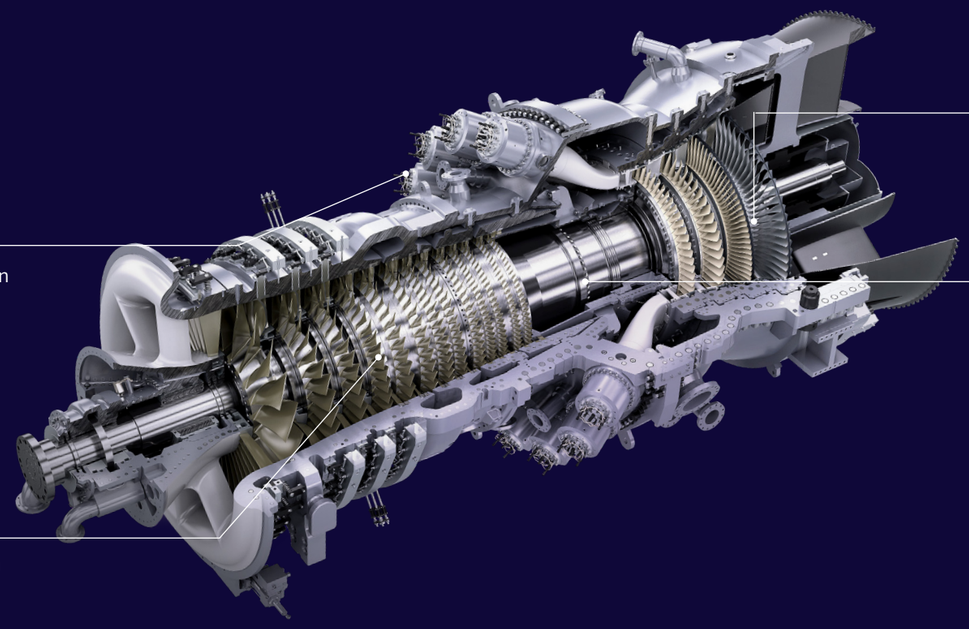
30%

hydrogen (by volume) with DLE burner

>29 million

Equivalent operating hours of fleet experience

03 Technical features



Combustion

- Fuel flexible and proven Ultra Low NOx combustion system
- Single digit emissions down to 30% load.

Compressor

- Variable guide vanes for part load efficiency and transient operation
- Blades and vanes replaceable without rotor lift or rotor de-stacking

Turbine

- Four stage turbine with proven conventionally cast turbine alloys
- Low firing temperature for long service intervals

Rotor

- Built disc-type rotor with radial hirth serrations. Light-weight, highly rigid design with excellent start-up performance and high cycling capability
- External rotor air cooler for constant cooling air temperature across the ambient range

Capable to burn **30%** H_2 hydrogen

Improved base load & transient efficiencies

24/7

Maintenance interval extension & outage optimization

Fuel mix & operational flexibility

Performance data for simple cycle power generation

Power output	up to 267 MW(e)
Fuel (examples)	Natural gas, LNG, sour gases, LPG,distillate oil, bio-diesel, Arabian Super Light crude oil (ASL), Arabian Extra Light crude oil (AXL),crude oil, kerosene, jet fuel, condensate; other fuels on request
Frequency	60 Hz
Gross efficiency	40.0%
Heat rate	9,000 kJ / kWh (9,611 Btu / kWh)
Turbine speed	3,600 rpm
Pressure ratio	19.5:1
Exhaust mass flow	586 kg/s (1,292 lb/s)
Exhaust temperature	592 °C (1,098 °F)
NOx emissions	~ 9 ppmvd at 15% O2 on fuel gas (without water injection for NOx control), ~ 25 ppmvd at 15% O2 on fuel oil (with water injection for NOx control)

Performance data for combined cycle power generation

Siemens Energy combined cycle power plant	SGT6-5000F 1×1	SGT6-5000F 2x1
Net plant power output	391 MW(e)	790 MW
Net plant efficiency	60.5%	60.7%
Net heat rate	5,950 kJ / kWh (5,640 Btu / kWh)	5,930 kJ / kWh (5,621 Btu / kWh)
Number of gas turbines	1	2
Pressure/Reheat	Triple/Yes	Triple/Yes

SGT6-5000F Focus

- Increase flexibility
- Unlock new capabilities
- Improve power and efficiency
- Expand operational profile



04 Experience

Siemens Energy is a global leader in energy technology. The company works with its customers and partners on energy systems for the future, thus supporting the transition to a more sustainable world.

With its portfolio of products, solutions and services, Siemens Energy covers virtually the entire value chain.

Today, more than 400 units of SGT6-5000F gas turbines have been sold resulting in a fleet experience of more than 29 million equivalent operating hours (EOH).

The SGT6-5000F fleet's overall best-in-class reliability constantly exceeding 99%.

Our decades of extensive operating experience has yielded

Excellent operational and fuel flexibility:

The SGT6-5000F offers dual fuel capability and excellent fuel flexibility. It can accept low calorific gases or gases containing CO_2, H_2, and N_2, as well as with crude oil and other liquid fuels with high viscosity. The engine, equipped with Dry Low Emission (DLE) combustion system, is already capable to process up to 30 vol% of hydrogen (H_2).

- Rotor exchange capability
- Extended inspection intervals
- Reduced outage time
- Increase runtime between outages

Best-in-class fleet reliability & availability:

The extensive fleet operating experience of the SGT6-5000F lets you benefit from best-in-class fleet reliability of >99%. It's robust turbine design is continuously enhanced by high-performance upgrades.

05 Increased power and efficiency

Power and efficiency increase

Advanced Turbine Efficiency Package (ATEP)

Thermal Performance Upgrade (TPU)

Global trends are advocating that gas turbines increase power production while improving their efficiency and reducing carbon footprint.

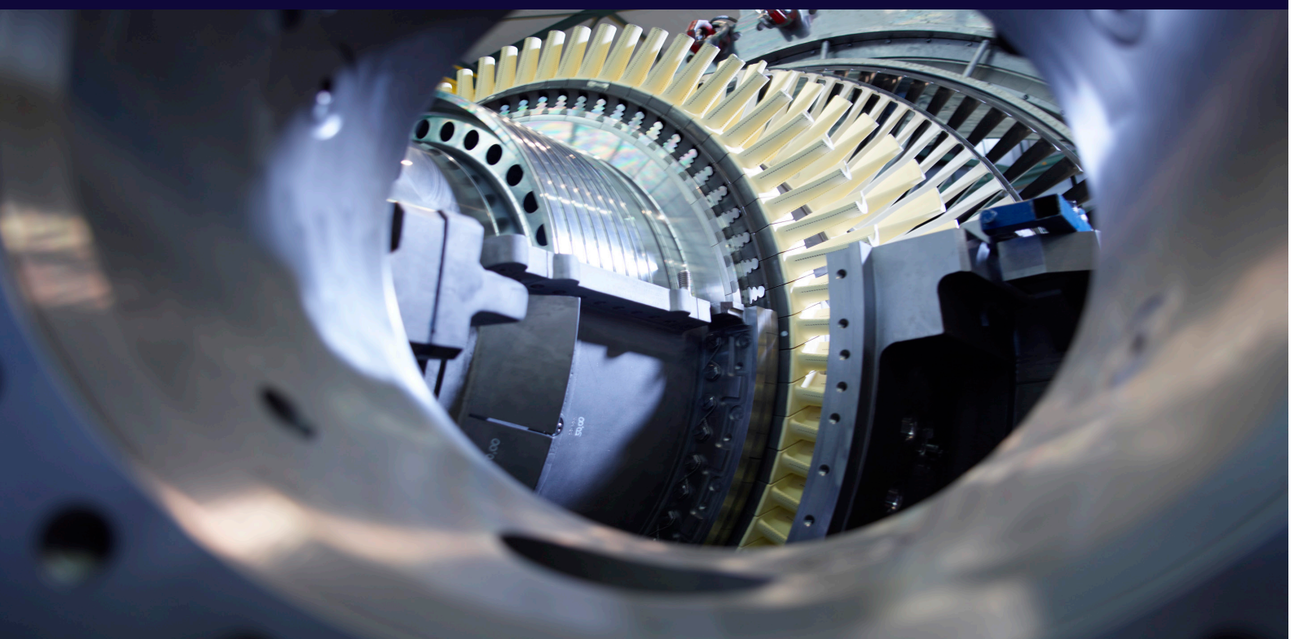
The Advanced Turbine Efficiency Package (ATEP) is designed to provide increased power and overall efficiency upgrades to your existing machine, enabling greater sustainability and ability to satisfy market demands.

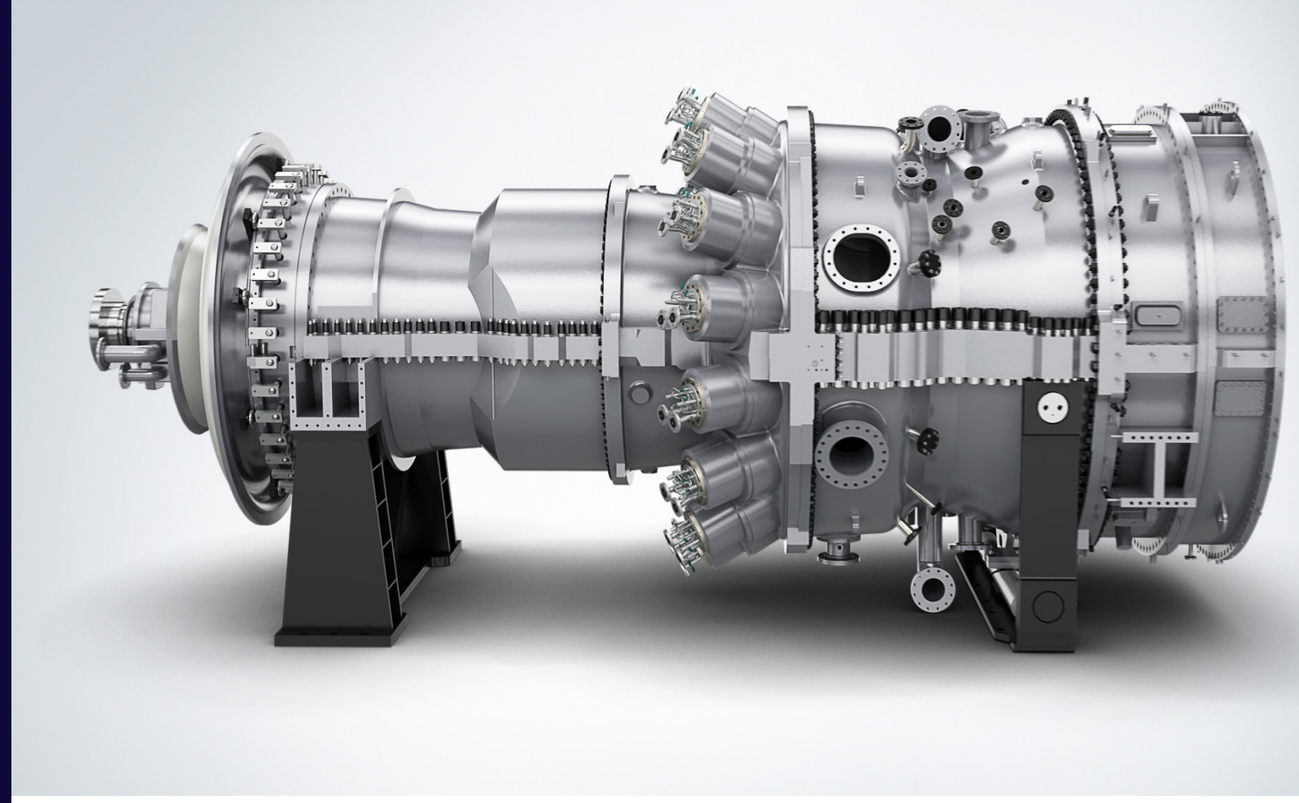
Gas turbine updated with ATEP, can enhance your turbines capabilities by updating your gas path with the most advanced materials, design and geometry. Plants equipped with up to date machinery can help satisfy the growing global energy demand and improve your ability to meet changing dispatch requirements.

Higher production capabilities can result in higher revenue, lower operating costs and reduced specific carbon footprint.

The ATEP updates your turbine with the most advanced Siemens Energy hardware technologies enabling you to reduce your electricity production cost and increase competitiveness through improved power and efficiency.

ATEP can provide up to 28 MW power output increase, 572 BTU heat rate improvement per turbine, depending on your current configuration, while reducing specific CO_2 emissions.





Competitive advantage

Advanced turbine efficiency package

Efficiency:

Fuel represents the highest cost item in the power plant equipped with a gas turbine. Improvement in efficiency enables reduction power production cost and may provide advantage over competition and better positioning on the energy market.

Power:

Increased base load power raises the total output of the power plant and overall power production potential, utilizing same equipment. Plants in areas with capacity incentive structure, will benefit from automatic increase in passive capacity income.

Sustainability:

One of the ways to achieve reduction in carbon footprint is by reduction in fuel consumption.
Reduction in relative carbon emissions, can translate to significant cost savings in locations with imposed carbon tax.

Increased power and efficiency as a tailored upgrade

Power and efficiency increase

Advanced Turbine Efficiency Package (ATEP)

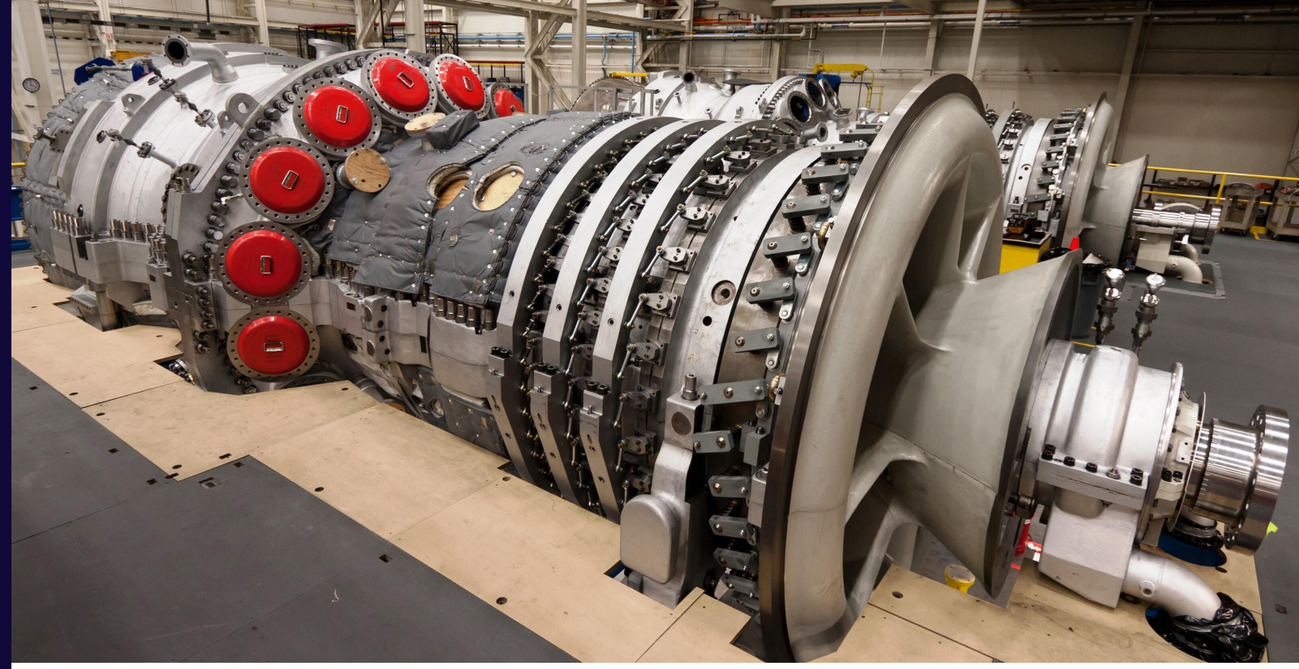
Thermal Performance Upgrade (TPU)

Global trends and predictions are forecasting increase in energy consumption in near future. To fulfill the demand, a significant increase in available capacity is expected. As the demand for new power plants is increasing, so is the demand for capacity increases in the existing power plants. Siemens Energy have the capability to provide tailored and cost effective turbine upgrades to improve the plant's power capacity.

Partial gas turbine upgrades are a great way to optimize your plant with upgrade solutions, providing capacity increases to match existing equipment without requirements for other major upgrades to balance of plant equipment. Partial upgrades will allow for increased power production which is ideal for competitive markets with growing energy demand. Thermal performance upgrades replace component parts with advanced technology allowing improved performance.

Increase in plant capacity and possible improvement in efficiency can help the plant remain competitive in future markets and provides an opportunity to generate higher revenue while reduce specific fuel cost.





Thermal performance upgrade

Tailored upgrades allow you to precisely choose which options you prefer, utilizing parts and upgrades with the highest value for your plant. Thermal Performance Upgrades enable increased power output and improved efficiency of the gas turbine.

The tailored upgrades may affect the compressor and turbine hardware up to complete rotor changes based on cost effectiveness and improvement value. Performance improvement can be matched to existing plant equipment avoiding major changes.

Competitive advantage

Efficiency:

Efficiency gains will reduce fuel relative fuel cost as well as carbon emission.
Fuel cost reduction directly improves competitiveness of the plant or yield higher profits.

Power:

Increased capacity allows for higher generation capability, providing increase in revenue possibilities.Plants with capacity contracts, can benefit from the output improvement, resulting in increased profit.

06 On demand power increases

With fluctuating demand and variable pricing within power generation, upgrades increasing flexibility are rising in demand. The growing renewable energy market is introducing volatility into the energy market, and will exponentially increase the demand for fast acting intermittent power to offset the inconsistency in the grid.

Volatile market situation provide opportunity for highly valued and well paid intermittent power demand.

Gas turbines equipped with Wet Compression have a capability to increase gas turbine power output above typical base load for a periods of time. This ability can allow users to capitalize on sudden increase in market demand, where intermittent increase in power output have a possibility to result in high revenues, or profits.

Although the Wet Compression system utilizes demineralized water during its operation, it is expected that the high market prices will more than compensate the increased operating costs.

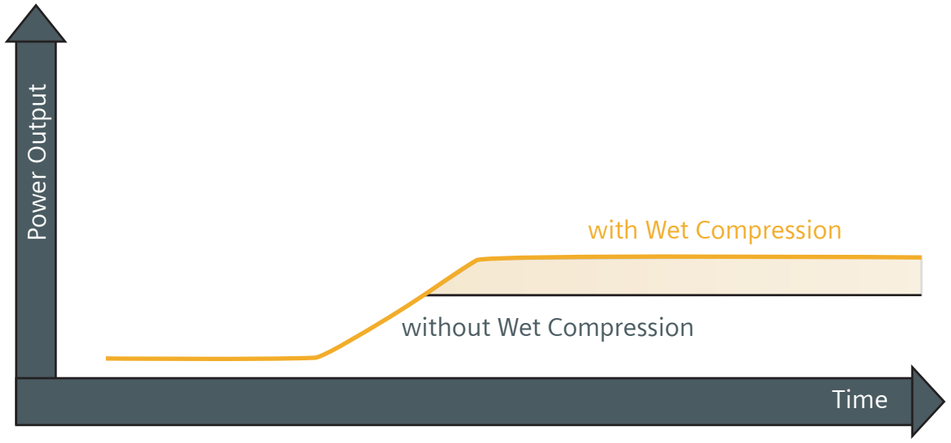


Power and flexibility solutions

Wet Compression

Inlet Fogging

Add a feature to your gas turbine that will be able to fulfill sudden and lucrative power demand. Quickly and easily increase the amount of power gas turbine produces allowing you to capitalize on the unplanned or unforeseen market needs.



Competitive advantage

Power:

Wet compression can increase gas turbine power output by up to 20%. Reliable and proven method of generating additional power beyond the base load.

Flexibility:

Allows for operational flexibility for intermittent power demand. Wet compression can be utilized independent of relative humidity. With a push of a button activate the fast acting system and watch the megawatts rise.

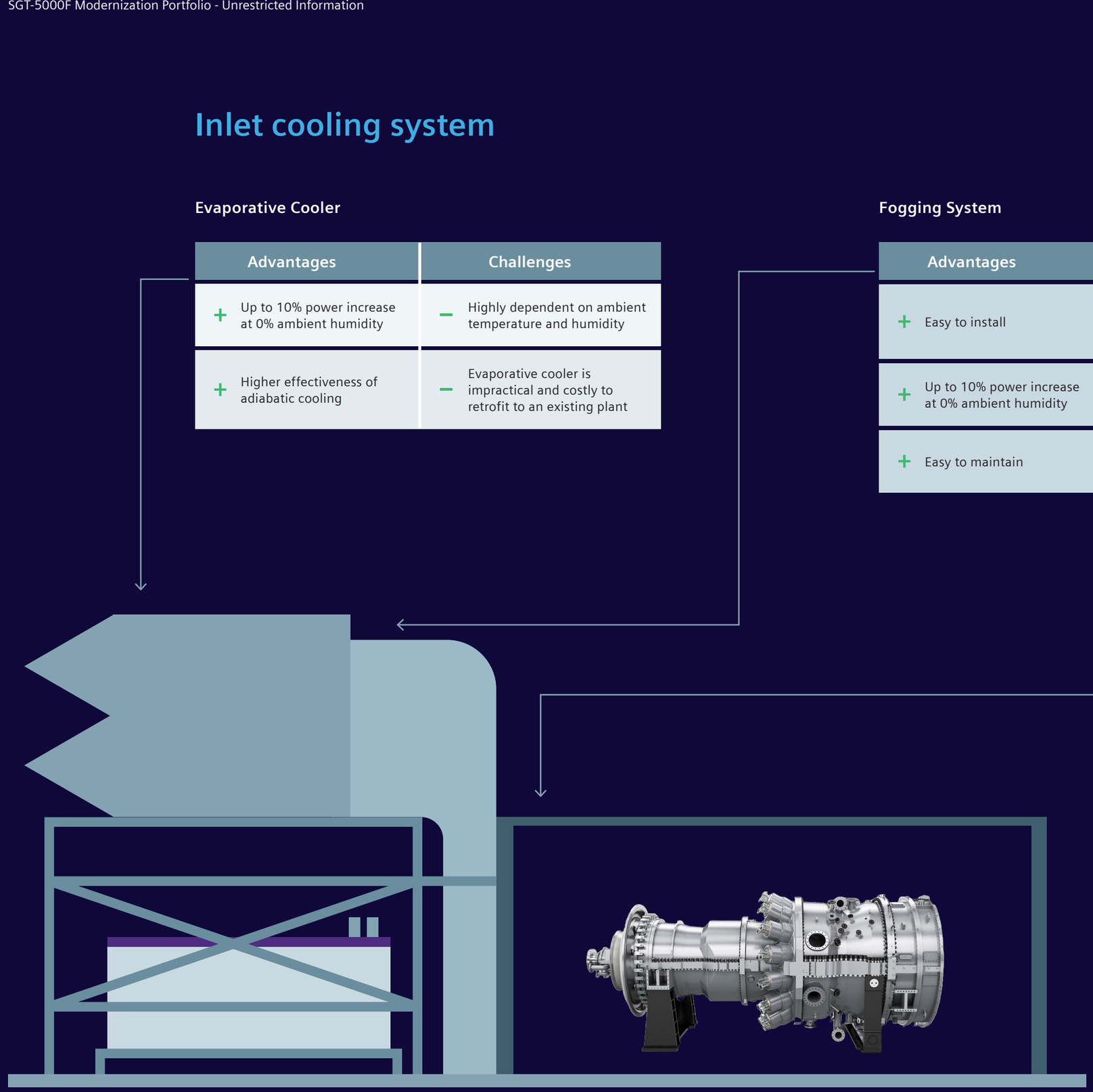
Inlet cooling system

Evaporative Cooler

Advantages	Challenges
+ Up to 10% power increase at 0% ambient humidity	– Highly dependent on ambient temperature and humidity
+ Higher effectiveness of adiabatic cooling	– Evaporative cooler is impractical and costly to retrofit to an existing plant

Fogging System

Advantages	Challenges
+ Easy to install	– Highly dependent on ambient temperature and humidity
+ Up to 10% power increase at 0% ambient humidity	– Lower effectiveness of Adiabatic cooling
+ Easy to maintain	– Demineralized water is required



Wet Compression (WetC)

Advantages	Challenges
+ Up to 15% power increase	– Compressor coating for all stages required
+ Power increase independent of ambient conditions	– Demineralized water is required
+ Higher effectiveness of adiabatic cooling	



Power and flexibility solutions

Wet Compression

Inlet Fogging

In locations with hot and dry ambient conditions the gas turbine is not able to operate to its full potential as the ambient air is at much lower density.

Inlet fogging can provide improvement to compressor inlet air, during these unfavorable conditions by increasing relative humidity, decreasing temperature and increasing air density.

Improving the condition of the inlet air and the gas turbine is able to operate closer to its design conditions, providing additional power and efficiency, increasing the plant production and revenue.

Inlet fogging can increase mass flow and decrease compressor inlet temperatures. While specific results vary based on ambient conditions, the deployment of inlet fogging system may increase the gas turbine power by up to 10% and its efficiency by up to 1%.

Competitive advantage

Efficiency:

Improves efficiency up to 1% resulting in lower specific fuel consumption and reducing specific cost per generated power.

Power:

Generates up to 10% of additional power while at base load. Additional power production improves plant revenue.

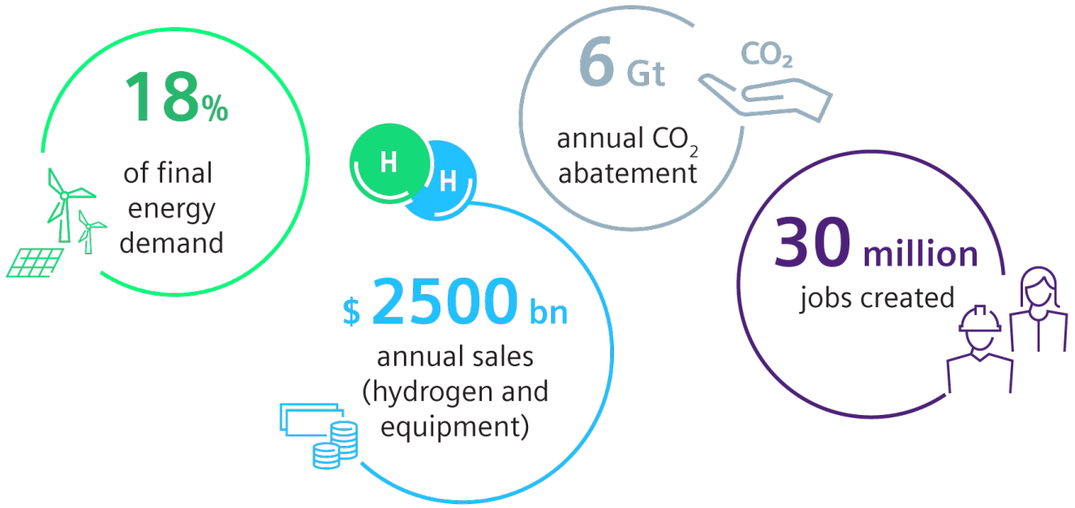
07 Hydrogen economy

Some forecasts predict a future where conventional fossil fuels will not be a widely used for power generation. In this future alternative of a decarbonized world, gas turbines and combined cycle plants will be operating on sustainable fuels, such as hydrogen, and will complement renewable energy with dispatchable, carbon-free supplement power to grid during the off periods.

As of today the SGT6-5000F is capable of accepting fuel containing up to 30% of hydrogen by volume. Some Siemens Energy gas turbine models can already process a fuel mixture containing up to 75% of hydrogen by volume, and extensive R&D programs are in place targeting 100% hydrogen capability within the upcoming decade.

Hydrogen readiness configurations are available to optimize front end installation costs while minimizing costs and disruptions of a later retrofit to newly developed combustion systems.

Hydrogen can be generated utilizing excess renewable energy sources and used as a energy storage medium. By having the capability to utilize stored hydrogen as a fuel, gas turbines may become the prime provider of flexible and dispatchable residual load in a fully decarbonized power scenario while eliminating the risk of stranded assets.



Estimated impact of the Hydrogen in the upcoming decade



08 Solutions increasing reliability and availability

Gas turbine power demand, reliability and availability will play a key role in meeting consumer demands today and in the future.

Additionally, with increased use of renewable energy, the gas turbines will be consistently called upon to fill demand when supplies are limited. Increasing your gas turbine availability while ensuring it's reliability is always a paramount.

This will in turn increase durations between required outages and improve the revenue stream.

Interval extensions and exhaust upgrades are one of the quickest and easiest ways to upgrade the gas turbine allowing for improved availability by utilizing parts with latest technology.



Reliability and availability solutions

Combustion Interval Extensions

Single Piece Exhaust Upgrade

Advanced Two Piece Exhaust Upgrade

Increases in durability, can be achieved by updating combustion system or exhaust components with new material capabilities and design with advanced aerodynamics. The new design of the exhaust section is designed to reduce the potential for cracking and deformation. Longer product life decreases the future maintenance cost.

New combustion systems also provide the possibility to reduce NOx emissions and offer extended parts life. Combustion system updates, in combination with other hardware upgrades and updated exhaust designs, can provide the ability to increase firing temperatures and improve plant thermal performance, causing positive effect on possible plant revenue.

Competitive advantage

24/7

Availability:

Improved component life, reduces the amount of inspections improving the unit's availability. With improved design the required time and cost for repairs is significantly reduced.

Reliability:

Improved design enhances parts durability, reducing the need for a forced outage and extend operational reliability. Upgraded parts may allow for additional improvements in thermal performance.

09 Digital Offerings

PDS Basic
Entry into digital services

The PDS Basic package

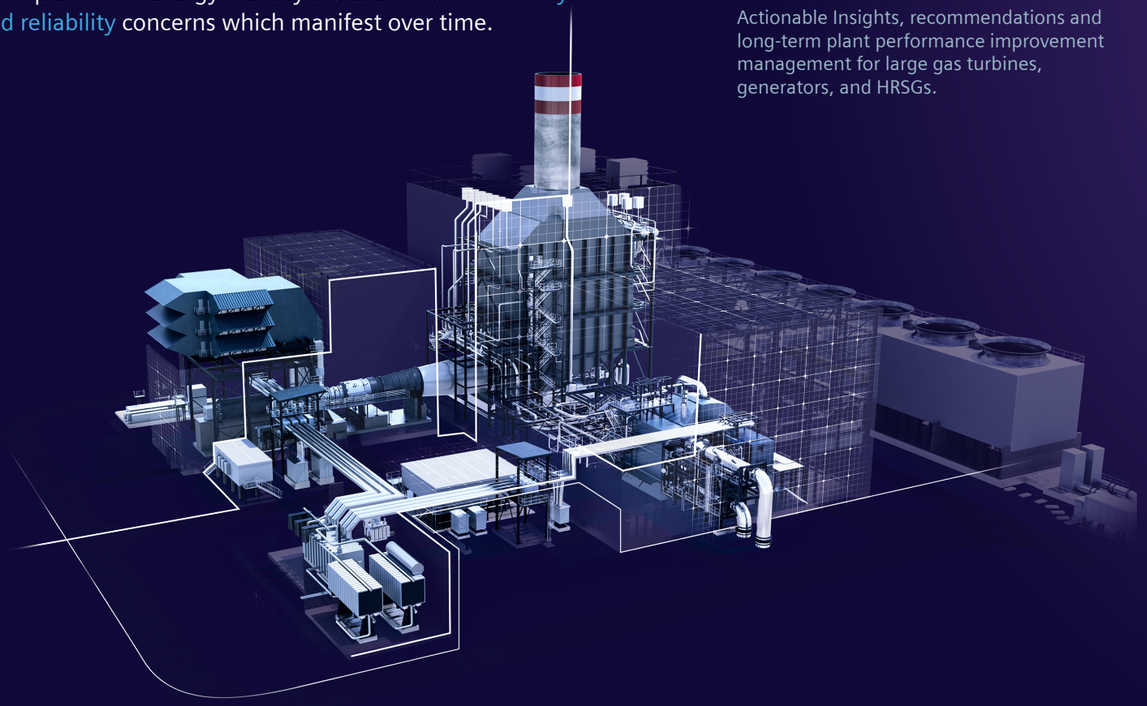
- is the foundation for all Power Diagnostics® Services
- provides effective analysis of long-term trends and identification of subtle deviations in the unit's operating data
- is designed to minimize unplanned shutdown events for issues that may occur greater than 24 hours after a detectable symptom

Siemens Energy has the necessary Fleet knowledge from monitoring more than 800 units for over 20 years.

There are premium add-on service products to enhance PDS Basic package such as PDS Advanced Analytics and Performance Monitoring.

Power Diagnostics® Basic

Analysis of 24h batch data of power train which is intended to help Siemens Energy identify indications of availability and reliability concerns which manifest over time.



Actionable Insights, recommendations and long-term plant performance improvement management for large gas turbines, generators, and HRSGs.



Deliverables:

- Anomaly detection & reporting, historical data analysis, and OEM engineering support
- Access to Siemens Energy specialists through 24/7 Hotline
- Secure transfer of data and remote access via Siemens Energy common Remote Service Platform (cRSP)
- Fleet statistics and notification system
- Interactive access to PDS features in the PDS Web Application or PDS Mobile App, when applicable

Intended Benefits:

- **Increased availability** through early detection of potential equipment issues and communication of focused inspection recommendations to the site
- **Increased reliability** through faster return to service with 24/7 operational support
- **Reduced trips** and **downtime** based on direct communication and collaboration with our specialists
- **Remote help** and advanced troubleshooting directly from specialists without the need for a site visit
- **Support** of decision process by providing access to Siemens Energy expertise analyzing fleet data
- **Improved data transparency** of plant assets through digital dashboards and data analysis results

Prevent problems by detecting them before they start

Obtain the advice needed to drive improvement

Maximize thermal efficiencies and minimize business risk

Increase power output and reduce fuel consumption

PDS Advanced Analytics

Combining domain expertise and advanced analytics to provide integrated solutions

Utilizing PDS, remote surveillance of on-site machinery and their dedicated monitoring systems is streamlined, offering expert support in evaluating irregularities from technologies such as GenAdvisor™, Blade Vibration Monitoring, and Blade Health Monitoring systems.

An Overview of PDS Advanced Analytics

Certain clients may face constraints with the availability or expertise of personnel to vigilantly oversee the alarms triggered by these bespoke monitoring systems installed at their facilities or might require assistance in deciphering the meaning behind these alerts. Neglecting or misinterpreting the warnings from these monitors could exacerbate the repercussions of an unscheduled outage by prolonging diagnostic and remedial measures. PDS Advanced Analytics steps in to furnish preemptive detection of anomalies, backed by OEM engineering expertise, and ensures continuous access to our specialist team via a 24/7 Hotline for prompt support.

GenAdvisor™:

The GenAdvisor™ Monitoring Platform features a suite of four distinct monitors designed for specific applications:

- Partial Discharge (PD),
- End Winding Vibration (EWV),
- Interturn Short Circuit (ISC) monitoring,
- Along with Rotor Shaft Voltage and Shaft Grounding Current (SVC) analysis.

These monitors are engineered for versatility, functioning both as independent applications or in synergy with other GenAdvisor™ monitors through a unified platform server. This centralized server not only enables simultaneous observation of several generators but also facilitates seamless integration with the Power Diagnostics Center.



Blade Health & Vibration:

Blade Vibration Monitoring (BVM) is a solution aimed at enhancing operational flexibility and potentially increasing blade longevity. It employs a blade tip timing system to gauge vibration amplitudes in a steam turbine during operation. Using non-contact sensors, it detects each blade's transit time in the instrumented row, comparing actual to expected timings to calculate blade deflection.

This data helps assess blade vibration behavior, crucial for identifying internal stress and potential fatigue that could lead to blade cracking, premature replacement, or in severe cases, detachment.

Blade Health Monitoring (BHM) tracks changes in blade frequency indicative of cracks in free-standing blades and monitors crack progression.

Accurate interpretation of BVM and BHM alarms demands specialized knowledge. PDS Advanced Analytics for both systems offers expert remote surveillance, delivering comprehensive alarm analyses, pinpointing potential issues, and providing actionable recommendations.

Omnivise Performance Monitoring

Leverage advanced analytics, thermal twin and expert services to enable increased revenue and fuel cost savings

Omnivise Performance Monitoring represents a forward-thinking managed service designed to activelynmonitor thermal performance and deliver insights that enable decisive action. Its primary aim is tonassist in the improvement of gas turbine efficiency, enhancing both heat rate and power output, while simultaneously fine-tuning overall performance.

This service aids customers not only in minimizing their environmental footprint by reducing emissions but also in enhancing the recovery of heat rate and plant power output, thereby ensuring adherence to capacity obligations.

By preemptively addressing performance-related shortfalls, Omnivise Performance Monitoring has the potential to bolster revenue generation for the plant.

The service's ability to swiftly identify and quantify performance losses is pivotal. Through prompt evaluation and corrective action, significant cost savings can be realized. Recovering these losses and pinpointing areas for improvement can lead to substantial financial benefits, underscoring the value of Omnivise Performance Monitoring as an integral component of plant management strategy.

How it works:

1. The "digital thermal twin" enables us to model "actual" vs "expected" plant performance
2. Fast detection is done by an intelligent "alert" database
3. Our specialists analyze the anomaly and recommend actions directly to your performance team
4. Recovery of thermal performance to an optimum state recovers power capacity as well as heat rate, increasing the plant revenue and lowering the cost of fuel.



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