SIEMENS energy

Advanced Operational Flexibility



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The Flex-Power Services™ and Omnivise Performance portfolio offers solutions in the various areas of Advanced Operational Flexibility.



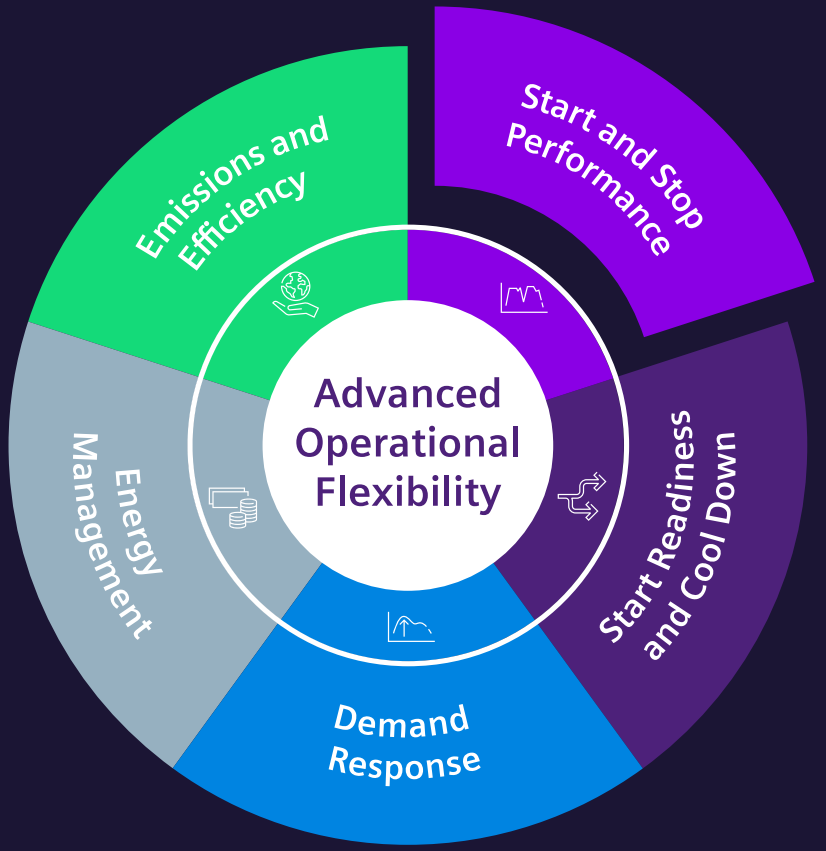
01

Start and Stop Performance

Products and solutions supporting power on demand are intended to enhance Start and Stop Performance and can include upgrades designed to decrease waiting times for water-steam cycle warm-up, decrease or even eliminate holding times and increase ramp rates of steam turbines (ST) and/or gas turbines (GT).



A shortened start-up or shutdown time may not only increase flexibility, but also support a reduction of fuel consumption and associated emissions in these operating conditions.



Hot Start on the Fly

Intended benefits

After an overnight shutdown, operators might be forced to restart in an unprofitable spark spread time period with poor gas turbine part load efficiency. Hot Start on the Fly can help to reduce start-up costs by a 4-digit amount per hot start.

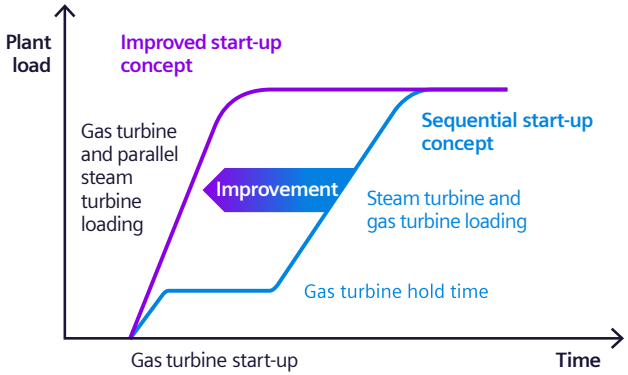


Figure 1: Start-up process with steam turbine Hot Start on the Fly procedure (illustration only, not to scale)

Benefits in a nutshell

- Increased start-up efficiency
- Significantly reduced combined cycle start-up time
- Higher plant load transients due to combination of GT & ST load output, resulting in reduced specific start-up costs
- Minimized fuel consumption for start-up
- Reduced CO-emissions during start-up

Scope

After an extensive assessment of the component limits Siemens Energy implements the modification, such as:

- New high pressure and hot reheat control philosophy
- Modifications within unit master control and major component subsystems
- Implementation of logic changes into the plant's digital control system

Warm Start on the Fly

Intended benefits

A start-up from warm conditions may take considerable time for a power plant originally built for less volatile operating profiles. In competitive markets, the ability to start up your plant faster from shutdown can help reduce time spent in transient conditions with non-optimal efficiency and make a difference in dispatch.

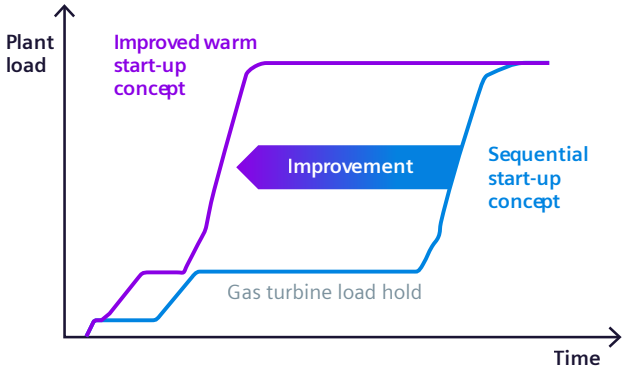


Figure 1: Enhanced warm start-up (illustration only, not to scale)

Has been designed to support

- Increased start-up efficiency
- Significantly reduced combined cycle warm start-up time, in some cases down to below 45 min*
- Reduced start-up fuel consumption by up to 400 MWh_{th}* and reduced associated emissions from reduced start-up time
- Increased responsiveness to transmission system operator

Scope

- Engineering of enhanced control philosophy and component evaluation as needed
- Automation and logic modifications within unit master control and major component subsystems
- Implementation of logic changes into the plant control system; typically no hard-ware required

* 50 Hz F-class 1×1 reference case, example only, actual results may vary

Fast Plant Shutdown

Intended benefits

A plant shutdown may consume considerable time and fuel for the unloading processes. In competitive markets, the ability to shutdown your plant faster can help reduce time spent in transient conditions with non-optimal efficiencies and enhance responsiveness.

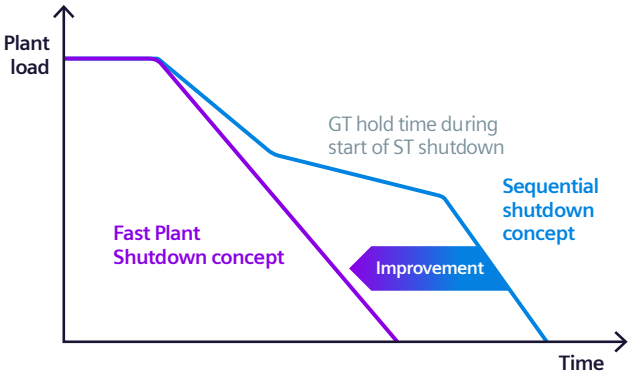


Figure 1: Impact from Fast Plant Shutdown (illustration only, not to scale)

Has been designed to support

- Significantly reduced combined cycle shutdown time, in some cases down to below 15 min*
- Reduced shutdown fuel consumption by up to 100 MWh_{th}* and reduced associated emissions, from reduced shutdown time
- Minimized fuel consumption for start-up
- Minimized fuel consumption for shut down
- Reduced emissions during start-up

* 50 Hz F-class 1S reference case, example only, actual results may vary

Scope

Applicable for combined cycle power plants with Siemens Energy design turbines and control system:

- Engineering of enhanced shutdown control concept and component evaluation as needed
- Automation and logic modifications within unit master control and major component subsystems
- Implementation of logic changes into the plant control system; typically no hardware required

Steam Turbine FlexStart Upgrades

Intended benefits

The steam turbine FlexStart upgrades may include multiple features designed to shorten the start-up time and enhance start-up flexibility, which can support:

- Reduced waiting and warm-up times as well as optimized speed and load gradients
- Increased responsiveness to the transmission system operator (TSO)
- More efficient start-up process
- Potential for reduced fuel consumption and emissions during start-up

Potential Features

- Advanced Fast Loading
- Early Pre-Warming and modified Pre-Warming concepts
- Degassed Conductivity for faster starts of combined cycle power plants

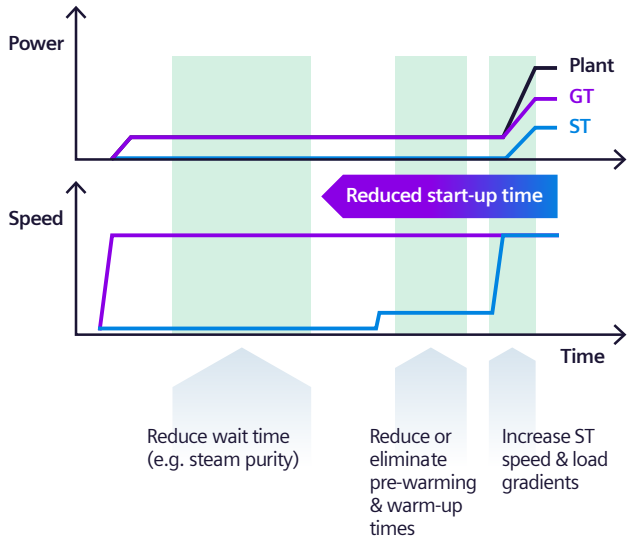


Figure 1: Impact areas for ST FlexStart upgrades (illustration only, not to scale)

Scope

Applicable for SSTx-3000/4000/5000/6000 steam turbines in CCPP:

- Unit-specific engineering evaluation of boundaries and applicable features
- Engineering of necessary adaptations & logic changes
- Implementation of control logic upgrades
- Typically no or only minor hardware required

Gas turbine Gradient Optimization

Intended benefits

Growing market share of renewables and decreasing generation from coal impact revenue streams of GT plants.

- Power prices become more volatile
- Changing grid requirements
- Increasing importance of ancillary services and capacity markets

As a consequence, plants start-up during low price periods in order to be fully dispatchable when market conditions are attractive:

- Start gradient optimization reduces your fuel spending during start-up signifcantly
- Improved start gradient
- Opportunity for fast tertiary frequency support

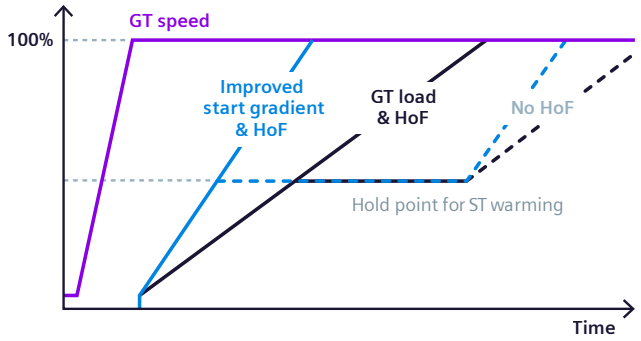


Figure 1: Starting curve for combined cycle – SGT5-4000F (illustration only, not to scale)

Scope

- Modification of I&C logic
- GT tuning for stable combustion with increased load gradients below the IGV range
- Modifying compressor diaphragm grooves with fillet radius

02

Start Readiness and Cool Down

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 can help to safeguard and enhance availability.



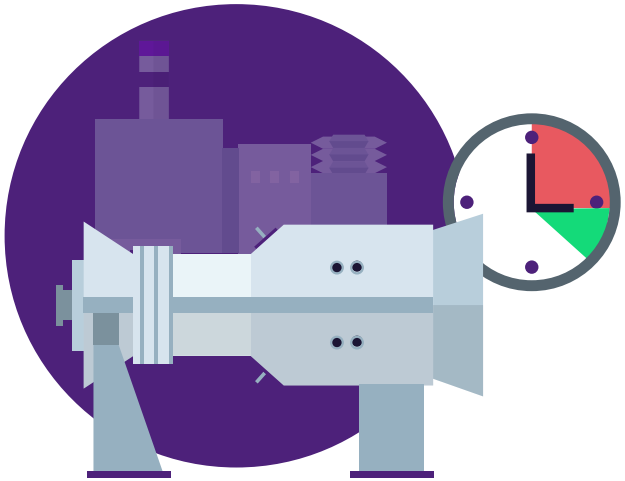
Go-Ready

Intended benefits

The more cooled down key plant components are after a shutdown, the longer the next start takes due to necessary times for achieving relevant criteria for e.g. pressures, steam flow, steam purity, warm-up, etc. In addition, life consumption for thick walled components is typically higher for cold starts. Already after a relatively short shutdown, temporary preservation measures are typically recommended to avoid or limit corrosion impact, which may need significant time to set up and revert prior to next start. Consequently, flexibility and responsiveness for a start after an extended shutdown can potentially be severely limited.

Go-Ready is a comprehensive and modular solution which aims to:

- Keep key components warm or delay cool-down
- Reduce setup time for and partially automate temporary preservation
- Reduce preparation time and effort ahead of next start such that start-up time and life consumption for the next start are possibly comparable to a warm start even after up to two weeks of standstill



Scope

- Plant-specific engineering evaluation of boundaries and components as needed
- Selection of modules and features based on engineering evaluation and customer objectives
- Engineering of necessary adaptations and of enhanced process logic
- Automation and logic modifications within unit master control and major component subsystems
- On-site implementation, operator training and documentation

Fast cooling of steam turbines

Intended benefits

Days of availability can be impacted by steam turbine cool-down times, impacting the opportunity to generate power. With the steam turbine fast cooling upgrade, the I&C system is updated with an automated cool-down control procedure, using the latest optimized parameters for cool-down gradients. The steam turbine fast cooling reduces off grid times and with that improves plant availability.

This upgrade can help to:

- Save up to 3½ days of outage time related to cool-downs compared to natural cool-downs
- Increase availability
- Reduce outage costs

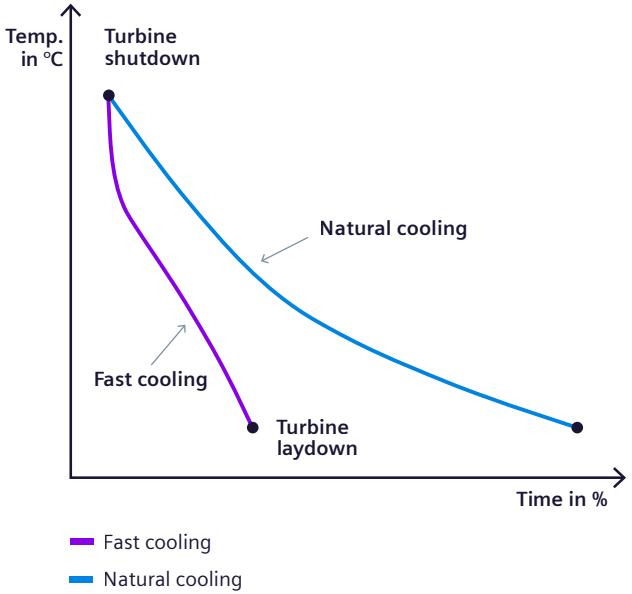


Figure 1: Different steam turbine cool-down procedures (illustration only, not to scale)

Scope

Fast cooling system enhancement options consisting of:

- Engineering solution package including required I&C software changes
- Depending on customer specific requirements and project scope, examples of additional optional scope may include:
  - Strainer and blind flanges
  - Installation services, provided by Siemens Energy field service personnel
- Training
- Documentation update

Flexible preservation for steam turbines, auxiliaries

Intended benefits

Steam turbine standstills can lead to increased exposure to air moisture which can result in parts corrosion. Preservation measures are recommended to remove and control residual moisture to below recommended thresholds. Siemens Energy has developed an enhanced preservation system for steam turbines and its auxiliaries to support more flexible shutdowns and longer standstills.

This enhanced dry air system has been designed to help:

- Reduce the potential for corrosion and resulting damage during shutdowns, contributing to improved reliability
- Reduce time and effort for installing and disconnecting the preservation system after shutdown and during start preparations
- Support better responsiveness and availability through reduced time for connecting / disconnecting to the dry air supply
- Enhance installation ease through redesigned and relocated access points
- Better control of preservation operation through automation and measuring points (optional)

Scope

Applicable for Siemens Energy design steam turbines in CCPP:

- Engineering, documentation and hardware (as needed). Reuse existing dryer(s) as possible
- Optional: Installation of required components (e.g. aditional valves*) and initial start-up of system
- Optional: automation & integration into control system

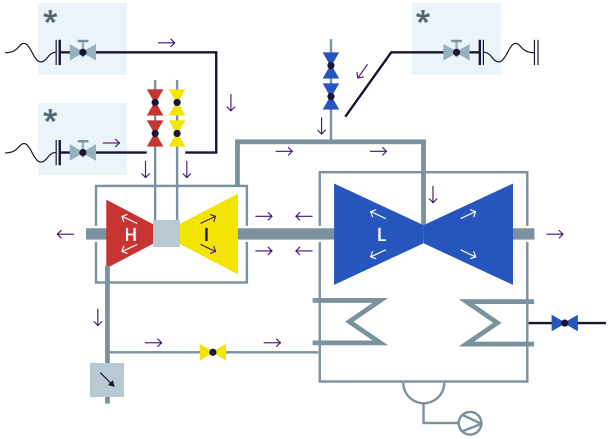


Figure 1: Dry air preservation concept (illustration only, not to scale)

03

Demand Response

Demand Response is intended to reduce minimum load, increase base load and improve grid response.



While on load, upgrades to enhance flexibility can include:

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

Wet compression for Siemens Energy gas turbines

Intended benefits

The customers in a capacity, peak power and hot ambient environment can maximize power plant revenue with Siemens Energy's wet compression (WetC) upgrade. It's a reliable and proven method of generating additional power while at base load.

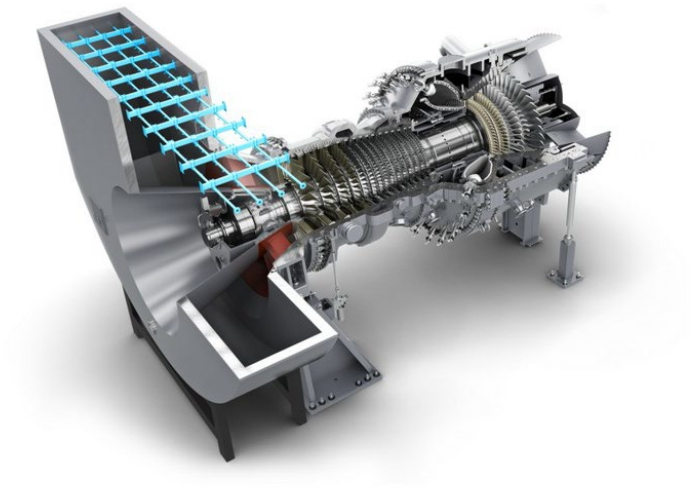


Figure 1: 4000F – wet compression (WetC) (illustration only, not to scale)

Benefits of Wet compression

- Up to 10% additional power output from the gas turbine
- Operational flexibility that can provide additional power on demand
- Independent of relative humidity unlike fogging or evaporative cooling solutions currently in the market which provide less benefit on humid days
- Compensation for reduced power output at higher ambient temperatures

Scope

Wet compression hardware scope* includes the following:

- WetC pump skid injection system
- Spray rack with nozzles designed to optimize droplet size & distribution
- Interconnect piping from pump skid to spray rack
- Integration with the gas turbine control system for reliable operation, surge protection and combustion dynamics
- Compressor coating is recommended to address erosion / corrosion and can extend WetC operating hours per maintenance intervals

* Available for all gas turbines

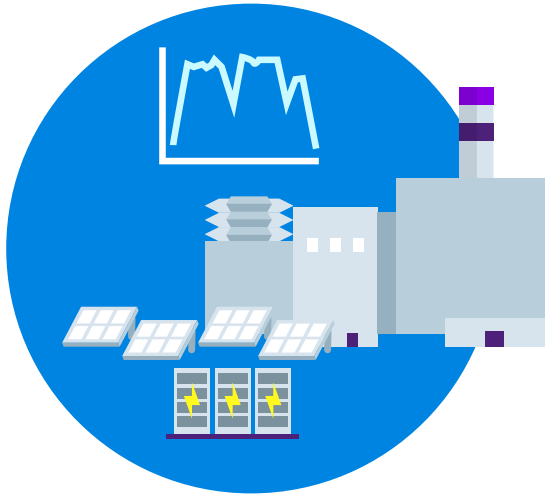
Turn Down

Intended benefits

In the contemporary energy market, there's a growing necessity to optimize part load operation in power plants. Traditionally, gas turbines have been designed for base load conditions. The changing market dynamics now require them to operate efficiently even at low load conditions while complying with CO emissions limits. To solve these challenges, the Turn Down solution was developed, which helps to give the power plant the operational flexibility it needs.

Benefits of Turn Down

- Improved turn down operations
- Optimization of Minimum Environmental Load
- Maintaining CO emissions limits while on low load
- Potential to continue plant operations during low demand periods, instead of shutdown
- Reduced operational costs



Scope

- Developing a holistic approach
- Expertise in managing whole power plant systems
- Providing tailor-made solutions to your specific needs
- Control logic changes

04

Energy Management

Energy markets are becoming increasingly complex due to the influx of new generation assets like renewables, microgrids and the hybridization of traditional CCPPs with storage and other energy assets. All of which makes it more difficult for asset operators to quickly respond and optimize their generation.

Solutions that manage the distribution of generation are needed to economically optimize plant operations:

- Dispatch optimization improving the energy management of your fleet through an optimized generation schedule
- Hybrid controller integration responds rapidly and automated to generation adjustments

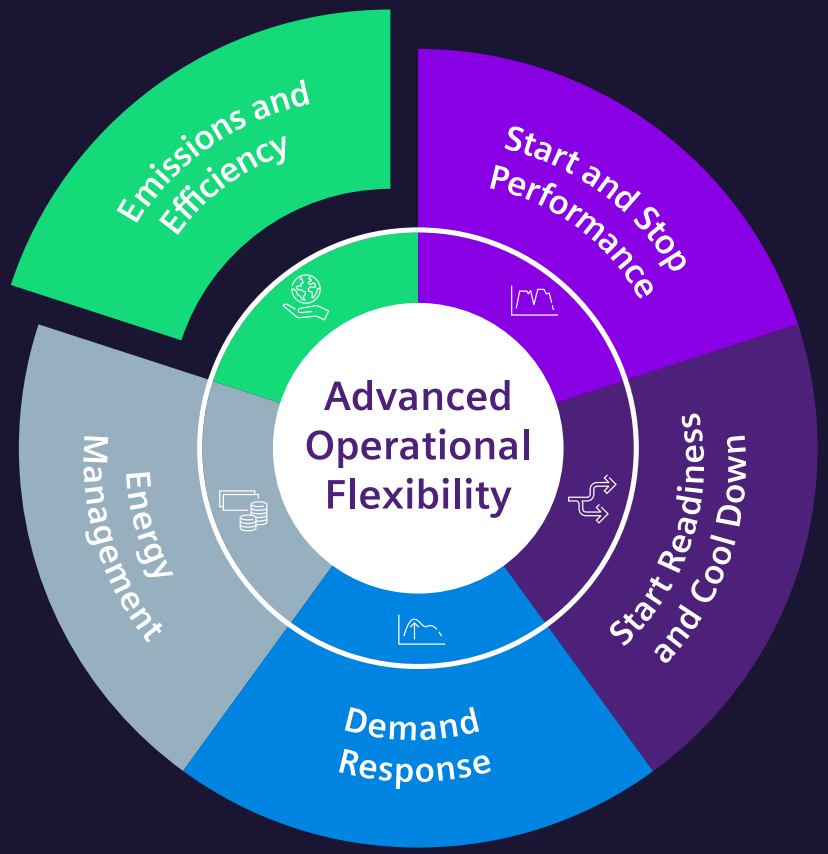


For more information on the Omnivise Performance solutions, please visit the Omnivise Performance webpage.

05

Emissions and Efficiency

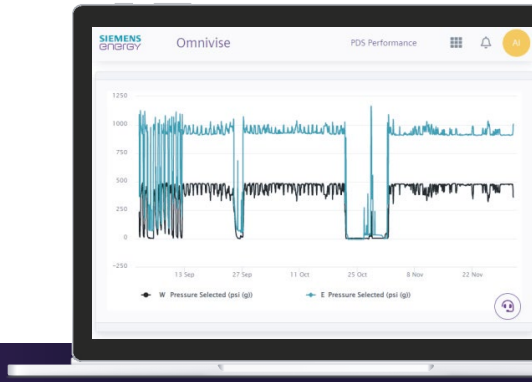
In energy markets with a volatile infeed from various generation sources, combined cycle power plants may find themselves in situations where they need to improve and monitor efficiency and emissions for minimum, part and base load.



Upgrades and Performance Monitoring are intended for:

- Improvement of efficiency especially in part load operation
- Monitoring efficiency and emissions at minimum, part and base load

Power Diagnostics® Performance Service



Intended benefits

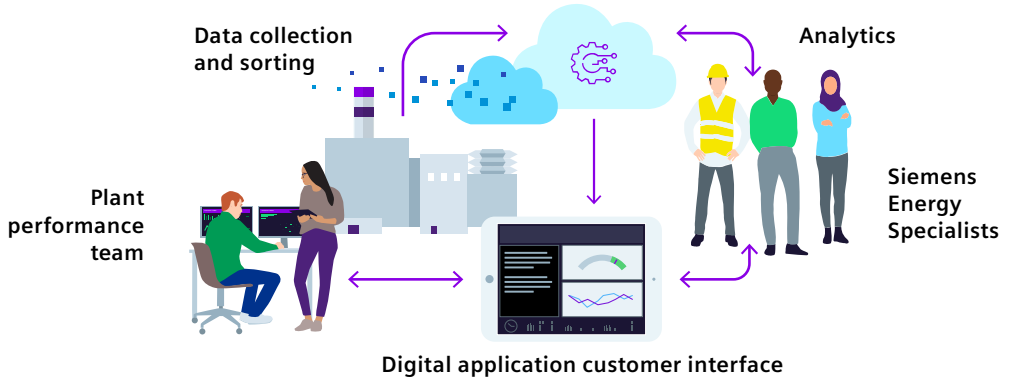
Thermal inefficiencies caused by non-optimal operation, degradation, wear, fouling, leakages, and malfunctions can result in significantly missed generation opportunities over time.

Performance Monitoring can provide:

- Recovery of power degradation
- Fuel cost savings
- CO_2 emission reduction through improvement in efficiency
- Increased revenue from additional power production and capacity payments
- Improvement in maintenance and operation by receiving actionable recommendations from our performance experts

Scope

- **Managed services:** continuous monitoring and reporting with actionable recommendations, and long-term plant performance improvement management
- **Services options:** On premises solution, or remote monitored service by Performance Diagnostics® Performance Services. Only remote monitored service includes expert advice and reports.
- **Plant level diagnostics and analytics:** Latest in diagnostic technologies utilized for prediction and prevention of plant thermal losses in performance
- **Thermal digital twin, specific for each unit:** Utilizing proprietary thermal performance modeling tools, thermal performance deficiencies can be identified and quantified, for the gas turbine only or the entire power plant
- **Digital application:** Interactive access to performance engineer, previous and current reports and recommendations



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For more information, please visit our website:
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