



# System 1\* PEMS Package for GE LM Gas Turbines

## Introduction

The System 1\* Predictive Emissions Monitoring System (PEMS) offered as part of GE's Bently Nevada product suite is specifically designed for GE LM2500 gas turbines in both SAC and DLE configurations and LM6000 gas turbines in SAC configuration. It can predict with high accuracy the level of emissions generated by gas turbines based on ambient conditions, fuel composition and machine operating conditions while taking into account real-time degradations. This unique solution leverages GE's internal aeroderivative gas turbine emissions model developed from fundamental physics and real data collected over many years during testing of these gas turbines. The resulting generalized model can additionally be tuned using periodic data from a temporarily mounted Continuous Emissions Monitoring System (CEMS) for improved accuracy.

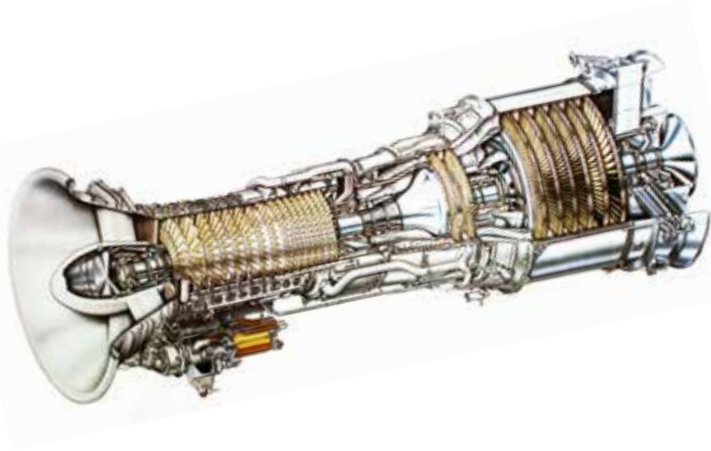
## Emissions Regulation and Issues

Governments around the world have been planning more stringent legislation to measure and regulate the level of emissions by industrial processes. In Europe, there are various legislations coming into enforcement (some based on the Kyoto Protocol) with respect to gas turbine emission monitoring. The most important of these for the offshore industry is the Offshore Combustion Installations (Prevention and Control of Pollution) Regulations. This regulation and others anticipated will require offshore operators to monitor, self-certify and justify emissions of NO<sub>x</sub>, CO, CO<sub>2</sub>, SO<sub>2</sub>, and unburned hydrocarbons to their country's trade and industry authorities.



Traditional estimates of emissions use a "multiplying factor" based on a CEMS audit. The "multiplying factor" applied to fuel consumption over a monthly or quarterly time period is inaccurate because actual gas turbine emissions are dependent on variable operating conditions such as ambient temperature, humidity, power output, machine degradation, and fuel composition. Today, two solutions are applicable to meet regulations requiring higher accuracy—permanently mounted continuous emissions monitoring systems (CEMS) and predictive emissions monitoring systems (PEMS). While a CEMS is preferred—due to its ability for continuous direct measurement, it can be very costly and may not be required or justifiable for offshore platforms.

The System 1 PEMS solution delivers the high accuracy and affordability demanded by offshore platforms. Our solution is designed to immediately serve the large installed fleet of GE LM2500 and LM6000 family of gas turbines.



## The GE PEMS Solution

Today, most offshore platforms perform an emissions test using temporarily placed equipment on an as-needed basis. The lack of any type of models prevents the extension of these tests to other operating regimes (e.g., different ambient conditions) resulting in poor emission estimates.

The System 1 PEMS software solution for gas turbines is based on the first principle fundamental engine emissions model developed by GE. Ambient conditions, various turbine operating parameters, and fuel properties are model inputs. The model is valid for both gas and diesel fuels and computes emissions estimates for NOx, CO and unburned hydrocarbons, while providing calculated values for CO2 and SO2.

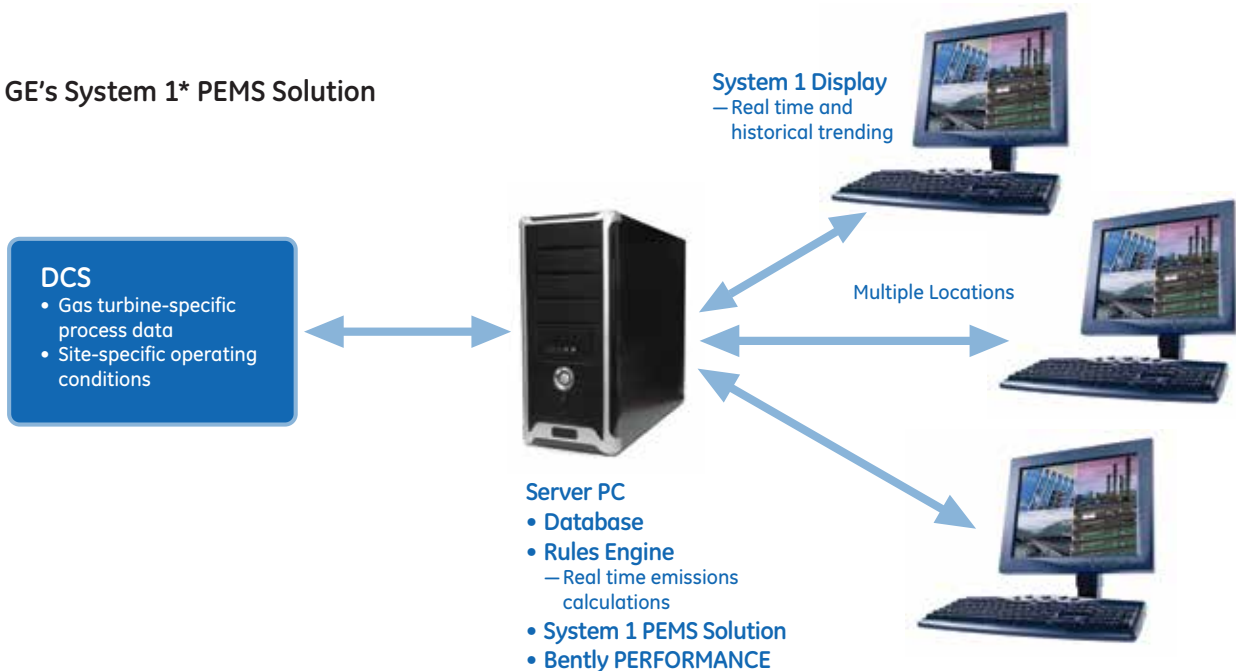
The generalized first principle model is created based on GE's proprietary Applications for Packaged Powered Solutions (APPS) software package. APPS includes physics models that have been developed specifically by GE to model their aeroderivative gas turbines. However, the models are tuned based on locally collected turbine test data. In addition to being highly accurate upon installation, GE's PEMS solution includes a calibration feature—which can be used to adjust the model output based on tuning adjustments derived from temporary CEMS and corresponding turbine data sets. This calibration feature enables improved accuracy and extends the time between calibrations.

Our PEMS solution requires the System 1 and Bently PERFORMANCE\* software applications. Together, these two packages provide an accurate estimate of cumulative CO2 generated over user-specified time periods such as consecutive monthly time intervals. Furthermore, Bently PERFORMANCE provides calculated or derived PEMS input parameters that may not be available online (i.e., unavailable measurements).

## Consequences of Current Practices

Without factoring in real-time machine degradation, ambient conditions and fuel composition, the traditional method of emissions estimation lacks accuracy when extrapolated into different operating regimes. The accuracy may be improved via more frequent CEMS testing for calibration, but it is very costly, especially for an offshore installation. Depending on the specific regulation that is in force, inaccurate emissions reporting may result in fines for the gas turbine operators. Although the offshore emissions regulation is still in its infancy, the accuracy of our solution may enable emissions trading in the future. The current method of factoring fuel consumption lacks sufficient site-specific accuracy and does not enable emissions trading that would reward operator-initiated process improvements.

## GE's System 1\* PEMS Solution



The GE model-based approach is desirable because it encapsulates performance measurements on multiple gas turbines. The model is based on fundamental engine parameters and conditions known to correlate to emissions output. The model can be customized to a specific installation by a calibration procedure using portable CEMS data for improved accuracy.

## Value

- **Lower Cost of Regulatory Compliance.** A PEMS solution reduces the installation and operating costs compared with a CEMS-only solution. The installed capital costs for CEMS on a remote platform can be as much as three times higher than PEMS.
- **Local and Remote Access.** The PEMS and System 1 Display client server can be installed anywhere (i.e., on or off platform) that has access to the required data. System maintenance, configuration and calibration updates do not require visits to the platform which helps to keep PEMS annual costs low.
- **Potential Enabler for Emissions Credits Trading.** Emissions trading is an administrative approach used to control pollution by providing economic incentives for achieving reductions in the emission of pollutants. Companies are issued emissions permits for a specific amount of emissions per year. They are required to purchase emissions permits if their emissions exceed their limits. Likewise, they can sell permits if their emissions are lower than their allotment. Meaningful emission reductions within a trading system can only occur if they can be measured at the level of operator or installation. Therefore, emissions trading is predicated on accurate estimation of past and future emissions.

## PEMS Configuration and Options

The System 1 PEMS solution requires the following:

- System 1 software, version 5.x or later
- Bently PERFORMANCE
- PEMS configuration, tuning, and installation services

For customers with an existing System 1 and Bently PERFORMANCE installation, the PEMS option is a simple add-on module and in most cases, can be installed remotely onshore.

## Supporting Services

GE's Bently Nevada can provide additional supporting services to ensure the System 1, Bently PERFORMANCE, and PEMS solutions have the required inputs of sufficient quality. As the quality of the calculated results is highly dependent upon the quality of the inputs and results, any changes to measurement and/or sensor quality may affect the calculated results. In addition, we can provide a long-term supporting services agreement to ensure our customers derive the most value out of their systems.

The System 1 PEMS solution is designed to be used outside the U.S. regulatory domain. For details on specific applications for your needs, please contact your local sales representative.

For complete ordering information on GE's Predictive Emissions Monitoring System (PEMS), please consult Specification and Ordering Information document 284015-01.

## Service and Expertise ... Delivered

For more than 100 years, GE has provided trusted service and expertise in the design, manufacturing, and monitoring of turbines and other plant machinery. This depth of application-specific experience allows us to tailor solutions that fully deliver your business objectives.



