Thomassen Energy
a Hanwha company

9E Product Offering

Together, Thomassen Energy and PSM now offer complete solutions for the Frame 9E, providing our customers with innovative products and services to lower emissions, extend life, and much more.

Complete 9E Service Offering

Thomassen Energy's complete single source solution brings together engineering capabilities and the innovative solutions of the independent service providers, Thomassen and PSM. With an extensive portfolio of field service, repair capabilities, spare parts supply, innovative upgrades, training and long-term service agreements, our goal is to serve the energy industry with a broad range of power generation equipment worldwide.

Optimizing Maintenance & Operations

Our mission is to lead the way in developing technology solutions, delivered with a wide range of services to help GT owners and operators decrease life cycle costs and improve the overall performance of their turbines and plants. Our Service teams bring you a wealth of expertise and years of experience. We're constantly searching for better ways to help you meet your goals, with an agile entrepreneurial spirit combined with a multifaceted engineering team. This combination has created unique equipment solutions, upgrade options and patented inventions that have improved the reliability and performance of power plants worldwide.

NEW HOT GAS PATH PARTS SOLUTIONS

We provide Frame 9E hot gas path buckets, nozzles, shrouds and compressor hardware. Improved durability and lower life cycle cost is achieved using our component and system product modeling and data evaluation tools, to identify the issues and failure modes in current OEM designs.

We manufacture all buckets, nozzles and shroud blocks to be compatible with the latest 1140C (2084F) firing temperature machines and are also backwards compatible. In normal operation the entire hot gas path has a minimum service interval of 24,000 FFH, which can be increased to 32,000 FFH on a unit by unit basis, with consultation from our experts.

Installation hardware and optional alternative coatings are available based on specific operating conditions such as a heavy corrosion environment.

Buckets

1st Stage:

+ Interchangeable with GE P/N 314B7168G013
+ Base Alloy-111-EA
+ MCrAlY airfoil coating plus internal aluminide diffusion coating
+ 11-cooling hole (8 turbulated) design with vented tip pocket to allow for increased inlet temperatures.

2nd Stage:

+ Interchangeable with GE P/N 314B7169G015 or 314B7169G021 (uncoated)
+ Base Alloy-111-EA
+ 6 camberline cooling hole design with scalloped tip shroud and cobalt base hardface material on the z-notches

3rd Stage:

+ Advanced aero design interchangeable with GE P/N 314B7170G014
+ Base Alloy-738-LC
+ Advanced airfoil shape designed to achieve an improved heat rate and power output if used in combination with the advanced airfoil 3rd stage nozzle

Nozzles

1st Stage:

+ Interchangeable with GE P/N 109E736G015
+ Base Alloy 414
+ Chordal hinge design to minimize cooling air leakage with optional TBC/ MCrAlY coating depending on operating conditions

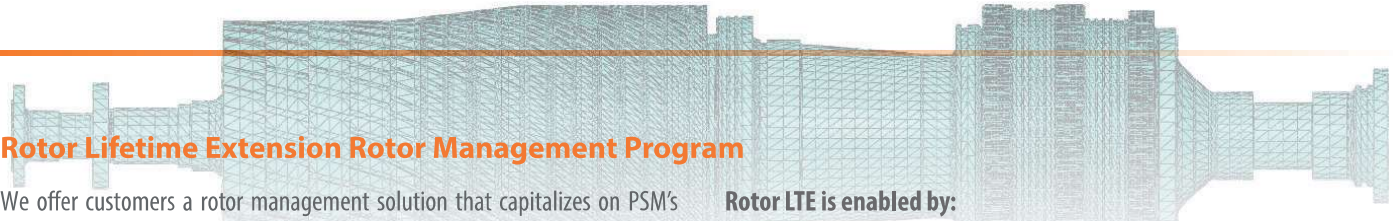
2nd Stage:

+ Interchangeable with GE P/N 119E2064G001 or or 119E2064G024 (brush seal)
+ Option available for brush seal design
+ Nozzle - Base Alloy-939-mod
+ Diaphragm – AISI 410
+ Brush seal configuration will generate an increased power output and improved heat rate. Standard configuration nozzles are coated with Al-Si diffusion coating to enhance oxidation resistance

3rd Stage:

+ Advanced aero design interchangeable with GE P/N 131E3123G007
+ Base Alloy-939-mod
+ Advanced airfoil shape designed in order to achieve an improved heat rate and power output if used in combination with the advanced airfoil stage 3 bucket

Before delivery a harmonic analysis is conducted on all nozzles to verify the assembly sequence. Nozzles are fully interchangeable with other GE group numbers without any modification to the gas turbine.



Rotor Lifetime Extension Rotor Management Program

We offer customers a rotor management solution that capitalizes on PSM's engineering expertise while utilizing Thomassen Energy's design history of the 9E unit and all its iterations. Our Rotor Lifetime Extension utilizes full 3D steady state and transient analysis models combined with advanced NDT inspections in accordance with a complete rotor overhaul. Should indications be found or upgrades deemed necessary by engineering review of past and future run parameters, Thomassen Energy can offer replacement discs and components to achieve longer life and higher efficiency.

Life Time Extension (LTE)

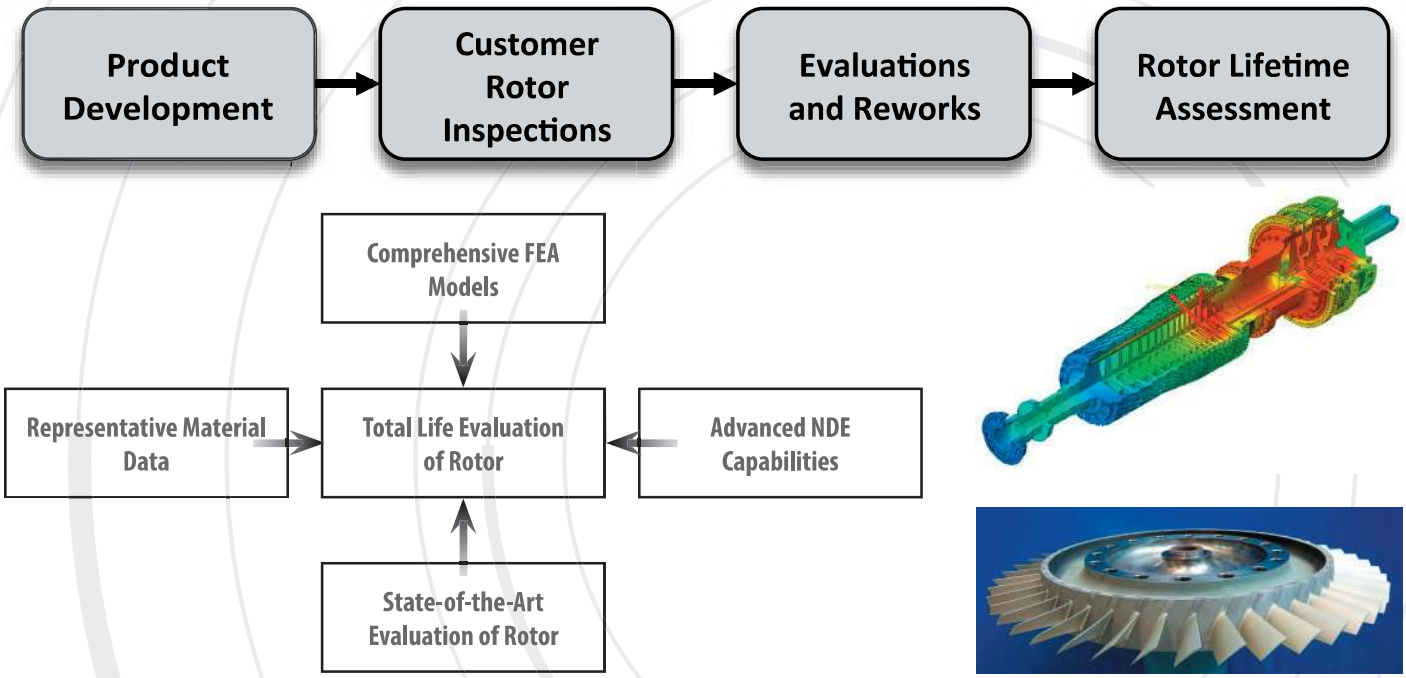
Our Rotor LTE program can extend the lifetime of your rotor. With the advancements in computing power, material properties, fracture mechanic methodologies, and inspection techniques, it is now possible to assess the potential to run rotors beyond their original published limits.

Rotor LTE is enabled by:

+ Advanced non-destructive inspection techniques, utilized to detect surface and volume flaws
+ Full rotor material characterization
+ Full 3D Finite Element Analysis (FEA) models for thermal and structural analysis
+ Inspection results and operational history fed back to the FEA Model

Any problematic flaws identified are analyzed, and a report detailing the predicted remaining rotor capability is generated, empowering owners to make informed decisions about their rotor assets.

Rotor LTE Program + New Disc Manufacturing + Rotor Overhaul = Our Rotor Management Program



ADVANCED COMBUSTION SOLUTIONS

Thomassen Energy and PSM have developed combustion solutions to specifically service market needs worldwide. Major environmental concerns make reducing emission levels a priority for the whole industry and we have developed a number of alternative systems that do just that. As a result, we have broken numerous emission records with our dry low NOx systems. Simply by installing this system to replace conventional combustion in turbines will make a major impact on CO and NOx levels in the environment.

Solution Offerings:

Combustion Liners, Fuel Nozzles, Transition Pieces

+ LEC-III™ and T-DLN
  - Ultra Low Emissions, as low as sub 4ppm, are achievable with the LEC-III™ Combustion System.
  - T-DLN is drop-in compatible with OEM DLN-1 as a cost conscious alternative with 9ppm NOx and dual fuel capability

+ Digitization and Controls

+ Fuel Flexibility

+ Turndown options including Inlet Bleed Heat (IBH) and Exhaust Bleed (ExB) for turndown as low as 40%

T-DLN Combustion System

Thomassen Dry Low NOx System

We offer our T-DLN system for dual fuel customers and customers that do not have ultra low emissions requirements. The Dry Low NOx combustion components have been designed with the experience gained during decades of manufacturing, repairing, commissioning, converting and maintaining gas turbines with Dry Low NOx and Low Emission Combustion technologies.

These components, either as individual parts or as complete system, are suitable as a replacement for existing DLN systems and for conversion of standard diffusion type combustors.

T-DLN Operational information

Emission levels achieved at base load for all models:

+ Gas fuel: 9 ppm NOx and 9 ppm CO

+ Liquid fuel: 42 ppm NOx with water injection

+ Premix operating range nominal 75% to 100% load

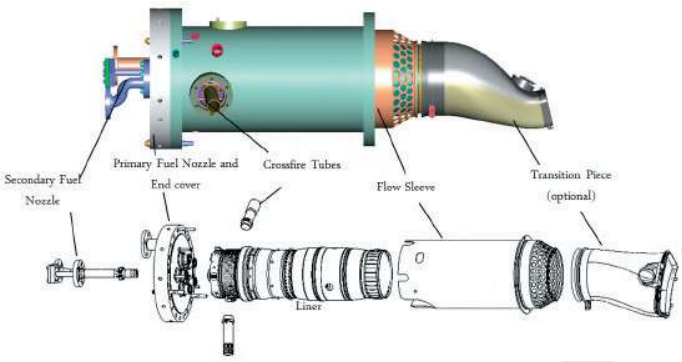
+ Turndown with bleed heat system to 50% load

LEC-III™ Combustion System – Ultra Low Emissions

Since 1998, with the introduction of PSM's first LEC generation, PSM has continuously developed new combustion technology to drive emissions to ultra-low levels. These patented and innovative technologies have allowed the current LEC-III™ systems to operate successfully to as low as <3ppm NOx operating on natural gas, with low single-digit CO, low combustion dynamics, and a large range of compliant turndown from base load conditions. The LEC-III™ system can be implemented as a drop-in, conversion, or individual parts replacement of existing OEM DLN1 systems.

Field Proven 3-5 PPM NOx

The patented LEC-III™ combustion technology, developed, and manufactured by PSM, guarantees sub-5 parts-per-million (ppm) NOx emission levels when operated on natural gas over the entire premix operating range, from baseload down to 80% relative load (respectively 50%-60% with Inlet Bleed Heat system). CO emissions under these conditions are typically measured in the low single digits to meet customer requirements.



Three key design features in the LEC-III™ combustion system enable this improved process and fundamentally differentiate the LEC-III™ from the OEM design: the forward flowing venturi, effusion cooling technology, and an advanced secondary fuel nozzle (SFN).

Summary of Design Features (Forward-Flowing Venturi Design)

The venturi acts as the main flame anchor while the combustor is operating in premix mode. The OEM venturi design dumps spent cooling air at the aft end of the venturi to surround and mix with the reacting/combustion gases. This works to cool down local reaction temperatures which prevents CO from completely oxidizing to CO_2.

PSM has taken a different approach. The PSM forward-flowing venturi design injects the cooling air at the downstream/aft end of the venturi, which flows toward the primary zone and eventually discharges into the premixer where it combines with the fuel and air mixture prior to combustion. This not only results in a leaner fuel-air mixture which produces less NOx, but significantly reduces CO levels.

Effusion Cooling Technology

Effusion cooling uses both conduction and convection and allows a more efficient use of available combustion air than the OEM configuration, which relies on a slot cooled impingement method. Because less air is used to cool the liner when compared to the OEM, more air can be mixed into the bulk fuel/air mixture via the premixer dilution holes, resulting in better mixing and a leaner combustion mixture which reduces NOx generation.

Advanced Secondary Fuel Nozzle Design

The patented Fin Mixer SFN design was developed to eliminate the diffusion flame at the pilot nozzle tip, present in the current OEM combustion design. This has eliminated a small but very hot tip burning zone which is responsible for a disproportionate amount of NOx formation.

9E CONTROL SOLUTIONS

Plant Optimization Utilizing FlexSuite and AutoTune

Customer Need

Annual or seasonal combustor system tuning often leaves the GT at a suboptimal set point, balancing wide ranging variables like atmospheric changes and engine degradation with the need to operate within strict emissions limits. Couple this with the economic factors decreasing plant profitability, and operators have a significant incentive to request a low cost solution that increase turndown, minimize emissions during AGC operation, and maximize peak MW output.

Our Solution

Through the FlexSuite and AutoTune Product Line, Thomassen Energy and PSM enhance existing control system functionality, without the need for extensive upgrades.

Combining controller logic modifications and the AutoTune system's powerful external computing capability, we offered solutions such as:

+ Extended Turndown
+ Transient Tuning, providing emissions optimization even when load fluctuates on Automatic Grid Control (AGC)
+ Reduction in start-up NOx
+ Additional optimization is available through PSM's 24/7 online Monitoring and Diagnostics Center
+ Fast transfer and start-up optimization

Digital Technologies

FlexSuite™

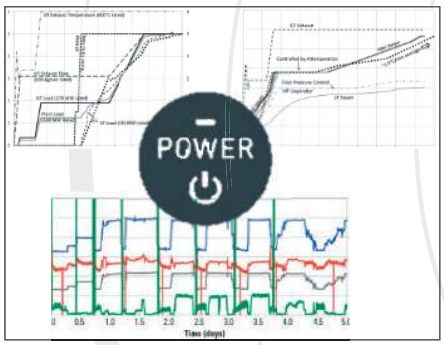
Portfolio of applications for your existing controller. Multiple optimization features offered to suit your individual needs.

FlexSuite building blocks:

+ Combustion Optimization
+ Start-up / Shut-down Optimization
+ Enlarged Load Range
+ Efficiency and Lifetime
+ Fuel Flexibility
+ Grid Support
+ Service Flexibility

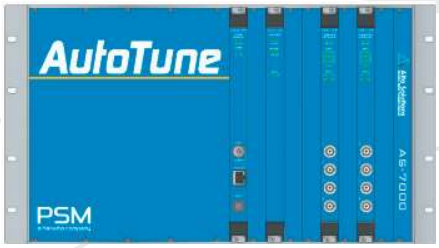
Start-Up Optimization

FastStart & FastRamp: Increase Reliability and Availability through control logic improvements and adaptations that allow your GT's to better meet your performance needs. No matter if you are in a 10 minute start-up market or auxiliary services, being able to stat faster and subsequently ramp fast both before and after heat soak can provide significant monetary value.



AutoTune™

Intelligent GT combustion optimization for emissions and combustion dynamics, while maximizing operational range and fuel variation. Utilize in conjunction with FlexSuite™, FlameSheet™ and GTOP™ to maximize the optimization potential.



System Features

AutoTune is an expert advisory system that provides extra level of intelligent protection to your existing controller

- External to control system
- HMI screen seamlessly integrated

Patented learning algorithms eliminate the need for seasonal tunes and provide significant system enhancement:

Tuning Optimization

- Dynamics - providing improved hardware life and Lean Blow Out Mitigation
- Emissions – avoiding excursions, providing consistent emissions even with atmospheric/ climate/seasonal changes, @ varying load points
- Learning – intelligent learning of known operational points allows for less tuning and therefore less chance for error
- Transient tuning – adapts to cycling of units and provides response to dynamics changes
- Trip Avoidance – provides ultra-fast reaction if combustor is flaming out to prevent a trip

Operational Flexibility

Continuously seeking to maximize load range while maintaining emissions and Dynamics, three modes are available:

- Power+ @ current firing temperature range with no impact to hardware life
- Peak+ @ option for increase peak firing mode to achieve greater improvements, with some hardware lifetime debit
- Turndown - minimizing low load point by maintaining output just above premix transfer
- AGC: Peak+/Power+, Turndown & Transient Tuning all active during Automated Generation Control (not waiting until stable load conditions)

Fuel Flexibility

Three levels of fuel flex technology are available offering +/- 2% MWI range improvement, does not require fuel gas chromatograph:

- FGT (Fuel Gas temperature): reduces Fuel Gas temperature to minimize Hot Tone Dynamics
- FPP (Fuel Property Parameter) table to enable extra dimension of tuning intelligence if distinct variations in fuel are detected (eg multiple sources of Fuel Gas)
- FTO (Fuel Temperature Optimization) utilizes a high performance fuel gas heater to actively manage the wobbe range of the fuel

Field Services

We offer a fully integrated outage team of highly experienced professionals capable of turning overhauls around in a timely, safe, and quality manner. Our Field Service department has the capability to support a wide range of power generation equipment including gas turbine, generator, steam turbine, and auxiliary equipment. Service support includes:

+ OSHA Compliant Safety Program
+ Detailed Outage Planning
+ Customized Tooling
+ Emergency Response Team
+ Control/Combustion Tuning
+ Instrumentation Support
+ Valve Calibration
+ Customized Work Instructions & Quality Plan
+ Foreign Material Exclusion Procedures
+ Field Inspection & Assessments
+ Detailed Lessons Learned & Improvement Plans

Repair

Thanks to our repair network we are located strategically in the USA, Netherlands and UAE, providing Repair Services for industrial gas turbines B, E and F-class fleets featuring the following capabilities:

+ Robotically controlled welding
+ Chemical Stripping
+ Full Metallurgical Laboratory with Engineering Services
+ Brazing
+ FIC Cleaning

+ Qualified fixture check for all components
+ Robotically controlled coating
+ Flow testing, gas and liquid, including F-class and DLN
+ Heat treat
+ 24 hour engineering and shop support
+ Latest Qualified Procedures/Process
+ State-of-the-Art Equipment
+ Warehouse for Spare & Emergency Parts
+ Lifetime assessment of components and rotors

Monitoring & Diagnostics Center

We provide engineering and operational support in troubleshooting issues outside of the normal inspection periods. The support includes staff located in Florida, USA and Rheden, the Netherlands supporting the monitoring function on a 24-hours-a-day, seven-days-per-week basis. The monitoring center personnel have the capability to perform an analysis of the cause of issues and recommendations on how to solve the issues in the short term and, if applicable, a recommendation for a longer term improvement. The data collected from the Monitoring & Diagnostics Center is essential in tracking the history of parts and providing the essential functions required for Long-Term Planning. The Monitoring Center function includes data analysis and trending for the following Gas Turbine Points:

+ Combustor Dynamics
+ Blade Path Spread
+ Exhaust Gas Temperature Spreads
+ Fuel Gas/Oil Temperature
+ Bearing Temperature & Vibration
+ Compressor Discharge Temperature & Pressure
+ Inlet Guide Vane Position
+ Turbine Speed
+ Compressor Inlet Temperature
+ Alarm Displays in the DCS
+ R-0 Vibration Monitoring

Customer Training

Our courses combine theoretical knowledge with practical training to ensure maximum value and relevance. The GE-type heavy-duty gas turbine program trains operators and maintenance personnel on this type of gas turbine and its associated systems. The Speedtronic™ Mark V & Mark VI control program familiarizes electrical and instrumental staff with the hardware and software of the control system and enhances their ability to find viable solutions.

These programs include:
– gas turbine basics
– major components
– auxiliary systems
– turbine maintenance
– turbine operations
– an introduction to turbine controls
– an introduction to Speedtronic™ controls
– panel hardware
– operating instructions
– introduction to software configurations
– user manuals, maintenance and application manuals
– control systems

When we conduct training at a client's location, we combine classroom sessions and visual presentations with practical instruction close to the machinery. This gives trainees the opportunity to apply theoretical knowledge to their own machines.

LONG TERM AGREEMENTS AND STRUCTURED MAINTENANCE CONTRACTS

Thomassen Energy can bring in all of our services and product lines specifically engineered for the 9E, to structure specific maintenance programs to provide our customers with significant life cycle cost reduction in order to maximize ROI. In summary, the various agreement offerings are structured to optimize your maintenance budget by offering competitive parts life guarantees, minimal parts fallout, coverage during unscheduled inspections, control of inventory, and proactive contract management to ensure total coverage.

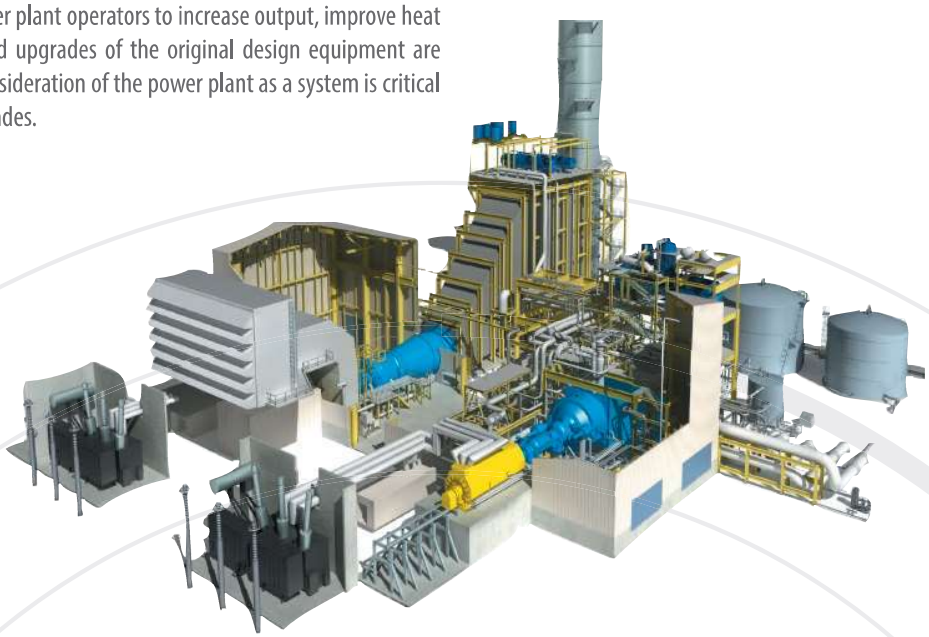
Scope of Supply — based on the customer requirements

The customer determines the level of scope for the Long Term Agreements, ranging from full service offerings to a pricing agreement. Service offered by Thomassen Energy within a Long Term Agreement include, but are not limited to, the following:

+ Parts Supply
+ Reconditioning
+ Field Services — including craft labor
+ Monitoring & Diagnostics (e.g. Remote Monitoring)
+ Contract Management
+ Inventory Management
+ Parts Tracking
+ Engineering Assessments
+ System Technical Support

PLANT ASSESSMENT FOR COMBINED CYCLE POWER PLANTS

The competitive power generation market drives power plant operators to increase output, improve heat rate and lower operational costs. Enhancements and upgrades of the original design equipment are typically implemented to accomplish these goals. Consideration of the power plant as a system is critical when making decisions to invest in performance upgrades.



Benefits

A Plant Assessment provides the knowledge to:

+ Ensure equipment and systems are compatible with proposed upgrades
+ Maximize asset potential
+ Assess real-time condition & performance
+ Increase operational flexibility
+ Forecast life expectancy
+ Manage emissions profile

Component Evaluation

Gas Turbine

+ Upgrade applications
+ Output and efficiency gains
+ Exhaust flow and temperature

Heat Recovery Steam Generator

+ Pressure part design limits
+ Flow accelerated corrosion areas
+ Capacity of attemperators

Steam Turbine

+ Steam path analysis
+ Thermal and mechanical stress limits
+ Output and efficiency gains

Generator

+ Operation during maximum output
+ Capability curves and cooling limitations
+ Magnetic saturation limits

Balance of Plant

+ Performance of environmental controls
+ Capacity of control valves, pumps, heat exchangers & safety valves

Modeling & Analysis

We can perform a detailed analysis of the power plant for multiple operational and ambient conditions. The following considerations are taken into account:

+ Original design and upgraded heat balances
+ Model calibration to as-is equipment condition
+ OEM and model-based upgrade potential for major equipment
+ Balance of plant systems and components capability

Plant Assessment Report

The plant assessment report provides the following evaluations:

+ Current vs. upgraded plant thermal performance
+ Emissions summary and environmental impact
+ Equipment and operational limitations/ recommendations
+ Business case development support

We combine engineering expertise in combustion dynamics, alternative Low NOx combustion solutions, airfoil design, and comprehensive engineered solutions for total power plant operations with our history of manufacturing 9E gas turbine products. From initial models to higher firing temperature upgrades with controls and DLN system changes, we offer you dynamic solutions for your 9E units in order to extend the life of your hardware and increase overall ROI of your power plant.

Here is a Summary of the Worldwide Services We Offer:

Combustion

LEC-III™ and T-DLN offerings are available and can be specifically tailored to customers' needs by incorporating our FlexSuite products, whether there are ultra low emissions, single or dual fuel needs.

Hot Gas Path

1st, 2nd, 3rd stage buckets, nozzles, and shrouds with the latest design improvements

Rotor

Rotor components from bolting to new compressor and turbine discs

Combustion System Engine Tuning including Monitoring & Diagnostics

Support for all rotating equipment (e.g. remote monitoring) of gas turbines worldwide.

Rotor Lifetime Extension (LTE)

Our Rotor LTE program can extend the useful lifetime of your rotor. With the advancements in computing power, material properties, fracture mechanic methodologies, and inspection techniques, it is now possible to assess the potential to run rotors beyond their original published limits.

Field Services and Outage Management

Developed globally and executed regionally, we offer complete field service solutions including on-staff bladers and supply of labor for gas turbines, steam turbines and generators worldwide

Reconditioning

We offer together with PSM global repair capabilities specifically for advanced industrial gas turbines with capabilities in the US, The Netherlands, and The Middle East to service customers worldwide.

Conversions, Modifications and Upgrades

As needs change, we bring the ability to upgrade aging equipment back to life to compete against a changing power grid allowing customers to reduce emissions, extend life, and much more

Flexible Long-Term Parts and Service Agreements

Combining all of our services into one robust package tailored to fit the needs of your 9E units from full LTAs to rotor or component management programs.

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Contact a Thomassen Energy Sales Representative for additional information.
Phone: 0031 (0)26 497 5800
Email: info@thomassen.energy

www.thomassen.energy

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