A team of engineers from Entegra Power Group LLC, Tampa, explained to colleagues during a user-only session at the 2009 7F conference how ECOMAX™, a gas-turbine (GT) optimization system, allowed them to improve engine performance and increase power output without exceeding OEM design limits. Ecomax was developed by GTE-Gas Turbine Efficiency, Orlando.

Entegra, formed in 2005, owns and operates 4400 MW of natural-gas-fired combined-cycle merchant capacity. The company’s assets consist of four 2 x 17FA-powered combined cycles at both its Union Power Station in El Dorado, Ark, and Gila River Power Station in Gila Bend, Ariz. In sum, the company operates 16 GE Energy Model 7241/DLN2.6 GTs with Mark V control systems, 16 supplementary fired heat-recovery steam generators (HRSGs) from Alstom Power Inc, and eight GE Model D11 steam turbines.

Both plants, which began commercial operation in 2003, were developed by TECO-Panda Generating Co LP, a joint-venture partnership between TECO Energy, Tampa, and Panda Energy International Inc, Dallas. TECO Energy owned the two facilities outright when it transferred them in May 2005 to the project lenders, who formed Entegra.

Gila River and Union were supported by the OEM’s long-term service agreement until 2005 when the new owners opted for a proactive culture that relies on the talents of the company’s employees to ensure profitability—one characterized by self-perform O&M, self-management of outages and major O&M, and self-perform energy trading.

The Entegra business model relies on taking quantifiable and justifiable technical risks as an “early adopter” to reap the benefits of new technology without investment in R&D. The intensely competitive merchant power market demands that the company pursue plant enhancements to continually improve its results. Goals include increasing output, improving heat rate, reducing life-cycle maintenance cost, maximizing availability and reliability, and reducing emissions. Ecomax offered the opportunity to optimize GT operation and extract more power from the engines when market conditions dictated. Such flexibility was particularly advantageous in the region served by Gila River.

Reasons include: (1) The area is characterized by very high ambient temperatures—up to 120°F in summer—and seasonal ambient-temperature changes of up to 100 deg F; (2) air-permit emissions limits are challenging both for startup periods and normal operation, and (3) aftermarket options for operational improvements are limited for units without LTSAs. This is in sharp contrast to the widespread availability of parts, and maintenance and repair services, offered by third-party providers for F-class units.

Due diligence was an important first step for both GTE and Entegra. The technology provider conducted a site audit and identified these key drivers for the implementation:
- Maintain optimal balance between emissions and dynamics.
- Adjust for changes in ambient conditions and fuel quality.
- Optimize performance to market needs—that is, maximize capacity or minimize heat rate depending on power and fuel prices.

GTE’s experts believed that more power could be squeezed from Entegra’s GTs, without exceeding the OEM’s recommended temperature setpoints, by recharacterizing the engines’ firing curves. This would be accomplished without exceeding the OEM’s recommended temperature setpoints. The economic driver of Entegra’s interest at Gila River was additional capacity. The ability to produce more power at Union was not as attractive because excess generation already existed in the area.

The power producer’s due diligence included a thorough evaluation of GTE’s capabilities and experience. Here’s what Entegra learned:

- GTEN’s technical capabilities were considerable. The experience of its technology team was deep and the company’s modeling and optimization capabilities state-of-the-art. Plus, in-house and field testing and validation processes warranted the highest confidence in the company’s products and services. GTE’s customer base included a relatively large fleet of DLN engines, and it had a robust monitoring and diagnostics (M&D) center to continually track the performance of installed equipment.
- The technology provider also had the financial wherewithal to absorb project risk until performance was demonstrated. Simply put, as an early adopter, Entegra would have no investment risk.
- A core component of Ecomax, GTE’s combustion dynamics monitoring system (CDMS), was installed on more than 100 GTs. To learn more about combustion dynamics monitoring, visit www.combinedcyclejournal.com/archives.html, click 3Q/2008, click “CDMS helps prevent forced outages, tune engine after overhaul.”
- Ecomax automatically tunes a gas turbine to maintain emissions and dynamics control.

Both companies passed each other’s litmus test and one of the Gila River GTs was outfitted with Ecomax in summer 2008, a modification that took only a few days. Based on the success of the demonstration unit, five more engines at the site were equipped with the system last November and December. The presenters reported that all delivered targeted performance and combustion-
control results were achieved. **What Ecomax does, how it works.**

The Entegra engineers explained how Ecomax works using the operational envelope diagrams in Figs A and B. The first illustration shows how ambient conditions and hardware changes impact the ideal operating point in the middle of the diamond. Fig 2 describes how Ecomax continuously tunes DLN combustors, optimizing emissions, dynamics, and performance in near real time after the plant defines its optimal performance goals based on parts durability, emissions, or power. Thus the system provides real-time emission and dynamics protection against changes in fuel composition, ambient conditions, and machine wear and tear.

The Ecomax systems at Gila River are equipped with GTE’s so-called “Tru-curve” option, a feature for taking advantage of the auto-tune capability that allows the unit to operate close to control limits and produce peak power. GTE representatives at the meeting told the editors there are other options as well, including:

- **“Peak fire,”** which goes beyond Tru-curve by allowing operators to increase a turbine’s firing temperature above design conditions. However, parts life may be adversely affected.
- **“Turndown,”** which extends the allowable operating emissions envelope of a GT, allowing the unit to run at low loads without exceeding limits and avoiding start/stop cycles.
- **“Startup emissions management,”** which manages both CO and NOx during startup.

Flexibility is key to the system’s value: Users can change optimization goals at will without exceeding emissions limits. For example, if the market price of power spikes, you can change your goal to maximum output from, say, low heat rate. Then when the market price of power declines you can re-establish the high-efficiency goal to conserve fuel. The Ecomax computer makes this possible at Gila River by advising the plant’s Ovation® DCS (Emerson Process Management) on how to control the GT.

**Experience.** The Entegra presenters said Ecomax successfully delivered targeted results at Gila River, including:

- Provides plant operating flexibility and optimization.
- Minimizes dynamics.
- Eliminates the need for manual tuning—even after combustor and hot-gas-path inspections. Routine annual DLN tuning can cost $10,000 or $15,000, according to Entegra engineers.
- Detailed operating data were included in the presentation. For example, in a typical week at Gila River, engineers said that the six GTs might be tuned a dozen times and that the Ecomax computer takes control only when a turbine gets close to the operating envelope defined in Fig B. Weekly data presented in Fig C show 11 tunings among the six engines—five high-NOx optimizations, six low-NOx optimizations. High NOx is of concern because of regulatory limits; low readings because of flame instability and the threat of flame-out. Fig D tracks a dynamics tuning event, which is rare. For example, months went by after Ecomax was installed on the six Gila River 7FAs before a dynamics optimization occurred. The illustration shows dynamics above the recommended limit for several minutes before Ecomax brings them back within spec. This is by design, the Entegra team said. Such deliberate readjustment prevents “hunting” by the controller and the potential for unstable operation. Being off-spec in this case was not of major concern because of significant owner-defined buffer margin.

In closing, the presenters said they were working on the implementation of the “Turndown” option to reduce Gila River’s minimum load under current emissions limits. The goal is to reduce the number of starts and achieve an hours-based maintenance paradigm and longer intervals between maintenance outages. The engineers thought there was an opportunity for heat-rate optimization at Gila River, as well. They are not considering the “Peak fire” option at this time because maintenance costs can increase significantly when operating at elevated temperature.