A Supplement to the October 2004 Issue of Energy-Tech Magazine

ENERGY-TECH

Devoted to Operations & Maintenance Solutions

Turbine Inlet Cooling Case Studies

BUYERS GUIDE:

Turbine Inlet Cooling Supply, Installation, Service Providers

www.energy-tech.com

A Publication Of
Magellan Publishing
A Division of Woodward Communications, Inc.
P.O. Box 388 • Dubuque, IA 52004-0388
800.977.0474 • Fax: 563.588.3848
Email: info@energy-tech.com
www.energy-tech.com

OFFICE OF THE PUBLISHER

General Manager and Publisher
Robin Nichols - Rnichols@magellanpubs.com

OFFICE OF THE EDITOR

Editor
Juli Ikonomopoulos - editorial@magellanpubs.com

Contributing Editor - editorial@magellanpubs.com
Dharam Punwani

ADVERTISING SALES

Sales Manager
Karen Ruden - kruden@magellanpubs.com

Sales Executive
Jeff Brimeyer - jbrimeyer@magellanpubs.com

OPERATIONS

Creative Team Leader
Charlotte Thumser - cthumser@magellanpubs.com

ADDRESS CORRECTION

Postmaster: Send address correction to: Energy-Tech, P.O. Box 388, Dubuque, IA 52004-0388.

SUBSCRIPTION INFORMATION

Energy-Tech is mailed free to all qualified requesters: Magellan Publishing, Circulation Department, P.O. Box 388, Dubuque, IA 52004-0388 or go to www.energy-tech.com.

MEDIA INFORMATION

For media kits contact Magellan Publishing at 800.977.0474 or sales@magellanpubs.com.

EDITORIAL

Send press releases to: Editorial Dept., Magellan Publishing, P.O. Box 388, Dubuque, IA 52004-0388
Ph 800.977.0474 • Fax 563.588.3848
email: editorial@magellanpubs.com

Energy-Tech (ISSN 1062-4147) is published 6 times yearly by Magellan Publishing, a division of Woodward Communications, Inc.

ARTWORK

Send Artwork to: Magellan Publishing
801 Bluff Street, Dubuque, Iowa 52001

Printed in the U.S.A.

Woodward Communications, Inc.
"Building our tomorrow, today"

ENERGY-TECH

Devoted to Operations and Maintenance Solutions

In This Issue

Turbine Inlet Cooling Sucess Stories, By Technology

On the Cover:
Exira station, located in the Midwest. Photos courtesy of TAS, Ltd.

TURBINE INLET COOLING (TIC)
INSTALLATION SUCCESS STORIES

TIC is cooling of the air before it enters the compressor that supplies high-pressure air to the combustion chamber from which hot air at high pressure enters the combustion turbine. The primary reason TIC is used is to enhance the power output of combustion turbines (CTs) when ambient air temperature is above 59°F.

The rated capacities of all CTs are based on the standard ambient conditions of 59°F, 14.7 psia at sea level selected by the International Standards Organization (ISO). One of the common and unattractive characteristics of all CTs is that their power output decreases as the inlet air temperature increases as shown in Figure 1. It shows the effects of inlet air temperature on power output for two types of CTs: Aeroderivative and Industrial/Frame. The data in Figure 1 are typical for the two turbine types for discussion purposes. The actual characteristics of each CT could be different and depends on its actual design. The data in Figure 1 shows that for a typical aeroderivative CT, as inlet air temperature increases from 59°F to 100°F on a hot summer day (in Las Vegas, for example), its power output decreases to about 73 percent of its rated capacity. This could lead to power producers losing opportunity to sell more power just when the increase in ambient temperature increases power demand for operating air conditioners. By cooling the inlet air from 100oF to 59°F, the loss of 27 percent of the rated generation capacity could be prevented. In fact, if the inlet air is cooled to about 42°F, the power generation capacity of the CT could be enhanced to 110 percent of the rated capacity. Therefore, cooling the inlet air from 100°F to 42°F, could increase power output of an aeroderivative CTs from 73 percent to 110 percent of the rated capacity or boost the output capacity by about 50 percent of the capacity at 100°F. The primary reason many power plants using CT cool the inlet air is to prevent loss of power output or even increase power output above the rated capacity when the ambient temperature is above 59°F.

The main benefit of TIC is that it allows the plant owners to prevent loss of CT output, compared to the rated capacity, when ambient temperature rises above 59°F or the plant is located in a warm/hot climate region. TIC can even allow plant owners to increase the CT output above the rated capacity by cooling the inlet air to below 59°F. The secondary benefit of TIC is that it also prevents decrease in fuel efficiency of the CT due to increase in ambient temperature above 59°F.

The ability to generate additional power beyond a plant's base capacity during peak power demand periods has become an important consideration for today's power plants. This supplement offers various TIC success stories, as shared by some of the industry's key players, to help power producers evaluate a variety of TIC technology options to enhance CT output and improve plant efficiency.

You will also find additional information about turbine inlet cooling either by logging on to www.energy-tech.com or visiting www.turbineinletcooling.org.

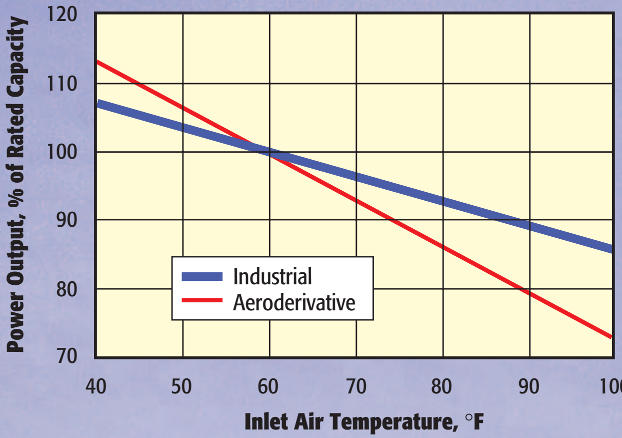


Figure 1

Trigen, Nassau County, N.Y. Photo courtesy of Trigen Energy Corporation.

Introduction

Numerous success stories portray the benefits of TIC installations. The examples described here serve to illustrate the very broad scope of applications. Specifically, they cover:

- Power plant capacities from 1 MW to 750 MW
- Simple-cycle and combined-cycle applications
- New construction and retrofit situations
- Electric utility and independent power/District Energy/Distributed Generation owners
- Electric motor-driven, absorption, steam turbine-driven, and hybrid chiller plants
- Real-time (or "on-line") chilling and Thermal Energy Storage (TES) systems
- Locales including FL, IL, NY, OK, and the Middle East/Persian Gulf region
- Systems operating for more than 10 years and others just coming on-line

Absorption Cooling

Trigen Energy Corporation

Nassau County, New York

A District Energy system in Nassau County, Long Island, N.Y., serves varied public and private sector thermal energy users (a large community college, medical center, sports coliseum, hotel, museum complex, etc.) with heating and cooling. The central Combined Heat & Power (CHP) plant comprises:

- A nominal 57 MW of electric power in a CT Combined Cycle (CTCC)
  - 42 MW from the CT
  - 15 MW from the steam turbine
- 267 MWt of steam heat
- 16,400 tons of chilled water cooling

A TIC system was retrofitted to the existing CTCC in the winter of 1996/97. The 1991 GE MS6001B CT was fitted with three banks of six chilled water (CHW) coils each in the inlet filter house. Coil design allowed inlet air with dry bulb/wet bulb temperatures of 92°/76°F (33°/24°C) to be cooled to 46.5°F (8°C), using CHW supply and return temperatures of 43°/60°F (6°/16°C). Design airflow was 240,000 cfm for a cooling load of 1,880 tons. Airside pressure drop was limited to 1.5 inches of water column (for the coils and the ducting) in order to minimize the negative impact of inlet air pressure losses on the CT power output. Simultaneously with the coil installation, a new 1,200 ton single-stage Lithium-Bromide and water absorption chiller was added to the existing 15,200 tons of steam turbine-driven chillers. (The mismatch in cooling coil load and chiller capacity was not an issue due to some excess installed cooling capacity in the existing chiller plant.)

Pictured are just a few of the downtown Tulsa buildings served by the Trigen-Tulsa plant. Photo courtesy of Trigen Energy Corporation.

The 1997 results exceeded expectations. Inlet air temperature was maintained at 46°F (8°C) during a period of 98°F (37°C) ambient dry bulb air temperature. CT power output was increased by approximately 8 MW (a 23.5 percent increase). And CT heat rate was improved by approximately 5 percent. As an added benefit, condensate run-off is collected from the inlet cooling coils and used for cooling tower make-up in the District Cooling plant.

Total project installation costs were $809,000 for the TIC portion and $671,000 for the absorption cooling addition. Simple payback for the project was slightly over three years. Total unit capital cost was $185 per kW of incremental power output, well below half the installed unit cost of new simple cycle CT capacity (typically $400 to $500 per kW). Of course the overall project economics were aided by the presence of the existing District Cooling plant equipment (without which, larger absorption chiller capacity and new cooling tower capacity would also have been required).

Mechanical Compression Refrigeration

Trigen Energy Corporation

Chicago, Oklahoma City, Tulsa, Okla.

District Energy (heating and cooling) systems in Chicago, Oklahoma City, and Tulsa each utilize one or more 1 MW Turbomeca Makila TI (helicopter engine derivative) CTs as key elements in their CHP systems. There are three CTs in the Chicago application (1997) and one each in the Oklahoma City and Tulsa applications (1993). CT power output in each case is enhanced through the use of TIC.

The CTs are each on a common shaft with not only an induction motor/generator, but also a 2,000-ton ammonia screw chiller that is one component of the larger District Cooling plant. A side stream of ammonia refrigerant is evaporated in a coil located in the inlet air stream to the CT, thus providing the desired inlet air cooling and CT power enhancement.

Using TIC to cool the inlet air to 50°F (10°C) enhances power output by 33 percent or more on the peak design day. In each of these three installations, the cooling duty for the TIC system is only a fraction of one percent of the total District Cooling system capacity. Accordingly, it was a simple and economical matter to add the inlet air coil and interconnecting refrigerant lines, with virtually no impact on the overall cooling system design, thus capturing the CT power output increase at very low capital cost.

Thermal Energy Storage (TES) & Hybrid Chiller Plant

Walt Disney World/Reedy Creek Improvement District

Lake Buena Vista, Fla.

A District Energy system outside Orlando, Fla., serves the world-renowned Walt Disney World entertainment complex with heating, cooling, and electric power (Clark, 1998). The central CHP plant comprises:

- A nominal 40 MW of electric power in a CTCC
  - 32 MW from the CT
  - 8.5 MW from the steam turbine
- 90,000 pounds/hour of steam from a HRSG (for HW District Heating and absorption chillers)
- 14,425 tons of chilled water cooling (absorption and, primarily, electric centrifugal chillers)

A TIC system was retrofitted to the existing CTCC in 1997/98. The existing GE LM5000 CT was fitted with four banks of CHW coils in the inlet filter house. Coil design allowed inlet air with dry bulb/wet bulb temperatures of 95°/79°F (35°/26°C) to be cooled to 50°F (10°C), using CHW supply and return temperatures of 40°/70°F (4°/21°C). Design airflow was 219,200 cfm. Air-side pressure drop was limited to 1.2 inches of water column (across the coils only) in order to minimize the negative impact of inlet air pressure losses on the CT power output. Simultaneously with the coil installation, a new 57,000 ton-hour stratified CHW TES tank was added to the existing 17,750 tons of electric and absorption chillers. (The addition of the TES capacity was sufficient, not only to meet the new load associated with the TIC system, but also to eliminate the need for two new chillers of 3,325 tons capacity that would otherwise have been required to replace aging, inefficient, CFC refrigerant chillers that were retired when the TES system was added. Even without those two new chillers, excess nighttime chiller plant capacity is adequate to meet nighttime cooling loads and to charge the TES tank for use the next day in meeting peak loads in both the District Cooling system and in the TIC system.)

CT power output is increased by up to 8 MW (more than a 30 percent increase) in extreme weather conditions, from 26 MW at 95°F (35°C) to 34 MW at 50°F (10°C). And CT heat rate is also improved by approximately 6 percent.

The 5 million gallon (19 million liter) stratified CHW TES reservoir is an insulated, above ground, welded-steel storage tank, 116 feet (35.4 m) in diameter and 67 feet (20.4 m) high. The 57,000 ton-hour capacity provides 2,000 tons for TIC and 3,500 tons for the District Cooling system, for up to 10 hours per day. Design CHW supply temperature is 40°F (4°C) for both systems, with CHW return temperatures of 70°F (21°C) for the TIC system and 55°F (13°C) for the District Cooling system.

Although actual project economics are not available for publication, the TIC-TES project achieved the following results:

- Up to an 8 MW (over 30 percent) increase in on-peak CT power output
- A 12 MW reduction in on-peak power purchases
- Elimination of the need for 3,325 tons of new chiller plant capacity
- Operating energy savings providing an attractive rate or return on the invested capital
- A Net Present Value (NPV) for the project totaling several millions of dollars.

Pictured is the Middle East/Persian Gulf TIC-TES system. Photo courtesy of The Stellar Group.

Thermal Energy Storage (TES)

Utility Power Plant

Middle East/Persian Gulf Region

An existing electric utility power plant in the Middle East/Persian Gulf region is being retrofitted with TIC. The applicable portion of the plant comprises 10 CTs, each a nominal 75 MW, in simple cycle configuration. The TIC system installation is nearly complete, with TIC operations scheduled to commence in 2005.

The existing GE Frame 7EA CTs are being fitted with cooling coils. Coil design will allow inlet air with a dry bulb temperature of 122°F (50°C) to be cooled to 54.5°F (12.5°C). Design cooling load is approximately 3,000 tons at each of the 10 CTs. Air-side pressure drop is limited across the coils and ducting in order to minimize the negative impact of inlet air pressure losses on the CT power output.

A combination chiller plant and TES system have been installed to provide the cooling. The chiller plant employs the packaged plant approach and uses electric motor-driven chillers and, due to the high value of water resources in the region, air-cooled condensers for the R-134a refrigerant. The stratified CHW TES reservoir is an above ground, welded-steel tank, which is charged during 18 non-peak hours per day and discharged during the six hours of peak power demand per day. The 193,000 ton-hour TES capacity provides 30,000 tons of cooling for TIC, for six hours per day, minimizing parasitic power consumption, and maximizing net power plant output, during the period of peak power value.

Net power plant output is guaranteed to be increased by 30 percent in the design day weather conditions. CT heat rate is also significantly improved.

A very low installed capital cost was achieved, in large part through the use of the packaged chiller plant approach, but most significantly by using the TES system to reduce the required capacity of the new chiller plant from 30,000 tons to only 11,000 tons. And by using a relatively high supply-to-return temperature differential in the chilled water system, the size and capital cost of the TES tank (and of the CHW pumps and piping) were minimized. The total project capital cost is well below half the installed cost of equivalent new simple cycle CT capacity (which would have required the addition of three more CTs).

References

1. Andrepont, J.S., "Combustion Turbine Inlet Air Cooling (CTIAC): Benefits, Technology Options, and Applications for District Energy," Proceedings of the IDEA (International District Energy Association) 91st Annual Conference, Montreal, Quebec, June 2000.
2. Clark, K.M. et al., "The Application of Thermal Energy Storage for District Cooling and Combustion Turbine Inlet Air Cooling," Proceedings of the IDEA 89th Annual Conference, San Antonio, Texas, June 1998.

The stories on pages 5-7 were submitted by John S. Andrepont, founder and president of The Cool Solutions Company, Lisle, Ill. John has 30 years of experience in energy technologies, including various turbine inlet cooling projects and over 100 thermal energy storage installations. Cool Solutions provides consulting services related to TIC, TES, and District Cooling systems. He is the current chairman and director of the Turbine Inlet Cooling Association (TICA), www.turbineinletcooling.org. You may contact John via editorial@magellanpubs.com

TURBINE INLET CHILLING
for Combined-Cycle Plant

Brazos Valley
Texas

Introduction

Turbine Air Systems (TAS) recently designed and installed two of their F-50C chiller packages for a 610MW power plant located near Richmond, Texas, about 30 miles south of Houston. The combined-cycle plant, originally built for NRG by Black & Veatch, E&C contractors, and now operated by Brazos Valley Energy LP, includes two GE Frame 7FA gas turbine-generating sets, Heat Recovery Steam Generation (HRSG), and steam turbine-generators, for a combined output of 631MW. The project was commissioned in April 2003 and has completed two summers of successful operations.

Project Description

The Brazos Valley Project has two F-50C chiller packages tied together by an optional "forward" pipe rack. Each F-50C package is anchored by two Trane CDHF 2500 "Duplex" Chillers and includes 3 x 50% redundant chilled water and condenser pumps; four cooling tower cells; forward pipe rack manifolds; an electrical distribution skid allowing a single medium voltage (4160V) feed from the customer; two sets of air inlet cooling coils; two sets of coil manifold piping; and two sets of supply and return riser piping. The use of Trane Duplex chillers in series provides for the most efficient chiller system in its class. Each basic chiller plant was delivered in three self-contained pieces and installed in one week by a crew of six.

Design conditions for the plant specified 93.4°F dry bulb and 76.9°F wet bulb, and inlet air at 56°F (13.3°C) with an alternate design point of 52°F (11.2°C), which was selected by the customer. The calculated load for the chilled water system was 9,590 tons, and 11,900 tons for the chosen alternate. TAS provided a turnkey installation of the chiller packages and the inlet air coils for this project. The installation was completed in less than eight weeks.

An inlet chilling system allows the facility to operate at peak output and efficiency year round. Photo courtesy of TAS, Ltd.

Customer Added Value

The TIC application added over 55 net MW to the facility combined cycle output, while maintaining combined cycle heat rate. A major benefit of inlet air chilling for this project is that the operator knows the absolute power output AND the heat rate of the plant every single day, regardless of ambient temperature or power demand fluctuations. This provides for accurate bidding of power into the merchant market AND reliable forecasting of natural gas usage.

In addition, at Brazos Valley, the operator is using the TIC system to control total system output, allowing the gas turbines to operate at base load while handling the variations in output by modifying the gas turbine inlet air temperature.

Summary

This is an example of TAS' flagship model, the F Series system. Although this package was originally conceived as a "clean-sheet" design to support the F-class fleet of gas turbines, the F-Series chiller model has become the reference standard for all large-tonnage applications, proceeding to support aero-derivative projects as well as District Cooling Applications.

TAS' scope also included the design, provision, and installation of the cooling coils at the filter house, including a sophisticated self-balancing reverse-return manifold and all local supply piping, with temperature control valves.

FOR COMPANY INFORMATION,
ENTER **04810** ON INFOLINK AT ENERGY-TECH.COM

TURBINE INLET CHILLING
for Simple-Cycle Peaker Plant

Exira Station
Midwest

Introduction

Turbine Air Systems (TAS) recently designed and installed a single F-50C packaged chiller system for a 90 MW power plant located between Des Moines, Iowa and Lincoln, Nebraska. The simple-cycle peaker plant, built by Harris Group, and RW Beck (owner's engineer) for a municipal utility, includes two GE LM6000PC Sprint gas turbine-generating sets. The project was commissioned in April 2004 and has been successfully operating throughout the summer.

Project Description

Design conditions for the plant specified 95.5°F dry bulb at a 58.6 percent relative humidity. The inlet chilling system cools the inlet air to 48°F for maximum gas turbine output and efficiency. The capacity of the chilled water system is 5,100 tons, at design conditions. The TAS' F-50C package is anchored by two Trane CDHF 2500 "Duplex" chillers and includes 3 x 50% redundant chilled water and condenser pumps; four cooling towers cells; dual electrical feeds from the customer; and Delta V controls. To improve off-design efficiency, the system is supplied with variable frequency drives on the chilled water pump and cooling tower fan motors. Each basic chiller plant was delivered in three self-contained pieces (chillers, pumps, and electrical controls), allowing for shorter construction time. TAS provided all materials to the site and included technical installation supervision. The installation was completed in approximately five weeks.

Exira Station. Photo courtesy of TAS, Ltd.

Customer Added Value

The TIC application added over 15 net MW to the facility's output, while improving the facility heat rate by over two percent. A major benefit, in addition to the 20 percent increase in output, of inlet air chilling for this project is that the utility knows months in advance the exact power output and heat rate for the plant, regardless of any day's temperature or special weather conditions (humid, dry, etc.). This provides for accurate planning of power production as well as better forecasting the municipal utility's need to purchase power from the market. The ability to know these exact conditions also allows the owner to make better long-term purchases of natural gas.

Summary

This is an example of TAS' flagship model, the F Series system. Although this package was originally conceived as a "clean-sheet" design to support the F-class fleet of gas turbines, the F-Series chiller model has become the reference standard for all large-tonnage applications, proceeding to support aero-derivative projects as well as District Cooling Applications.

FOR COMPANY INFORMATION,
ENTER **04810** ON INFOLINK AT ENERGY-TECH.COM

Evaporative Cooling
for Cogeneration Plant

Hunts Bay Power Station
Kingston, Jaimaica

Introduction

The Hunts Bay Power Station is a 668-megawatt (MW) combined-cycle cogeneration power plant located in Kingston, Jamaica. The plant is owned by Jamaica Public Service Company Ltd.

The Hunts Bay facility includes three combustion turbines: two GT Browns and one GE Frame 7. They needed to improve plant operations and increase output and efficiency in order to recover power and generate greater revenue. In addition, nitrous oxides and carbon monoxide emissions must be continuously monitored and controlled at the facility with minimal environmental impact. Installation of an evaporative cooling system increased power output by 2.4 MW.

Project Description

The average annual growth in demand for electricity in Jamaica over the past 10 years was approximately 5 percent and the forecast for the next five years is 6 percent/annum.

“It was expected that by the years 2003 and 2004 the demand will have surpassed our generating capacity,” said Dave Stamp, Facility Engineer for Hunts Bay Power Station.

A gradual reduction in capacity is expected with increased ambient temperature, hence in Kingston, with high ambient temperatures of 90º-92ºF in the summer months, only approximately 85 percent of ISO MCR can be realized.

It was with this in mind that Jamaica Public Service Company Ltd. investigated ways to increase the capacity of its generating units. One such method utilizes evaporative cooling technology to cool the inlet air to the gas turbine.

The Solution

In order to prove the suitability of the inlet air cooling technology to the Jamaican climatic conditions, a pilot project was conceived. Gas Turbine no. 4, a John Brown Engineering MS5001 (Frame 5) unit with an ISO rating of 25.5 MW [59ºF and 14.7 pounds per square inch absolute (psia) inlet air] and a site rating of 21.750 MW (88°F and 14.7 psia), was selected.

There were several reasons Hunts Bay chose to use an evaporative cooling system at the plant versus other cooling methods: ease of retrofit installation, low operating cost, and low inlet pressure drop.

The pilot test was conducted for six months, from January through June 2000. The results of the test proved that Hunts Bay Power Station benefited from the installation of the evaporative cooling system.

Summary

The Hunts Bay Power Station regained as much as 10 percent of the power capacity with the addition of the evaporative cooling unit.

Benefits:

Increased Power Output: The maximum load achieved during the test was 24.6 MW at 88ºF. This represents an increase of 2.4 MW.

Reduced Pressure Drop: The old inlet filters were removed and replaced with the evaporative cooler, which resulted in a much lower pressure drop.

Reduction in Heat: An average reduction in heat rate of 1.6 percent with annual savings of $40,857.00.

Low Maintenance: The evaporative cooling system is low in maintenance.

This success story was submitted by Munters Corporation.

Evaporative Cooling
for Combined-Cycle Plant

Kalaeloa Cogeneration Plant
Kalaeloa, Hawaii

Introduction

Kalaeloa Cogeneration Plant is a combined-cycle combustion turbine facility located in Kapolei, Hawaii. As a partnership between ABB Energy Ventures and Kalaeloa Investment Partners, the cogeneration plant provides a portion of the steam needs for Tesoro Hawaii Corporation, one of the two oil refineries in the state of Hawaii, as well as 180 MW of firm capacity net electrical power to Hawaiian Electric Company.

The combined-cycle plant design includes two ABB 74.6 MW type 11N gas turbines, one ABB 51.5 MW extraction/condensing steam turbine, and two Deltak heat recovery steam generators (HRSG), plus a balance of equipment that completes the combined cycle.

Project Description

Kalaeloa Partners L.P. decided to examine the plant’s system design to determine what capital upgrades could be implemented to increase plant output and efficiency. They found that an evaporative cooling system was one such upgrade that could do just that.

The cleaner and cooler the air taken into the turbine, the more efficiently the turbines operate, resulting in a higher power output. Conversely, as the air inlet temperature rises, power output falls and efficiency decreases.

Kalaeloa Partners knew they could recover lost power by cooling intake air before it enters the gas turbine. That is when Kalaeloa contacted a few evaporative cooling manufacturers, including Munters Corporation, Systems Division.

After careful analysis, Kalaeloa Partners L.P. decided to retrofit both of the ABB 11N gas turbines with a stand-alone evaporative cooling system designed and developed to increase output levels and improve thermal efficiency. This system was chosen over the other types of cooling systems such as fogging and air chillers because of simplicity, reliability, and cost. The fogging systems did not appear to have the track record of producing the reliable cooling effect we were looking for, and the air chillers are very costly to install and operate.

Kalaeloa projected an approximate 2.1 MW increase on each combustion turbine, for a total plant output increase of 4.2 MW.

Summary

Actual power increase has been higher than anticipated – closer to a 5 MW total increase. In addition, they have experienced almost a full MW increase on the steam turbine as well because the heat energy in the exhaust gas increased, thus allowing the HRSG to produce more steam for the combined cycle to take advantage of.

In evaporative cooling, intake air is passed through one or more wet pads to simultaneously absorb moisture and cool the air. The cool, humid air is directed to the area where it is needed. The installed evaporative cooling system cools the inlet air, creating denser air and giving gas turbines a higher mass flow rate and pressure ratio, thus resulting in an increase in power output and efficiency.

This success story was submitted by Munters Corporation.

AD INDEX

WANT MORE INFORMATION...

About our Products and Advertisers?

Complete this form and **FAX** it to us at 563.588.3848, **MAIL** it to us at P.O. Box 388, Dubuque, Iowa 52001,

OR Visit us online at *www.energy-tech.com* click infolink and enter the 5 digit number under the product or customer you want more information about.

I Want More Information About These Customers:

Please Send Information To:

Name: ______________________

Company: ______________________

Address: ______________________

City/State/Zip: ______________________

Phone: ______________________

Fax: ______________________

Email: ______________________

BUYERS GUIDE:

TURBINE INLET COOLING SUPPLY, INSTALLATION & SERVICE PROVIDERS

This is an alphabetical listing of Turbine Inlet Cooling Supply, Installation & Service providers, and related services, who responded to Energy-Tech's *request for company and product information.*

AAF International, Louisville, IL
Tom Day, Marketing Manager
P | 888.223.3596
E | info@aafintl.com
Inlet cooling systems ductwork, acoustic enclosures, exhaust silencers, anti-icing inlet filtration support structures, bleed systems.

Anderson – Snow Corp., Schiller Park, IL
Mark Beck, Sales
P | 847.678.3823
E | mark@anscorcoils.com
Manufactures a complete line of heavy duty heating and cooling coils for new applications or replacement.

Atomizing Systems Inc., Ho-Ho-Kus, NJ
Michael Elkas, President
P | 201.447.1222
E | mvelkas@coldfog.com
Non-wearing fog nozzles, lifetime guarantee, and high pressure fog pump systems equipped with VFD controls.

BETE Fog Nozzle, Inc., Greenfield, MA
Victor Urquiola, Chief Sales Executive
P | 413.772.2166
E | sales@bete.com
BETE is a leading designer and manufacturer of nozzles for industry, pollution control, and fire protection.

Brentwood Industries, Reading, PA
Don Zelek, Service Manager
P | 610.236.1100
E | Don.Zelek@brentw.com
Manufacturer of turbine inlet drift eliminators and cooling tower film fills produced from non-corrosive PVC.

Caldwell Energy Company, Louisville, KY
John Kraft, President
P | 502.964.6450
E | jekraft@caldwellenergy.com

Camfil Farr, Houston, TX
Greg Jandjez, Sales Manager
P | 281.861.8488
E | jandjelg@camfilfarr.com
Camfil Farr designs and manufactures complete gas turbine air inlet systems, filtration, cooling, and noise control.

CAT PUMPS®
The Pumps with Nine Lives

CAT PUMPS, MINNEAPOLIS, MN
Darla Jean Thompson
P | 763.780.5440
E | techsupport@catpumps.com
Energy-efficient low-maintenance high-pressure reciprocating pumps for mist cooling, wash down, reverse osmosis, injection, metering.

Colmac Coil Manufacturing, Inc., Colville, WA
Randy Carstens, P.E.,
Heat Transfer Products Mgr.
P | 800.845.6778
E | mail@colmaccoil.com
Colmac Coil manufactures custom cooling systems and coils for the combustion turbine inlet cooling market.

Donaldson®
Filtration Solutions

DONALDSON COMPANY, INC., MINNEAPOLIS, MN
Patty Gulsrig
P | 800.431.0555
E | filterinfo@mail.donaldson.com
Air filters, hydraulic filters, filtration system spare parts, evap coolers, chiller coil systems.

ECT Inc., Bridgeport, PA
Bruce Tassone, Director
P | 610.239.5120
E | techsupport@ectinc.net
ECT manufactures R-MC, Powerbaek gas turbine cleaners and fogging, mass augmentation and customized cleaning hardware systems.

ETS Power Group, Stuart, FL
Mark Dender, Vice President
P | 772.781.3883
E | mark.dender@etspower.com
Gas turbine reverse engineering company producing hot gas path components for all makes of turbines.

FES Systems, York, PA
Teresa Sauble
P | 717.767.6411
E | saubleta@fessystems.com

HRT-POWER
...turbine inlet treatment systems

HRT POWER
19901 SW Freeway
Sugarland, TX 77479
P | 281.207.1258
F | 281.937.0806
E | sales@hrtpower.com
W | www.hrtpower.com
The PCM™ series of CT Performance Enhancement systems are available in enclosed, road transportable, single-lift skid packages, capable of supplying 200-6,000 tons of chilling capacity. All system components, refrigeration, pumping, controls, and switchgear are pre-piped, wired, and require only power and condenser/chilled water connections once on the site.

Mee Industries, Monrovia, CA
John Mee
P | 800.732.5364
E | john.mee@meefog.com

Munters Corporation, Ft. Myers, FL
P | 239-936-1555
E | usfmycs_hc@americas.munters.com

Rolls-Royce, Mount Vernon, OH
Tony Brough
Vice President, Marketing
P | 740.393.8888
E | energy@rolls-royce.com
Provides aeroderivative gas turbine-based power generation solutions from 4 MW to 58 MW.

STELLAR
POWER AND UTILITIES

THE STELLAR GROUP
2900 Hartley Road
Jacksonville, FL 32257
P | 800.488.2900
F | 904.899.9295
E | msolms@thestellargroup.com
W | www.thestellargroup.com
Stellar is an international firm that provides design, engineering, construction, and mechanical services on design/build, general contracting, and construction management projects. Stellar is recognized as a leader developing projects for Industrial, Process & Distribution, Institutional, Healthcare, Power & Utility, and Commercial applications.

See Our Ad In This Issue

TAS™ TURBINE AIR SYSTEMS

TURBINE AIR SYSTEMS
4300 Dixie Drive
Houston, TX 77021
P | 713.877.8700
F | 713.877.8701
E | sales@tas.com
W | www.tas.com
TAS has a broad range of packaged and systems integration experience in three key market areas: commercial & industrial cooling (CIC); turbine inlet cooling (TIC); and cooling, heating & power (CHP).

See Our Ad In This Issue

Turbine Inlet Cooling Association, Naperville, IL
P | 630.357.3960
E | admin@turbineinletcooling.org
The mission of the Turbine Inlet Cooling Association (TICA) is to promote the development and exchange of knowledge related to gas turbine inlet cooling (TIC) for enhancing power generation worldwide.

Turbine Inlet Chilling

for Cogeneration Plant

Calpine Clear Lake Cogeneration, Inc.
Texas

Introduction

The natural gas fired Calpine Clear Lake Cogeneration power plant in Pasadena, Texas went into operation in 1982. Steam is produced and sold to an adjacent chemical plant; electricity is produced and sold to the plant with excess going to the market. A fogging system was retrofitted later to increase power output by turbine inlet cooling. To further increase the plant's reliability and capacity for selling additional electric energy during "on-peak" periods, the plant was retrofitted in 1999 with a turbine inlet cooling system comprised of hot water driven absorption chillers, one electric chiller, and a chilled water thermal energy storage system.

Project Description

The cogeneration plant operated with three W501D's combustion turbines, each of 105.6 MW rated capacity, with total rated capacity of 316.8 MW before the plant was retrofitted in 1999. The retrofit included installation of a hybrid refrigeration system including five absorption chillers (total capacity of 8,300 TR) and one electric chiller (1,200 TR); one 184,000 ton-hr (6.5 mill gallon) capacity thermal energy storage tank, custom built filter houses with cooling coils; and a heat recovery coil retrofit.

The gas combustion turbine inlet air cooling system was designed to cool the ambient air from 95°F dry-bulb/80°F wet-bulb temperature to a 50°F combustion turbine inlet air temperature.

The turbine inlet chilling system also utilizes thermal energy storage. The system is designed to produce and store chilled water energy during 14 "nighttime, off-peak" hours and discharge the energy to cool the air during 10 "on-peak" hours of the day to supplement the chillers during the on-peak period. This "partial-storage" design not only reduces the amount of chillers needed but also reduces the on-peak steam and power consumption. During operating periods when the ambient temperatures are less than design, the air can be cooled to temperatures slightly lower than 50°F or alternately the 50°F temp can be maintained for longer than the 10 hr design period per day.

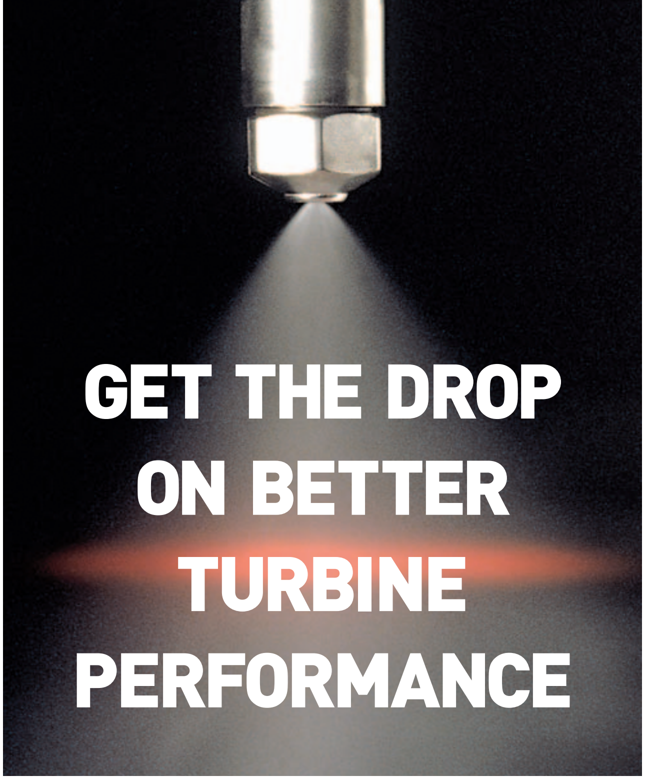
Customer Added Value

The TIC application added over 51 net MW to the facility's output on the hot day (95°F dry-bulb/80°F wet-bulb temperature) while improving the "on-peak" heat rate by approximately 3.5 percent. A major benefit, in addition to the increase in output for this project, is that Calpine uses waste heat which otherwise would be exhausted to the atmosphere to produce additional "sellable" power during "on-peak" hours of the day. In addition, the colder inlet air temperature increases the mass flow of the air through the gas turbine which results in more cogen steam produced and available for export.

Summary

The owner of this facility has combined multiple strategies including absorption chillers in series with mechanical chilling combined with thermal energy storage to optimize operator flexibility and increase "dispatchable" power. The output and heat rate for the plant is known in advance, regardless of any day's temperature or special weather conditions (humid, dry, etc.) to take weather variability out of the production equation. This provides for accurate planning of power production as well as better forecasting of power for sale to the market.

Thermal energy storage increases the flexibility and predictability by the operator compared to "on-line" systems, the work of the refrigeration system is done prior to need and the full value of the waste heat is utilized 24hrs/day. In addition, using nighttime hours to store thermal energy reduces plant emissions. Think "green."

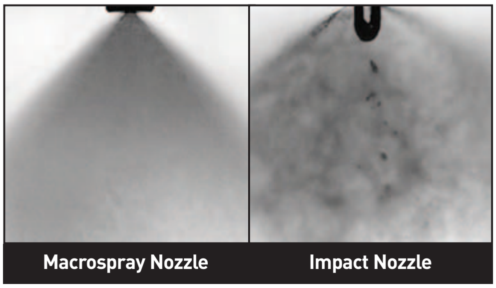


Macrospray single-point nozzles replace conventional pressure swirl-type and impact nozzles.

During peak power demand, make sure your turbines can deliver. Equip your turbine inlet air cooling systems with Parker Macrospray™ single-point or Spider nozzles — the ones that produce extremely small drop sizes.

Macrospray nozzles create fine sprays of more uniformly dispersed water droplets, which provide more effective cooling. Better atomization also reduces equipment erosion issues.

With multiple spray points, Macrospray Spider nozzles provide a much larger spray area than conventional nozzles, resulting in fewer bosses, less piping.



The Macrospray nozzle (left) provides consistent water dispersion, superior to the impact nozzle's pattern (right), which exhibits voids and rogue droplets.

Get the drop on higher power output. Contact Parker Macrospray Systems at **(440) 954-8175**, visit **www.macrospray.com**, or e-mail **kaiken@parker.com**.

Parker
anything possible

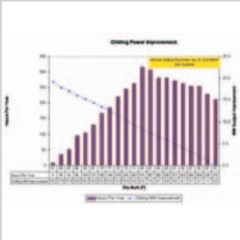
Aerospace | Automation | Climate & Industrial Controls | Filtration | Fluid Connectors | Hydraulics | Instrumentation | Seal

For more information enter **04523** on infolink at energy-tech.com or see the **AD INDEX** page 11

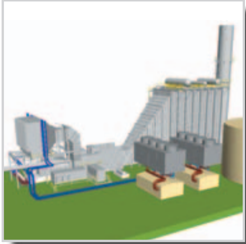
Turbine Inlet Air Chilling

A STELLAR SOLUTION

EXPERT ANALYSIS



INNOVATIVE ENGINEERING



MODULAR FABRICATION

PROFESSIONAL CONSTRUCTION

QUALITY INSTALLATION

GUARANTEED PERFORMANCE

TURNKEY DELIVERY

OPERATION & MAINTENANCE

Innovative Power & Utility Project Solutions

STELLAR

POWER AND UTILITIES

2900 Hartley Road • Jacksonville, Florida 32257 • 800-488-2900/904-260-2900 • Fax 904-899-9295

Americas • Europe • Middle East • Asia

www.stellarpower.com

For more information enter **04858** on infolink at energy-tech.com or see the **AD INDEX** page 11