Palm Sprngs March 2016

26th Annual Conference and Exhibition

What's Inside:

- 3 President's Welcome
- 4 Technical Program
- 6 Social Functions
- 8 Convention Center Map
- 10 Honor Roll
- 12 Acronyms
- 14 Officers, Board of Directors
- **16 Breakout Session Chairs**
- 22 Best Practices
- 26 The ORAP® Advantage
- 27 Badge Rules
- 28 Exhibit Hall Floor Plan
- 28 Exhibitors (alphabetical)
- 34 Exhibitors (booth number)
- 40 Sponsors
- 42 WTUI's Rich History
- 52 LM Engine History

Mark Your Calendar

Celebrating 27 Years of Service to the Industry

WESTERN TURBINE USERS 2017 Conference & Expo

South Point Hotel & Casino Las Vegas, Nevada March 19 - 22

Conference Highlights

SUNDAY, March 20

5:30 p.m. to 8:30 Welcome Hospitality Reception

Exhibit Hall, Palm Springs Convention Center

Special raffles (users only) every 30 minutes, beginning at 6 p.m. Great prizes (see p 6 for list). Listen for announcements on the hour and half hour.

MONDAY, March 21

8:00 a.m. to 10:15

Chairman Chuck Casey's Welcome Catalina/Madera/Pasadena Ballrooms WTUI's value proposition, program updates, treasurer's report, introductions, depot presentations. This session sets the tone for the meeting; important to attend. Breakout Sessions for the LM2500, LM5000, LM6000, and LMS100 engines start at 2:30 (see p 4 for details).

10:45 a.m. to 11:45 **Gas-Turbine Business Update** Catalina/Madera/Pasadena Ballrooms Noted consultant Mark Axford reflects on 2015 market statistics and gives his predictions for 2016. This annual presentation is rated "two thumbs up" by most

attendees. 6:30 p.m. to 11:00 **Monday Night Reception** Renaissance Pool Deck

WTUI's first Hawaiian Luau. Experience a fun-filled evening with fine food and excellent entertainment-including a Polynesian Dance Show.

TUESDAY, March 22

12:30 p.m.

Best Practices Awards Convention Center Luncheon Area This year's awards to aero-powered generating stations go to Waterside Power LLC, Lawrence Generating Station, and Worthington Generating Station.









Kawamoto



Axford

Feature Articles

- 22 WTUL CCJ to collaborate on best practices
- 26 Automated data collection assures accuracy Salvatore A DellaVilla Jr, CEO, Strategic Power Systems Inc (SPS)
- 42 Western Turbine history Principal contributors: Wayne Kawamoto, Mike Raaker, Salvatore DellaVilla

52 LM engine history

Principal contributors: Madhu Madhavan, Mike Pipes, Gil Badeer, Tayo Montgomery, Rick Hook, Preetham BalasuZbramanyam, Kumar Khemchandani

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PRESIDENT'S MESSAGE

WESTERN TURBINE Users

26th Annual Conference and Exhibition

Published by the **COMBINED CYCLE Journal**, **PSI Media Inc**

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CCJ ONscreen, www.ccj-online.com/ onscreen. Our interactive web-based learning resource with a classroom feel. Meet screen-to-screen with industry experts, listen and view presentations, and connect with fellow users from the comfort of your office.

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Susie Carahalios Carahalios Media 5921 Crestbrook Drive Morrison, Colo 80465 susie@carahaliosmedia.com Tel: 303-697-5009 Fax: 303-697-5709 elcome to the Western Turbine Users Inc's (WTUI) 26th annual technical conference and exposition. Our mission remains to advance the reliability and operability of the General Electric line of aeroderivative gas turbines.

On behalf of the Board of Directors, Officers, and support staff, thank you for being a part of Western Turbine Users' 26th year of collaboration. What started as a small group of users to discuss their operational issues has now grown to be the largest LM user group in the world.

The power generation industry is changing quickly. As coal and nuclear plants are decommissioned simultaneously, the federal Clean Power Plan mandates historic levels of renewable energy supply challenging our LM turbines to start faster, start more often, and operate at lower emissions, lower power turndown, and higher output—all while staying reliable and available, and under budget.

Natural gas prices are at 20-year lows and experts expect them to remain at about this level in the near term, amplifying the relevance of gas turbine/generators. To remain competitive, you must maximize the flexibility of your aeroderivative engines to meet the needs of owners and regulators, and the "black box" future.

Please join me in sharing experiences with other LM users. We must challenge equipment suppliers to improve their products as we strive to improve the performance and extend the lives of our gas turbines and all support equipment. As a WTUI member your conference contribution is at the root of our success. You are a vital element of this volunteer organization as we answer the challenges ahead.

Chuck Casey, Riverside Public Utilities President, WTUI



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TECHNICAL

Where to go (see floor plan, p 8)

Registration: Renaissance Ballroom Foyer Exhibition: Convention Center Breakfasts: Renaissance Ballroom Foyer Luncheons: Convention Center LM2500 Breakout Meetings: Renaissance Mojave Chair: John Baker, Riverside Public Utilities LM5000 Breakout Meetings: Renaissance Pasadena Chair: Perry Leslie, Wellhead Services Inc LM6000 Breakout Meetings: Renaissance Catalina/Madera Chair: Andrew Gundershaug, Calpine Corp LMS100 Breakout Meetings: Renaissance Sierra/Ventura Chair: Jason King, DGC Operations

AFTERNOON

2:00 to 7:30 Registration 3:30 to 5:30 New User Orientation/SPS Introduction, *Renaissance Andreas* Bryan Atkisson, Riverside Public Utilities **Registered active users only**

EVENING

5:30 to 8:30 Welcome Hospitality Reception, Convention Center All conference attendees and spouses/guests Monday, March 21

MORNING

I		
	7:00 to 4:00	Registration
	7:00 to 8:00	Breakfast
		All registered conference attendees
	8:00 to 9:00	General Session, Catalina/Madera/Pasadena
		All registered conference attendees
	9:00 to 5:00	Exhibit Hall open
		Must have name badge to enter
	9:00 to 10:15	Depot Presentations,
		Catalina/Madera/Pasadena
		All registered conference attendees
	10:15 to 10:45	Break, Convention Center
	10:45 to 11:45	Gas-Turbine Business Update,
		Catalina/Madera/Pasadena
		Mark Axford, Axford Turbine Consultants LLC
		All registered conference attendees
	11:45 to noon	GE Services Presentation,
		Catalina/Madera/Pasadena
		All registered conference attendees
	AFIERNOON	
	Noon to 2:30	Lunch/Exhibits, Convention Center
		All registered conference attendees
	2:30 to 5:30	Breakout Meetings: LM2500, LM5000, LM6000, LMS100
		Users, Depots, and GE only
	EVENING	

6:30 to 11:00 Monday Night Reception, *Renaissance Pool Deck* **All registered conference attendees and registered spouses/guests. Must have name badge and must be 21 years old for entry.**

Western Turbine Users Inc

PROGRAM

s of Feb 15

Tuesday, March 22 MORNING 7:00 to 4:00 Registration 7:00 to 8:00 Breakfast All registered conference attendees 8:00 to 4:30 Exhibit Hall open Must have name badge to enter 8:00 to 9:30 Breakout Meetings: LM2500, LM5000, LM6000, LMS100 Active users only 9:30 to 10:00 Break, Convention Center 10:00 to noon Breakout Meetings: LM2500, LM5000, LM5000, LM6000, LM5100

Users, Depots, and GE only

AFTERNOON

Noon to 4:30 Lunch/Exhibits, Convention Center All registered conference attendees 2:30 to 5:30 Special Technical Presentations All registered conference attendees 2:30 to 3:30 "Aero GT Control Systems 101," Catalina/Madera Mike Toll, Woodward Inc "EMI Diagnostics for Condition-Based Generator Testing," Sierra/Ventura James Timperley, Doble Engineering Co "Effects of California's Cap-and-Trade on the Power Sector," Mojave Jackie Ferlita, Element Markets Inc 3:30 to 4:30 "Importance of LM6000 OEM-Prescribed Maintenance," Catalina/Madera Dale Reed, Reed Services Inc "HRSG Superheaters," Sierra/Ventura Ned Congdon, HRST Inc "Surrogate Technologies for Water Chemistry," Mojave Denton Slovacek, Hach Company 4:30 to 5:30 "LM Engine Component Repair Options," Catalina/Madera Rick Kowalski, MT R&O LCC "Software-Based Emissions Monitoring," Sierra/Ventura Aaron Dodgson, Rockwell Automation Inc "Performance Testing: Boring is Good," Mojave Tina Toburen, T2E3

Wednesday, March 23 MORNING

7:00 to 8:00 Breakfast 8:00 to 10:30 Breakout Meetings: LM2500, LM5000, LM6000, LMS100 Users, Depots, and GE only

10:30 to 10:45 Break, Renaissance Ballroom Foyer

10:45 to 11:45 GE New Products Update, Catalina/Madera/Pasadena

All registered conference attendees

11:45 to noon Wrap-up/Adjourn, Catalina/Madera/Pasadena

All registered conference attendees

26th Annual Conference, Palm Springs, 2016



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SOCIAL FUNCTIONS

he Western Turbine Users' annual meeting returned to Palm Springs in 2016. For those of you here for the first time, this is a favorite venue of many members of the organization. Palm Springs is nestled at the base of the majestic San Jacinto Mountains and generally blessed with gorgeous weather. The village atmosphere mingles with the city's renowned "modernism" style. Sunny streets lined with palm trees invite you to explore boutique shops, art galleries, and museums and to enjoy meals at restaurants with outdoor tables.

Social events are critical to the success of every user group because they enable attendees to meet in a relaxed environment and expand their networks for problem-solving. The Western Turbine Users is hosting several important functions as part of the organization's 26th annual conference; they would not have been possible without the financial support of sponsors identified on signage in the exhibit hall and on the special acknowledgments page of this program guide (p 40). Please thank them when you have the opportunity. Below are short descriptions of social events you won't want to miss.

Sunday: Welcome Hospitality Recep-tion. This event, which includes the opening of the exhibition, begins promptly at 5:30 p.m. in the Convention Center and runs until 8:30. All conference attendees and spouses/ guests are invited. The Convention Center is connected to the Renaissance Hotel as shown in the floor plan provided on p 8.

You get to meet with old friends, find new ones, visit vendors, and have some food while listening for your name to be announced as the winner of one of several special raffle prizes. Raffles are conducted at the top and bottom of every hour (users only), beginning at 6 p.m. Here's the lineup of prizes:

6:00 \$100 Visa® gift card.6:30 GoPro® Hero.

- 7:00 Apple iPad mini 2 (16 GB).
- 7:30 Apple Watch (38 mm).
- 8:00 Apple iPad Air (16 GB, Wi-Fi).
- 8:30 Apple iPad Air (32 GB, Wi-Fi).

Monday: The spouse tour is a halfday excursion (bus loads at 8:45 a.m. outside the Renaissance lobby, returns at 3) which includes a 20-minute ride in the Palm Springs Aerial Tramway, the world's largest rotating tramcar. The scenery is breathtaking. Then there's an opportunity to walk through pristine wilderness and/or visit the souvenir shop for about an hour. A special fee of \$75 covers the tour and luncheon. Bring along a sweater or light jacket, just in case. And don't forget your camera.

The Monday Night Reception, WTUI's first Hawaiian Luau and Polynesian Show, will be held on the Renaissance pool deck from 6:30 to 11. Participation is exclusive to registered attendees and registered spouses/guests. Must have name badge and be 21 years old for entry.







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ACRONYMS TO REMEMBER

AGB—Accessory gearbox (also called the transfer gearbox)

AVR—Automatic voltage regulator

CCM–Condition maintenance manual

- CCR–Customized customer repair
- CFF—Compressor front frame

COD—Commercial operating date

CPLM—Critical-parts life management

CRF—Compressor rear frame

- CWC–Customer web center (GE)
- DEL–Deleted part
- DLE–Dry, low emissions combustor

DOD–Domestic object damage

- EM—Engine manual
- FFA—Front frame assembly
- FOD—Foreign object damage
- FPI—Fluorescent penetrant inspection
- FSNL—Full speed, no load
- GG—Gas generator (consists of the compressor and hot sections only)
- GT–Gas turbine (consists of the gas generator pieces with the power turbine attached)
- HCF—High-cycle fatigue
- HGP—Hot gas path
- HPC—High-pressure compressor
- HPCR—High-pressure compressor rotor
- HPCS—High-pressure compressor stator

HPT—High-pressure turbine

HPTN—High-pressure turbine nozzle

- HPTR—High-pressure turbine rotor
- IGB-Inlet gearbox
- IGV–Inlet guide vane
- IPT—Intermediate-pressure turbine (LMS100)

IRM—Industrial repair manual

LM—Land and marine

LCF-Low-cycle fatigue

LO–Lube oil

- LPC—Low-pressure compressor (not on LM2500; just LM5000 and LM6000)
- LPCR—Low-pressure compressor rotor
- LPT—Low-pressure turbine
- LPTR—Low-pressure turbine rotor
- LPTS—Low-pressure turbine stator
- NGV–Nozzle guide vane
- OEM—Original equipment manufacturer
- PN—Part number
- PT—Power turbine (turns a generator, pump, compressor, propeller, etc)
- PtAl-Platinum aluminide
- RCA-Root cause analysis
- RFQ—Request for quote
- RPL—Replaced part
- SAC—Single annular combustor
- SB–Service bulletin
- SL–Service letter
- SUP—Superseded part
- STIG—Steam-injected gas turbine
- TA—Technical advisor
- TAT—Turnaround time
- TAN—Total acid number (lube oil)
- TBC—Thermal barrier coating
- TGB—Transfer gearbox (also called the accessory gearbox)
- TMF—Turbine mid frame and thermal mechanical fatigue
- VBV–Variable bleed valve (not on LM2500; just LM5000 and LM6000)
- VIGV–Variable inlet guide vanes

VSV–Variable stator vane

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OFFICERS Chuck Casey

President Chuck is Utility Generation Manager for Riverside Public Utilities (Calif), which serves over 105,000 electric residents and business customers with an LM2500



combined cycle, four LM6000 peakers, and four GE10B1 peakers. He has 29 years of generation experience-specializing in plant construction and commissioning, and regulatory compliance. Before joining Riverside in 2006, Chuck was a plant operator, I&E technician, and plant manager for Stewart & Stevenson, GE, and PurEnergy. He began his career as a nuclear electrician on US Navy fast attack submarines. Chuck was elected President of WTUI in 2013; during his 14 years with Western Turbine he has been LM6000 session chair, secretary, exhibit hall manager, and a member of the Board of Directors. He also serves as Chairman of the Southern California Public Power Authority Generation Group and participates in other industry user groups.

Jim Bloomquist

Vice President Jim served as a WTUI board member before being elected one of the organization's vice presidents. He has more than 39 years of experience with Chevron and is a



subject-matter expert specializing in major electrical power systems and process and gas-turbine cogeneration facilities. Jim currently leads the Electrical Engineering Team for Chevron's California San Joaquin Valley Business Unit, an upstream oil producing company.

Bill Lewis

Vice President Bill is Plant Manager of a 700-MW combined-cycle facility in Lebanon, Pa. Previously, he was Plant Manager of PPL Generation LLC's Lower Mount Bethel Ener-



gy LLC. Before that assignment, he was responsible for the company's simple-cycle peaking gas turbines located in Connecticut, Pennsylvania, and Illinois. Lewis served six years in the US Navy as a Gas Turbine Specialist, rising to the rank of Petty Officer First Class before taking a shore-side job.

David Merritt

Vice President David, the Deputy General Manager for Kings River Conservation District, oversees the power generation and development, flood maintenance, and environmental



divisions. Previously, he spent 19 years with GWF Power Systems/GWF Energy LLC. There David managed three facilities, four LM6000 peakers, and a 23-MW solid-fuel-fired combustor with a steam turbine. Before joining GWF, David served in the US Navy.

Wayne Kawamoto

Treasurer Wayne is one of the founders of the Western Turbine Users and has served on the Board and as Treasurer since incorporation. He has a BS degree in Civil Engineering



from the University of Hawaii and has held numerous positions in project management throughout his 40+ years of professional employment. Wayne is the Plant Manager of Corona Energy Partners Ltd.

Alvin Boyd

Secretary Alvin has been working since May 2015 as an independent contractor for companies requiring his LM6000 and general powerplant expertise. He was O&M man-



ager at Kings River Conservation District's Malaga Peaking Power Plant which was sold last spring. Before joining KRDC in 2011, Alvin spent 24 years at the Pasadena (Calif) Water & Power Dept as power production superintendent managing the city's Broadway and Glenarm plants. He served nine years in the US Navy, mustering out as a Machinist Mate 1/c. Alvin served on the WTUI Board of Directors from 2008 to 2013, when he was elected secretary and co-manager of the exhibit hall.

BOARD OF DIRECTORS

Board Member Ed is Plant Manager of Missouri River Energy Services' Exira Generating Station in Brayton, Iowa. His gas-turbine experience includes Allison 501s, Solar Centaurs,



LM2500s, and LM6000s. Previously he was a combined-cycle plant supervisor at Maui Electric Co and a field service and commissioning engineer for Stewart & Stevenson. Jackson spent eight years in the US Navy as a GT systems technician (electrical).

Andrew Gundershaug

Board Member Andrew is the Plant Manager for Calpine's Solano Peakers (five LM6000s), located in Northern California's Solano County. Previously he held various other positions at the compa-



ny's aero generating assets in Northern California—including Operations Manager, Maintenance Manager, DCS Technician, and IC&E Technician. He has been with Calpine since entering the industry in 1998 as IC&E Technician at the Watsonville Cogeneration Plant following graduation from UC Santa Cruz. Andrew currently is serving his third year as the LM6000 Breakout Session chair; he served the previous three years as the LM5000 Breakout Session chair.

Bryan Atkisson

Board Member Bryan is a Plant Manager for Riverside Public Utilities (Calif) with responsibility for four LM6000PCs and four GE10B1 peaking gas turbines. He has 15 years of experi-



ence operating and maintaining LM6000s and was involved in the construction and commissioning of the four Riverside units that he now manages. Bryan served eight years in the US Marine Corps, most of that time spent performing GT overhauls as a jet engine mechanic. He served WTUI as the LM6000 session chair for six years prior to joining the Board of Directors in 2013.

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Jermaine Woodall

Board Member Jermaine is a Fleet O&M Manager for Exelon Generation. He has worked in various powerplant settings comprised of peaking units, frames, and renewables. Jermaine



brings 15 years of industry experience to WTUI, gained in positions such as Instrumentation Controls & Electrical Technician. He also served in the US Navy for 10 years as an Aviation Electrician's, Mate. An alumnus of the University of Phoenix, his academic credentials include Master of Business Administration and Bachelors of Science in Management with a minor in Electronics.

Devin Chapin

Board Member Devin has over 20 years of experience in power generation. For the past 14, he has worked at Turlock Irrigation District (Calif), a municipal utility. Devin is Power

Plant Supervisor, responsible for O&M

WESTERN TURBINE LEADERSHIP TEAM

management at TID's Almond Power Plant, which has four LM6000s. The oldest of these is a steam-injected LM6000PC Sprint, converted from an LM5000 STIG in 2003. The remaining three gas turbines represent GE's first production LM6000P-Gs, which are operated in simple-cycle mode and are valued for their rapid start capability. Devin has been involved with the LM6000PG project from the design phase through construction, commissioning, and commercial operation.

Howard Hoffmann

Board Member Howard works in Ameren Missouri's turbine engineering organization, which is responsible for O&M of the company's 14 gas-turbine facilities; it also provides engi-



neering support on steam turbines. At Ameren he has managed five simple-cycle energy centers equipped with LM6000s, plus GE and Siemens frames 7EA, 6B, and 501D5A. Howard's 25+ years of experience in power generation includes manager of engineering for an unregulated fleet of assets and field engineer for GE Power Systems.

Rick McPherson

Board Member Rick is plant manager of NRG's Walnut Creek Energy Park in the Los Angeles Basin, which is equipped with five LMS100 peakers. He has been involved with the proj-



ect since construction. Prior to joining NRG, Rick spent 26 years at Edison Mission Energy where he served as maintenance supervisor, operations supervisor, senior wind project manager, and plant manager at various projects in California, Utah, and Wyoming equipped with GE 7Es, Suzlon wind turbines, and LMS100s.

BREAKOUT SESSION CHAIRS Bryan Atkisson

New Users

Bryan is a Plant Manager for Riverside Public Utilities (Calif) with responsibility for four LM6000PCs and four GE10B1 peaking gas turbines. He has 15 years of experience operating and maintaining LM6000s and was involved in the construction and commissioning of the four Riverside units that he now manages. Bryan served eight years in the US Marine

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Corps, most of that time spent performing GT overhauls as a jet engine mechanic. He served WTUI as the LM6000 session chair for six years prior to joining the Board of Directors in 2013.

John Baker

IM2500John is a Plant Manager for Riverside Public Utilities (Calif). Previously he was O&M Manager for Calpine Corp's Bethpage Energy Center in



Hicksville, NY, where he was responsible for two LM2500s and two LM6000s. He started his gas-turbine career with Calpine at Watsonville, later working at the company's Agnews and Los Esteros facilities before moving to the East Coast. Prior to Calpine, John was in boiler operations at

Foster Wheeler Energy Corp. This is John's ninth year as session chairman for the LM2500 group.

Perry Leslie LM5000 Perry has been a Plant Technician for



WESTERN TURBINE LEADERSHIP TEAM

Wellhead Electric Co at the Yuba City Cogeneration Plant since 2004. Responsibilities include I&C and mechanical maintenance, and operations. He also is the GT management team leader for Wellhead. Previously, Perry spent six years as a field service technician for GE in the Bakersfield area, working on LM1600, LM2500, LM5000, and LM6000 engines. Earlier, he served in the US Navy for six years as a GT systems technician-electrical (GSE).

Andrew Gundershaug

LM6000

Andrew is the Plant Manager for Calpine's Solano Peakers (five LM6000s). located in Northern California's Solano County. Previously he held various other positions at the company's aero generating assets in Northern California-including Operations Manager, Maintenance Manager, DCS Technician, and IC&E Technician. He has been with Calpine since entering the industry in 1998 as IC&E Technician at the Watsonville Cogeneration Plant following graduation from UC Santa Cruz. Andrew currently is serving his third year as the LM6000 Breakout Session chair; he served the previous three years as the LM5000 Breakout Session chair.

Jason King

LMS100 Jason currently works for DGC Operations LLC as the O&M Manager for CPV Sentinel Energy LLC in North Palm Springs, Calif. He is responsible for the safe operation and



maintenance of eight LMS100 peaking gas turbines. Prior to joining the Sentinel Project in 2012, Jason served as the Plant Manager for Wildflower Energy LP where he was responsible for the safe operation of five LM6000s. Jason has worked in the power generation business for over 15 years and has experience ranging from construction, commissioning, and operations of both LMS100 and LM6000 gas turbines. Prior to working in power generation, Jason served five years in the US Marines Corps as a helicopter gas-turbine mechanic.

SUPPORTING STAFF **Mike Raaker**

Historian/Ambassador

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For more information visit www.ductballoon.com gary@ductballoon.com TEL: 630-564-7471 company's towel and tissue plant in Oxnard, Calif. The LM2500powered facility would keep Mike busy for the next 30 years and would lead to his, and wife Charlene's, participation in WTUI.



Charlene Raaker

Registration Coordinator As WTUI's Registration Coordinator (and Mike Raaker's better half), Charlene has been supporting the organization for almost as long as it has been in existence. Charlene's

is the "voice on the other end of the line" whenever anyone calls the group.

Wayne Feragen



Wayne is Senior West Coast Plant Manager for Noresco, currently responsible for powerplants in Colton, Calif, and San Diego. Wayne has over 23 years of powerplant experience, starting as a Gas Turbine Electronics Technician First Class in the US Navy. After leaving the service, he went to Newark Pacific Paperboard and ran an LM2500. After that, he worked at two Sunlaw plants running LM2500s. Wayne has served as WTUI's Webmaster for the last eight years.



Conference Coordinator Mumtaz Marketing

& Events has been assisting the WTUI Board in producing the conference for the past several years.



Mumtaz has produced the past several Monday Night events, assisted with the registration process, coordinated the spouse tours, and has made the WTUI conference "Mumtaz!" As logistical mavens they thrive on the details. Their motto: Details make the big picture happen. Visit www. MumtazMarketing.com for more information on the Mumtaz team, which looks forward to meeting attendees at the registration desk.





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WTUI, CCJ to collaborate on

he Western Turbine Users and CCJ will work together to expand the sharing of best practices among owner/operators of GE aero engines. WTUI Board Member Ed Jackson, plant manager of Missouri River Energy Services' Exira Generating Station in Brayton, Iowa, said the organization's mission is to help members better operate and maintain their plants, and a proactive best practices program would support this objective. Plan is to add a one-hour session on best practices to the Special Presentations portion of the technical program (Tuesday afternoon), beginning in 2017.

Here in Palm Springs, Jackson, and the WTUI officers, directors, and session breakout chairs, will encourage your support of the initiative and explain how you can participate and benefit from the experience. Three plants will be recognized for their best practices this year during the Tuesday luncheon: Waterside, Lawrence, and Worthington. Their best practices are summarized below.

Waterside

Waterside Power LLC, an emergency oilfired peaking plant located in Stamford, Conn, is equipped with three trailer-mounted TM2500s capable of generating a total of 72 MW. It is owned by FREIF North American Power I LLC and operated by Consolidated Asset Management Services (CAMS) with a staff of three: Plant Manager Bill Jolly and Technicians Colin Cameron and Robbie Nelson.

ISO New England requires this facility to meet the grid's generation requirement within 30 minutes of an electronic or telephone dispatch. Important to note is that ISO-NE recently implemented much stronger penalties for not meeting the 30-min dispatch requirement and for the failure to provide reserve.

The inability of this relatively small project to meet grid needs even one time could jeopardize the plant's future. Thus, the three best practices shared this year by the plant staff focus on reliability improvement through automation, an ongoing initiative. Since the reliability improvements were implemented, the plant has maintained a 100% performance factor and an equivalent forced-outage rate demand of zero.

Generator emergency lubeoil system

As installed, Waterside required considerable manual intervention to operate the plant in accordance with recommended procedures. Example: To monitor and control generator bearing temperature, an operator had to start and stop the emergency lube-oil pump manually when required to maintain a start permissive. The turbines would lose their start permissive when bearing temperatures fell below the required minimum. Loss of the permissive would have had a major negative financial impact on the project.

There was another concern, too. If the system was not monitored closely, the pump would run longer than required, increasing the parasitic power draw and adding to equipment wear and tear.

The pump only had to run during peak hours when the plant was in the 30-minute reserve mode.

Plant elected to automate the system. The operations team opted to change the logic so when the units were in auto-synch mode (used only during the 30-minute reserve periods) the generator lube-oil system would maintain bearing temperature within the manufacturer's specifications. Shutdown was initiated at a predetermined point to conserve wear and tear on the equipment, excess power consumption of AC fans and motors, and excess battery draw on the DC system.

There has not been a loss-of-start-permissive attributed to bearing temperature since commissioning of the automation feature. "Flawless" is the term personnel used to describe the performance of the upgraded system.

Automation of fuel isolation

If a leak occurred in the fuel system provided with each of the plant's TM2500 engines, the shift operator would not have been aware of a malfunction until a fire started or a substantial amount of fuel was lost. Because of the time it would have taken for the operator to respond, a plant shutdown was likely. With capacity and availability critical to success, plant staff investigated ways to reduce this operational risk.

A control system upgrade and the instal-

lation of a motor-operated valve on each unit's auxiliary skid reduced the risk of loss of generation and/or equipment caused by fire or a major leak. The system is tied into the HMI and visual status of valve position always is available. The operating system alarm summary/shutdown screen was updated to accommodate the upgrades, which have performed flawlessly and reduced the operator's time away from the control room.

Fuel building fire protection

The reliability of Waterside's fuel forwarding system was investigated by plant staff. Reason: If system operation were interrupted, the facility would be unable to meet its dispatch requirement. The plant was designed with two 100% fuel forwarding pumps, two 100% fuel off-loading pumps, and two 126,000-gal storage tanks (one in ready reserve).

Personnel had some concerns about their ability to maintain plant reliability at the level demanded by the grid with no fire detection system installed in the fuel pumphouse. Were a fire to start, building and equipment could be lost before first responders got to the site. This would cause a total loss of generation and the ability to make the plant available for future dispatches until a temporary fuel system was in place or the existing fuel building and equipment were replaced.

Also, not having fire-detection capability meant the shift operator would have to leave his or her post periodically to visually confirm there were no issues within the fuel building.

Absent the operator from the control room, there was no one to monitor plant performance and insure Waterside was meeting desired dispatch parameters.

Waterside installed a cross-zone thermal fire detection system and provided indication of system status to the local control room at each TM2500 as well as the main control room. Cross-zoning of the thermal detection system assures the plant's fuel system would not trip from the loss of a single signal, or the failure of a single detection device, while still providing adequate system/plant protection in the event of an actual fire. When both zones are activated, the system shuts down the turbines and helps isolate all

BEST PRACTICES

best practices

Lawrence Generating Station has six gas-fired LM6000s

potential fuel sources—including the fuel forwarding pumps that otherwise would continue to feed the fire.

Real-time monitoring of the fuel building by the fire detection system has reduced the amount of time the operator must be away from the control room to monitor the system locally. Immediate indication of an abnormal thermal condition in the fuel building also reduces significantly the chances of a total system loss in the unlikely event of an actual fire.

Lawrence

Top hat prevents water from entering line-side cubicle

During annual inspections of the generator line-side cubicle, Lawrence Generating Station personnel occasionally found corrosion, with minor evidence of moisture intrusion. Staff inspected and replaced door gaskets as necessary, but snow accumulates on top of the cubicle during winter and the melt-off leaked into the interior, as indicated by water stains. Concern was that with an increase in wintertime dispatches, additional protection was required to guard against corrosion and potential arcing failures.

"Top hat" design prevents snow accumulation and water from entering the generator line-side cubicle

After evaluating the risks, Lead O&M Technician Matt O'Hara, O&M-ICE Tech Robert Bauman, and O&M Tech Jared Thomas collaborated to identify an effective way for preventing snow accumulation on the cubicle and water intrusion.

The "top hat" design made by a local metal fabricator was the solution (photo). Since the top hats were installed, inspections have revealed no evidence of water intrusion; the tops of the cubicles are dry and snow-free. The additional protection will extend component life and prevent a possible catastrophic failure caused by arc flash.

Lawrence is an LM6000-powered, 258-MW, 6×0 gas-fired peaking station located in Lawrence County, Ind, co-owned by Hoosier Energy (four units) and Wabash Valley Power Assn (two units). Robert Van-Denburgh manages the facility for NAES Corp, the contract operator.

Worthington Safer, faster chiller winterization

Hoosier Energy's 174-MW Worthington Generating Station, a 4×0 gas-fired peaking station powered by inlet-chillerequipped LM6000s was designed to operate from April through October and later modified for year-round peaking power. Wintertime operation required lay-up of the chillers, plus freeze protection of the chilled-water system by use of a glycol/ water mixture and an auxiliary boiler.

Each spring and fall, Worthington personnel had to change out the glycol solution for summer and winter operations, respectively. In winter, the fluid contains

1. Worthington Generating Station has four LM6000 peakers. Aerial photo shows location of the gas turbines, glycol storage tank, and vault

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2. New eductor isolation valve

3. Glycol fill line

4. New skid-mounted transfer pump

35% glycol, in summer less than 10%. The following procedure had been used since the plant went commercial:

- 1. Drain chilled-water/glycol loop into the glycol tank (Fig 1) using the eductor. This removes about 30,000 gal, but leaves about 12,000 gal in the system which has to be drained manually using a sandpiper (low flow rate; constant supervision required) and totes.
- 2. Load a 1000-gal poly tank on a trailer and move it to the vault using a forklift.
- 3. Connect a 2-in.-diam hose to the supply riser at the vault and pump glycol into the poly tank unit it's full.
- 4. Load hoses and sandpiper onto the trailer and drive the fully loaded poly tank to the 50,000-gal glycol tank.
- 5. Remove the sandpiper and hoses. Connect a hose to the bottom of the poly tank at one end and to the glycol tank at the other end.
- 6. Pump glycol from the poly tank into the glycol tank using the sandpiper.
- 7. Load hoses and sandpiper into the trailer and drive the empty poly tank back to the vault.
- 8. Repeat steps 2-7 as necessary. Task can take up to four days using three operators 12 hours per day.

Several problems were identified with this procedure, including these:

- Safety and environmental concerns associated with moving the loaded totes.
- Excessive overtime payments.
- Restrictions on plant operations during the transition.

Plant had to streamline the transfer process to eliminate these issues.

Worthington staff—specifically Plant Manager Robert VanDenburgh, Lead O&M Tech Matthew O'Hara, O&M Tech Bruce Button, and O&M/IC&E Tech Jason Robertson—collaborated and developed a new procedure requiring a few plant modifications, including elimination of the low-flow sandpiper. The following physical changes were made to the system:

- A valve was added to isolate the eductor (Fig 2).
- A tee was installed in the supply riser line with an isolation valve and fittings (Fig 3) to connect to a transfer pump.
- A properly sized, skid-mounted transfer pump was installed to replace the sandpiper (Fig 4).

When the improved system was commissioned, the following new procedure was implemented:

- 1. Drain the glycol/water solution into the glycol tank using the eductor.
- 2. Connect a 2-in. hose (about 15 ft required) from the supply riser to the new 2-in. connection at the eductor station.
- 3. Isolate the eductor using the new isolation valve shown in Fig 3.
- Pump glycol from the riser to the glycol tank using the new skid-mounted pump and existing eductor piping until the system is empty.

The bottom line: Two operators can perform the new procedure in only about eight hours (total of 16 man-hours), meaning the plant can be restored to full operation in a single shift instead of the four full days it used to take (144 man-hours, 40% of that at the overtime rate). The new procedure completely eliminates the safety and environmental hazards associated with the old one.

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All entries will receive industry recognition by way of a profile in a special editorial section on Best Practices published in the throughout the year in COMBINED CYCLE Journal. A panel of judges from the WTUI Board of Directors will select for formal recognition and technical presentations at WTUI 2017, the Best Practices they believe offer the greatest benefit to the industry given today's demanding goals of improving performance, reliability/availability, and safety, and reducing costs, while satisfying the requirements of ever more challenging regulations promulgated by EPA, NERC, OSHA, regional grids, etc.

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ORAP® UPDATE

Automated data collection assures accuracy

By Salvatore A DellaVilla Jr,

CEO, Strategic Power Systems Inc[®] (SPS)

t is important that SPS continue to provide industry benchmarks leading up to, and during, the annual WTUI conference. Your participation in the ORAP® program allows us to aggregate data and provide meaningful analytics to the group.

Our effort to provide the high-quality information required for decision-making demands automated collection of data from the control system. We bring this to your attention now because our engineers and analytics team are seeing more and more issues related to the manual submittal of data. For example, you may have noticed that we do not provide any metrics for starting reliability. Our experts are concerned that the information submitted to SPS regarding starts is increasingly inaccurate and we are not confident in the starting reliability data to

Table 1: Key performance indicators developed from ORAP [®] simple- cycle RAM metrics			
Parameter	2015 Aero	2010- 2014 Aero	
Peaking units:			
Annual service hours	350	356	
Annual starts	95	86	
Service hours/start	3.7	4.1	
Service factor, %	4.0	4.1	
Capacity factor, %	4.0	4.2	
Availability, %	93.6	91.9	
Reliability, %	96.7	96.3	
Cycling units:			
Annual service hours	1863	2193	
Annual starts	166	162	
Service hours/start	11.2	13.5	
Service factor, %	21.3	25.0	
Capacity factor, %	13.9	17.8	
Availability, %	91.8	92.2	
Reliability, %	96.6	96.5	
Base-load units:			
Annual service hours	7185	6935	
Annual starts	48	56	
Service hours/start	151.2	124.4	
Service factor, %	82.0	/9.2	
Capacity factor, %	70.6	66.5	
Availability, %	93.4	92.8	
Reliability, %	97.1	97.4	

provide it as an industry benchmark.

As stated in IEEE Standard 762, the document SPS uses to guide the processing of ORAP data, "a starting failure is an unsuccessful attempt to bring a unit from shutdown to the in-service state within a specified period (which may be different for individual units). Repeated initiations of the starting sequence without accomplishing corrective repairs are counted as a single attempt." Simply, if the unit does not reach breaker closure in a specified period of time, it is considered a failure to start.

Additionally, we are questioning much of the information reported to us from NERC GADS. We continually see issues in the fidelity of the data as that information relates to causes of downtime and duration. Our engineers have conducted a dataquality comparison referencing one of our long-time customers that recently moved from submitting data directly to us versus submitting NERC GADS data.

We found NERC GADS data are inherently high-level and do not have the same granularity of detail that ORAP requires. Plus, NERC GADS does not require users to identify component-level root causes to forced-outage events, a detail that creates issues when trying to compare this customer to the rest of the fleet.

These data also raise concerns with the manufacturer. Periodically, we conduct quality reviews with the OEMs. During these

reviews we often are questioned on the accuracy of events that have been submitted from NERC GADS reports. All the issues identified above make it difficult to use NERC GADS data to allow meaningful and accurate comparison with the rest of the fleet in ORAP.

The easiest way to remedy these issues

WEST

is by use of automated data collection from the control system. By automating the data, the system records each mission, from startup to shutdown—including all major states from signal to start, through the permissives, to ignition, flame established, acceleration, breaker closure, through each change in load state, to shutdown, and then the cool-down period. This is the only way to eliminate human error and ambiguity and ensure data accuracy.

However, we still do need input from your maintenance staff regarding the symptom, corrective action, and eventually the root cause of outages to ensure that the full scope of the event is captured correctly.

Table 2: Comparing capacity(CF) and reserve standby (RSF)factors regionally

Parameter West:	2015 Aero	2010-2014 Aero
CF, %	16.4	23.8
Midwest:	00.1	01.0
CF, % RSF, %	9.0 79.1	9.1 77.4
Northeast:		
CF, % RSF, %	21.3 65.7	14.9 71.5
South:	10 5	15 4
RSF, %	76.4	75.0
Noto: West includes Alas	o and Howe	

Note: West includes Alaska and Hawaii

Western Turbine Users Inc

There always will be a human element to this reporting.

That said, SPS has prepared the latest RAM KPIs from ORAP (Table 1). Our engineers have completed an exhaustive review of the data and analyzed it for accuracy. The information compiled in the table comes from 627 aero units for 2015 and 1067 units for the 2010-2014 period. The aeroderivative gas turbines in the sample include engines from GE, P&W, and Siemens AGT (formerly Rolls-Royce) and represent units operating worldwide.

Note that there was very little change in annual operating (service) hours for peaking units from the 2010-2014 period to 2015; availability was up about 1.7% for 2015 and reliability increased slightly. Cycling units operated 330 hours less in 2015 than they averaged in 2010-2014; availability dropped by 0.4% while reliability improved slightly (0.1%). Base-load units operated 250 more hours in 2015 versus 2010-2014 while starts decreased.

The regional analysis in Table 2 shows capacity factor was down by 7.4% in the West, with reserve standby factor in that region up by 4.3%. Another significant change was the 6.4% increase in capacity factor in the Northeast in 2015 compared with the previous five-year period.

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Program is under development. Prospective **delegates** and **exhibitors** are urged to contact WTUI conference staff today, by e-mail (info@wtui.com), and ask to be placed on the mailing list for meeting announcements as they are made available.

WTUI EXHIBIT HALL

EXHIBIT HALL

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AMETEK Power Instruments	101
ANZGT	508
ARB Inc	210
Arnold Group	
Arrow Products Support	127
ATCO Emissions Management Ltd	
Aviation Power & Marine	
Babcock & Wilcox Co	124
Baseload Power and Generation Parts & Services LLC.	
BASF Corp	219
Borri Power (US) Inc	
Braden Manufacturing LLC	1106
Bremco Inc	
Caldwell Energy	
Camfil Power Systems	
CEMTEK Environmental	108

Company	Booth
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Chromalloy	
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Clean and Science Co Ltd	
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Compression Source Inc	
Conntect Inc	
Cormetech Inc	1021
CrownElectric Engineering & Manufacturing LLC	
Cullum Detuners Ltd	103
Cust-O-Fab Specialty Services LLC	118
Danfoss High Pressure Pumps	927
DCL International Inc	211
Dekomte de Temple	1109
Detector Electronics Corp	1009
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MTU Maintenance616Munters Corp920NAES Corp908Nalco Co321National Electric Coil309Nationwide Boiler Inc902OEM Parts Network Inc817Olympus107ORR Protection Systems1023Parker Hannifin Corp222PAS MRO125Peerless Mfg Co226Peter Paul Electronics Co303Petrotech Inc903PIC Group Inc1103PME Babbitt Bearings109Pneumafil/Nederman204Powerflow Fluid Systems LLC220Powerflow Fluid Systems LLC220PowerPHASE LLC110Precision Iceblast Corp223ProEnergy Services910Puretec Industrial Water405Quality Avaition Inc205Quality Generator Services818Reed Electric and Field Service1108REXA227Robinson Fans Inc104Rochem Technical Services USA Ltd706Score Energy Ltd322Siemens Industry Inc322Siemens Industry Inc309SISU Energy & Environmental704S J Turbine Inc408SKE LISA Inc102102102	Montrose Environmental Group Inc	
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Sweeney, Hydratight	
Switch Filtration	
Synergy Catalyst	
T2E3 Inc	
TAW Miami Service Center	
Technical Training Professionals	
Teledyne Monitor Labs Inc	
Thermo Fisher Scientific Inc	1005
TransCanada Turbines Ltd	416
Turbine Technics Inc	
Turbine Technology Services Corp	
TVS Filters	708
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710	HPI LLC
716	Meggitt
724	GE Inspection Technologies
726	AGT Services
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804	Arnold Group
806	Turbine Technology Services Corp
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211	DCL International Inc
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219	BASF Corp
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221	Clean and Science Co Ltd
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223	Precision Iceblast Corp
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227	REXA
300	Airgas Specialty Products
302	GT lce
303	Peter Paul Electronics Co
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307	Mee Industries Inc
308	Iris Power-Qualitrol
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Western Turbine history

Editor's note: "It is an interesting and challenging proposition to look back over time. Remembering and reconstructing events, like beauty, is in the eyes of the beholder. However, there are circumstances that demand a look back, and, typically, these circumstances are related to people whose contributions have made, and continue to make, a difference. And that describes WTUI to a tee. Since its inception, it has been a group of people with a mission and that mission has been all about adding value."

hese words from Sal DellaVilla, CEO, Strategic Power Systems Inc, provided motivation for this section covering the many facets of WTUI history: the pre-incorporation years, the years since incorporation, and the LM engines themselves.

WTUI has a history primarily because of people like Wayne Kawamoto, Mike Raaker, DellaVilla, Mark Axford, Steve Johnson, and a few others who have been around since before the organization took root, have good memories, took good notes, and are loathe to deposit in the circular file anything that someday might be of value. All contributed to this historical perspective on the world's largest independent user organization dedicated to gas turbines.

As you read the next few pages, keep in mind that the company and plant affiliations sited are consistent with the timing of the reference. In some cases, the individuals mentioned are still employed by those organizations, in others the companies may no longer exist, or plants have been renamed.

Before incorporation

The history of WTUI dates back about 10 years prior to incorporation. During the late 1970s, the US was challenged with oil and gas shortages and record-high fuel prices—much of this caused by wasteful energy practices. Remember when automobiles were averaging 9 mpg and some power boilers were operating at efficiencies as low as 60%?

In 1978, President Jimmy Carter signed into law the Public Utility Regulatory Policies Act (Purpa), aimed at correcting some of the problems. For the first time, utilities were required to purchase electricity from qualified cogenerators at a price equivalent to what it would have cost the utilities to produce the same power with their leastefficient equipment. This had two effects:

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HISTORY

It forced the utilities to shut down marginal equipment and it ushered in the era of high-efficiency cogeneration facilities.

The 15-yr power-purchase contracts typical of that time were particularly advantageous to companies with processes having fuel-to-product efficiencies of 80% or more. The Northeast and West Coast, saddled with the highest energy prices in the nation, were the prime locations for cogeneration plants. GE, one of the first companies to recognize this opportunity, began marketing its Turbine Business Operation's LM2500 package, initially capable of 17.8 MW. In the early 1980s, GE introduced the LM5000 package, capable of 50 MW.

Utilities were not going to take all this lying down. Concerned with the ability of small energy producers to provide electricity reliably, and consistently, they developed a set of strict rules that created a lot of pain for someone entering into a contract and failing to meet the requirements. Example: Failure to meet the 80+% availability requirement at the contracted capacity could result in the loss of a month's revenue; in the extreme it might require repayment of annual profits.

During the first few years of Purpa, the number of cogeneration sites on the West

Coast grew dramatically—each usually having a unique process to earn Qualifying Facility status. However, the turbines, packages, and processes did not start and run as expected. GE engines were very good at operating for short periods, with a rest to perform maintenance.

But most sites were required to run for weeks—sometimes months—without a shutdown, depending on the process supported. Starter failures, igniter liberation, fuel-nozzle failures, etc, caused many sleepless nights for the operators as well as the OEM. Both parties stood to lose considerable sums if the turbines and packages could not be made reliable.

GE found itself running from site to site trying to put out fires and keep the owners from defaulting on their contracts. Generating units on both the East and West Coasts were experiencing the same types of failures, making it obvious that owner/ operators needed to share best practices and lessons learned among themselves and with the OEM.

GE's business leaders—like Bill Baker, Mike Hynd, Dan Harmon, and Horace Magely—were traveling cross country regularly to support their customers. To differentiate between the two distinct groups of owner/operators, the OEM began to refer to them as Western Turbine Users (WTU) and Eastern Turbine Users (ETU). The acronym WTUI came to being after the group formalized and incorporated in 1990.

To share information, users gathered at each other's sites for tours of the equipment and to share individual experiences. GE was always part of these meetings. The host site would supply meeting space and usually lunch or dinner. The group began with four attendees, growing to eight, 20, 40—about the point it was no longer feasible for a single operator site to manage and fund the quarterly get-togethers.

As far back as I can remember, GE hosted a sales and customer appreciation meeting in Cincinnati—years later, in Houston—which usually culminated with a relaxing team-building event. Many productive relationships among GE personnel and users were nurtured during these three-day meetings.

Many of the temporary fixes and improvements made by operators to keep their sites running in the early years were reviewed by GE and many became permanent fixes for all sites. A major contributor to fleet availability and reliability improvement was the sharing of parts. Each participating site would generate a

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HISTORY

list of its inventory and share that with the other participating sites.

We could get parts to each other much quicker than GE. This worked very well when the group was small, but it got a bit cumbersome as the group grew and some folks "forgot" to return parts. Partssharing continues today, but on a more personal basis.

Package improvements were another benefit of user meetings. Example: Owner/operators realized turbines could fire hotter and produce additional power just by "turning up the wick." Output of the LM2500 increased from 17.8 to 21 MW over the first few years with very little hot-section life reduction. The increased revenues more than paid for the additional wear and tear on parts.

Plus, many cost-effective repair and overhaul procedures were developed working with small authorized repair facilities—like Batch Air Inc. Some of those were borrowed from aircraft procedures and became standard, authorized repairs for combustors, blades, nozzles, bearings, and frame parts on land-based machines. They reduced the cost of operating LM engines by a significant amount.

The option to use repaired parts versus new parts and expecting GE to warrant the engines became an issue with the OEM in the early years. That was understandable: Users were installing remanufactured parts, and if they failed during the shop warranty period, GE was responsible for the damage.

Users were in hands-on creative mode, continually developing new repair procedures and bringing on innovative vendors that developed such improvements as the Orange Box (individual T-54 thermocouples), longer-lived repairs for bearings and combustors, etc; some were adopted by GE as time passed.

As the number of LM sites grew, WTUI came to be recognized as the place to learn and benefit from both GE and other owner/operators. As the organization expanded, the cost of managing conferences was more than any one company could support. This forced WTUI in 1990 to begin the second phase of its history as an incorporated business. It permitted dues collection, golf outings, tennis tournaments, evening entertainment, and other managing tools that have made WTUI the world-class organization it is today.

Mike Raaker, WTUI historian/ambassador

After incorporation

I will always remember the chain of events that led to the introduction of Strategic Power Systems Inc (SPS) to three of the founders of the Western Turbine Users: John Tunks, the organization's first president (California Cogeneration Operators Inc), Ernie Soczka (Destec's San Joaquin Cogen), and Bob Fields (Container Corp of America). The meeting took place at Ricky's Hyatt in Palo Alto, Calif, in fall 1990, just prior to WTUI's incorporation. The number of GE LM units operating in cogeneration service, especially in California, was rapidly increasing because of Purpa.

Existing users, who already were meeting at various plants, wanted a more formal structure to support the expanding base of operators. They understood new users would require operating knowledge and experience, and would share their desire for continuous product improvement.

They also understood the need to establish and follow a uniform process that the Western Turbine Users, as an organization, could use to track and report the availability and reliability performance of the LM5000 and LM2500 fleets. The objective was to have unbiased and accurate data to document the performance of their gas turbines and plant equipment. The users wanted data and metrics they could share among themselves, and with GE. SPS hoped WTUI would agree that ORAP[®] (for Operational Reliability Analysis Program) was the system they needed.

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The first link in the chain of events was a call I received from Lou Pasquarelli, an old GE friend. Lou explained that both the Western Turbine Users and the GE Marine & Industrial business unit (today a part of GE Power) were interested in tracking the reliability and availability of the LM product family to support the expanding user base.

He suggested I contact John Campbell (now deceased) who was GM of the Customer Service business unit to discuss the opportunity. John understood the market for the LM product line was growing and recognized that for continued success, product performance had to meet customer expectations. He recognized the benefits ORAP offered and invited me to Cincinnati to present the system. Afterwards, he decided that GE would fund and use ORAP to cooperate with and support the Western Turbine Users—cooperation and support that continues today.

In due course, John, Larry Lewis (then the GE point of contact, now retired), and I made several plant visits in California to introduce the LM users to ORAP. From the Shasta mountain range to Santa Clara, from Los Angeles to Bakersfield, the goal was to grow user participation on the ORAP system, and to begin the reporting and feedback process.

The objective was to obtain and process plant data as quickly as possible and to show meaningful results. We were on our way. We had the strong endorsement of GE and the Western Turbine Users, and our job was to demonstrate and add value for the users.

WTUI veterans know that the success of this conference did not just happen by accident. The word "serendipity" does not apply to WTUI. Its success has been built on the efforts of dedicated people with vision and a long-term commitment to their industry—and to each other. Now, after 26 years of hard work, a meeting that started out in a few plant conference rooms has been transformed into a world-class conference that attracts a global audience.

The first meeting attended by SPS staff was Sacramento, March 1991. There were 130 registered attendees—including users, vendors, spouses, and guests. The board of directors included Tunks (he had moved on to Stewart & Stevenson Services, S&S, by this time), Soczka, Fields, Jim Hinrichs (Sithe Energies), Wayne Kawamoto (Wheelabrator Norwalk and WTUI treasurer, an office he continues to hold), and Steve Johnson (Simpson Paper, Shasta Mill).

At that meeting, Hinrichs became the WTUI president, a position he was to hold for 17 years. Other founding members of the organization who were present included: Mike Raaker (Proctor & Gamble), Jack Dow (Sithe Energies), Jim Bloomquist (Chevron), and Brian Hulse (Destec Bakersfield). Tom Christiansen of SPS was given the opportunity to present to the users and to solicit their participation on the ORAP system. The goal was to add more users on ORAP and to produce a formal data analysis and report as soon as possible.

The first ORAP report went out to both participating users and GE in June 1991. It included data from 24 operating plants representing 19 LM2500s and 14 LM5000s, and provided an overview of the reliability metrics that the users desired including component causes of downtime and engine removal rates.

Interestingly, these LM units operated with very high service factors (greater than 85%), and had hours-per-start ratios ranging from 135 to 250)—exactly what you would expect from cogeneration units. At the time, SPS had a commitment from an additional 20 operating plants to join and

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participate on the ORAP system.

Newsletters. From January 1993 through February 1994, WTUI and SPS issued monthly newsletters to all participating members that discussed various technical topics or other items of interest. In the February 1994 newsletter, for example, Johnson wrote "LM5000 Compressors: Cold-End Problems." He had already provided an article of interest on "LM5000 Lube Oil Chip Detection," where he informed that "a chip detection system is a very vital tool." Another article by Kawamoto on "Enhanced Steam Injection" addressed an approach that Wheelabrator Norwalk implemented for improved NO_x abatement.

In the early 1990s, "fall mini conferences" were held to address specific technical issues. For example, Hulse, a board member at the time, arranged a conference at the Pacific Suites Hotel in San Luis Obispo, where issues such as gas-path coatings were discussed. The idea was to add value for the user community by regularly publishing newsletters and conducting mini-conferences.

ORAP. By the time the first newsletter was issued, ORAP participation had grown to 40 plants and new people were getting involved. The January 1993 edition notes

that Brent Newton had joined the board, while the terms of both Soczka and Fields were ending. The visionary founders of WTUI had laid the groundwork for the inevitable changing of the guard. WTUI was preparing for change.

Looking through these newsletters offers a memorable trip back in time. To illustrate: In February 1994, items of interest included the following:

- Announcement that Hulse had submitted the winning design for the WTUI logo, which still is in use today.
- Jack and Gae Dow were identified as the "go-to" team regarding the 1994 conference in Las Vegas.
- SPS would begin taking and issuing notes for each of the LM product line breakout sessions, a practice that continues today.

Breakouts. From the beginning, the two and a half days of breakout sessions covering each LM product line have provided the foundation for sharing knowledge and solving problems. These invaluable sessions provide the opportunity for users to openly discuss installation and commissioning issues, O&M concerns, lessons learned, and the opportunities for plant improvements.

package, controls and all ancillary systems. The intent is to share and document, thereby creating a history through the notes of relevant and meaningful "real life" experiences to help the operating community improve as a group.

Over the years, discussion leaders for the breakout sessions have included Jimmie Wooten (DPS Juniper), Frank Oldread (Destec), Johnson (K&M Services), Grant McDaniel (Carson Cogen), Joel Lepoutre (S&S), Roy Burchfield (Sithe Energies), Norm Duperron (Bonneville Pacific Services), Mel Murphy (Kingsburg Cogen), Bob Anderson (Florida Power Corp), Charlie Hoock (Calpine), Kevin Koszalka (TGB Cogen), James Hardin (El Paso Cogen), and Bob Mason (Goal Line LP).

Also, Rich Frank (GECS Camarillo), Chuck Casey (Goal Line LP), Bob Nelson (SMUD), Chris Kimmich (Nevada Cogen), Bill Lewis (PPL), John Baker (Calpine), Bryan Atkisson (City of Riverside), James Charles (Ripon Cogen), Mark Breen (Wood Group), Chuck Toulou (Ripon Cogen), Don Haines (Panoche Energy Center), David Merritt (Kings River), Andrew Gundershaug (Calpine), Perry Leslie (Yuba City Cogen), and Jason King (DGC Operations).

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discussion leaders is what makes the breakout sessions so successful and meaningful. Plus, the technical sessions have been strongly supported by GE and the depots, adding to their value.

Winds of change. WTUI conferences continue to grow annually, providing opportunities to renew old friendships and establish new ones. Equally important, the conference attracts a significant percentage of new users and attendees each year who bring fresh ideas and perspective vital to long-term health.

Continuing growth testifies to the hard work and dedication of the organization's leadership, and to the increasing value and need for face-to-face information exchange. Such success, however, brings change and occasionally presents very real challenges to the relatively small group of volunteers who make WTUI happen.

President Jim Hinrichs and the officers and directors in place during the first few years of the new millennium faced significant challenges as the need for WTUI's services increased markedly while the duty cycle for the LM sector of the industry was migrating from base- to part-load generation and there was a question as to whether GE could continue to support WTUI with the same commitment as they had in the past.

The good news was growing conference attendance, which went from an average of 470 in the 1996-2000 period to 667 from 2001 to 2005. In the last four years, the average attendance was nearly 800. With this success came the difficulties associated with venue selection; relatively few locations can accommodate groups of this size. Plus there were the additional work loads associated with registration, meeting attendee expectations, etc. More hands were needed; the volunteers could no longer do everything.

Both the organization and its owner/ operator members were forced to adjust to market influences. The once dominant cogeneration market was contracting; units were operating fewer hours per start and they were beginning to cycle. SPS verified the market shift using ORAP data that the company provided for the Combined Cycle Journal's report on the 17th annual conference in Phoenix.

SPS stated in that report, "Two operating profiles are distinctly visible: A baseload duty between 1995 and 1999, and a cycling duty between 2002 and 2006. The years 2000 and 2001 appear to be a transition period where the shift in duty cycle began." ORAP data also indicated that annual service hours had decreased by more than 40% comparing the new paradigm against the old. Further, that service hours per start had decreased by about 60% and the number of annual starts had increased—all as gas prices were spiking.

As the duty cycle was changing, the LM6000 and LM2500 solidified their positions as the product lines for growth, and component life, coatings, and emissions were the issues that had to be addressed.

Growth of depot support. It was during the market evolution that GE communicated to the board that it would not be able to sustain WTUI support at the same levels as in the past. The board took that in stride, solidifying its relationships with the depots and redoubling its efforts to assure that the annual meeting's technical content, and the currency and relevancy of issues covered, would continue to meet expectations.

Larry Flood (EPCO), Rich Recor (Sithe Energies' Greeley), Mike Horn (Calpine), Mike Pankratz (FPB Cogen), Joe Campanelli (Air Products), John Cates (Globeleq), Robert Kofsky (Modesto Irrigation District), and others put in extra hours to ensure that WTUI's mission would be sustained.

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SPS was located in upstate New York, a major benefit of the conference's timing was the opportunity to fly to the West Coast for a week and leave the bitter cold behind. Often, we would leave in a snow storm and return to a snow storm. The opportunity to participate in the Sunday golf or tennis event coordinated by the users (Hinrichs, Kawamoto, Bloomquist, and Ronnie McCray) always was a highlight.

My golf was bad (and still is), but the chance to catch up with old friends and the opportunity to make new acquaintances made it easy to laugh off the comments on my game. Golf with guys like Mark Dobler (Fulton Cogen), Jim Murray (Fulton Cogen), Tony Thorton (Turbine Technology Services), Ron Brooks (United Cogen), Don Haines (City of Santa Clara), Roy Davis (GE), Wayne Feragen (City of Colton), Mike Kolkebeck (City of Colton), Don Driscoll (SSOI), and others always provided the welcome opportunity to mix business with pleasure.

The formal event begins Sunday afternoon with the New User Orientation, which is followed by the opening of the exhibit hall. Jack Gunsett (Kinder Morgan) conducted the orientation for years, eventually passing the baton to Oldread, who later put it in Bob Boozer's (Reed Service) hands. Boozer retired in 2015 and responsibility for New User Orientation now rests with Bryan Atkisson (Riverside Public Utilities). The goal of the session is to introduce first-timers to LM engines, terminology, nomenclature, and other hands-on knowledge and experience to prepare them for the discussions that would take place during the breakout sessions beginning Monday morning. SPS also participates in the New User Orientation to introduce ORAP.

Monday morning the conference begins. Members look forward to the first session and to the ritual handing-out of much-desired WTUI jackets awarded to those users at the session whose names are pulled from the fish bowl.

The months of preparation by the board, the breakout-session chairs, and the depots (Air New Zealand Gas Turbines, MTU Maintenance, TransCanada Turbines, and IHI) kick the conference into high gear. Western Turbine is about organizations and people who see value in what the user group offers and provides, and they want to be a part of it. As the exhibit hall fills with friends, family, and colleagues, the mood is good-spirited, and all are ready for business and a fun time.

In our industry, there are many conferences and user groups, all founded with a desire to add value. And they do. But WTUI is special. It is celebrating its 26th year not just because of the desire and need to share information and knowledge, but rather because it is genuinely focused on the user.

There is a strong sense that the full WTUI membership is interested in fleet performance. By helping to drive improvement fleet-wide, members improve their own plants. Competition among users exists, to be sure; however, there is a very real sense that the WTUI membership wants the term "best in class" to apply to the whole fleet. And they want unbiased third-party data-data available through ORAP.

The hard work and effort that has carried WTUI to its 26th year is a significant feat, and SPS has had the pleasure of supporting the group for most of those years. It is clear that WTUI has a strong commitment to excellence, and a clear vision for continually adding value for its membership. In sum, WTUI is special-not only for its service to the users, but for the users' service to it.

> Salvatore A DellaVilla Jr, CEO, Strategic Power Systems Inc

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LM engine history

he early history of GE land and marine (LM) gas turbines began in the late 1950s and continued through 1970. It started with the introduction of a few small LM products and the larger LM1500 gas turbine. The latter was derived from the OEM's popular J79 fighter engine, widely known for its thousands of applications in the US Air Force (USAF) and the US Navy's (USN) F4 Phantom fighter. The initial LM1500 application was aboard a hydrofoil ship.

In 1969, GE launched the LM2500, a nominal 20,000-shp gas turbine based on the TF39 engine, which powered the USAF's largest transport aircraft—the C5 Galaxy. The first ship to use the LM2500 turbine for main propulsion was the GTS Admiral W M Callaghan (AKR-1001). Two LM2500s replaced the twin-screw vessel's non-GE first-generation turbines, which had been installed only two years earlier.

After several successful USN appli-

cations—such as on the Spruance and Ticonderoga classes of ships—the first LM2500 industrial application was on a pipeline, in 1971, followed by the first power-generation application in 1979. The LM2500, with its versatile free power turbine, high efficiency, light weight and high reliability, quickly became the oiland-gas (O&G) industry's engine of choice for pipeline compression and oil platform power applications.

The need for higher output led to the introduction in 1996 of the LM2500+ engine, which eventually was rated a nominal 42,000 shp. Essentially a turbo-charged base LM2500, the "plus" engine has found widespread acceptance in the O&G industry. It has an additional HP compressor stage in front of the original Stage One. Also, the plus has more-capable hotsection materials and other refinements.

Further technological improvements led to the introduction of the fourth generation

LM2500+G4 engine, with a nominal rating of 46,000 shp. Today, there are well over 2400 engines from the versatile LM2500 family operating worldwide. Applications include propulsion of naval, ferry, and cruise ships; power generation; O&G platforms and pipeline and LNG compression—a testament to the LM2500's longevity and success.

In 1978, GE introduced the LM5000, a larger machine based on the company's CF6-50 aircraft engine, with a nominal output of 38 MW. More than 100 of these workhorses were produced. The LM5000 has a twin-spool gas generator driving a free power turbine. Many LM5000 units are still in service and are favored for cogeneration applications. They laid the foundation for an even bigger and vastly more successful engine to come.

In 1988, GE introduced the LM1600 for small-pipeline applications. The high-performance engine has a two-spool

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gas generator and a free power turbine. Like the LM1500, it was derived from a fighter aircraft engine—GE's F404 engine powering the F/A-18 flown by the USN and Marines. About 100 of these units are still in service.

Building on the LM5000 experience, GE recognized the success and potential of aero engines. In the early 1990s, it saw a market for a larger power-generation machine.

In 1991, the innovative LM6000PA was introduced: It could drive an electric generator either from the cold end or the hot end. This GT was based on GE's highly successful CF6-80C2 engine, which powers many wide-body aircraft-such as the Airbus A310 and Boeing 747/767 models. The LM6000 family quickly grew to the PC model, which is a higher-output engine, rated a nominal 43 MW.

Today, the family includes a PG single annular combustor (SAC) model rated a nominal 54 MW and a PG Dry Low Emissions (DLE) combustor model rated a nominal 48 MW. There are now more than 850 LM6000 units worldwide, serving in a wide variety of applications-including base-load and peaking power generation, combined cycle, cogeneration, and mechanical-drive LNG.

In the early 2000s, US interest in an efficient 100-MW-class gas turbine

capable of fast starts and load-following ability gained traction. GE developed the LMS100 engine to meet these needs. It used some parts and technology from GE's heavy-duty frame gas turbines and the company's latest aircraft engines. Examples: 6FA compressor technology is used in the LMS100's LPC, while the HP compressor and turbines are derived from the CF6-80E1 aircraft engine.

The LMS100 has an all-new lightweight two-stage intermediate-pressure turbine and a five-stage free power turbine for operational flexibility. The engine also is intercooled-that is, the LP compressor discharge air is cooled before it enters the HP compressor. This is largely responsible for the engine's enviable performance and makes it one of the most efficient simplecycle gas turbines in the world. The first LMS100PA (SAC) unit was commissioned in the US in July 2006. Today there are more than 50 of these units in service; the expectation is that many more will be installed in the next five years.

The business side. In the years since the first LM engine was introduced, the actual management of the business itself has undergone several changes. Up until the late 1990s, the LM business was commonly referred to as GE Aeroderivative Engines, and was an integral part of GE Aviation.

At that time, the LM business became part of GE Power Systems, since renamed GE Power. While the LM engines still are manufactured by GE Aviation, the aero product line is part of the GE Power portfolio. Despite the organizational changes, GE's commitment to WTUI has remained steadfast over the last 26 years.

In the early days of the LM business under GE Aviation, the company's primary focus was on manufacturing engines and parts. GE worked with some of its authorized airline engine repair shops and convinced them to take on the responsibility of repairing the new LM engines in-shop. Over time GE also worked with its packagers-they built the powerplant around the gas-turbine core-to develop service and repair capability. These firms included Stewart & Stevenson Services, Kverner, Thomassen Stewart & Stevenson, Avio, IHI, and MTU.

The early-1990s meetings, where a group of WTUI users banded together to see if they could help each other out, were pivotal in making the LM product successful and gaining it wider industry acceptance. They were key to exchanging operational experience, creating the back and forth dialogue around areas of improvement, new and evolving matters, and the solutions developed. There were numerous frank discussions between the

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users and GE at that time. Some of the key GE players: Rudy Garza out of the Ontario shop, Jim McDonel from Cincinnati engines customer support, and Shaun Riley as one of the engine product-line leaders.

The WTUI conference had product-line breakout sessions in which the GE team prepared and presented all of the material for the engine experience and matters, and package sessions, where the material and areas of improvement were presented by the packagers.

In the mid-1990s there were some fruitful discussions around the LM5000 engine. Over a period of years, Paul Maciulewicz. Jim Gardner, and Kumar Khemchandani from GE, and Mike Pipes from S&S, were right in the middle of these discussions. Some of the product improvements were tested at customer facilities-like the Destec sites around Bakersfield, where GE worked very closely with Brian Hulse; Fulton Cogen, where GE worked with Mark Dobler and Jim Murray; Sithe Energy with Rich Recor; and many others. They were supported from the S&S side by some expert engineers like Randy Kleen, Michael Williams, Harley Ross, Robert Baten, and Jack Patton, and later on by a young and energetic field

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C C Jensen Inc 18, 30
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Cust-O-Fab Specialty Services LLC 32
Donaldson49
Duct Balloon20
ECT Inc 50
Emerson Process Management 16
EthosEnergy Group
GasTOPS 50
Gas Turbine Controls 36
W L Gore & Associates Inc51
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HRST Inc
Hy-Pro Filtration5

IHI Corp, Power Systems Div 11
International Generator Technical
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Americas Inc45
Montrose Environmental Group 51
MTU Maintenance Berlin-
Brandenburg
NAES Corp43
National Electric Coil24
Nationwide Environmental
Solutions21
Precision Iceblast Corp
ProEnergy Services52
R F System Lab54
Score Energy48
SISU
SSS Clutch Company Inc12
Strategic Power Systems Inc 47
Sulzer Turbo Services55
TransCanada Turbines Ltd
Turbine Technics Inc9
G R Werth & Associates Inc
Western Turbine Users Inc
Zokman Products Inc12

controls engineer, Nick Voorhis.

In the late 1990s, GE began acquiring some of its authorized packagers and services providers, moving to a more direct end-user service model, which improved direct communications with customers. In the opinion of many people, the removal of an intermediary on significant matters helped improve communications, and ultimately increased GE's direct accountability to its customers, which benefited many users.

With the reintroduction of the GEsponsored users conferences in the early 2000s, each organization was focused on providing the best support to the LM users, and they needed time to work through how they could each accomplish this shared goal through different meetings.

It was during this period that the responsibilities for assembling the material and presenting during the WTUI engine product breakout sessions shifted from GE to several of the company's authorized service shops. GE instead focused most of its support efforts on creating content and leading the engine and package breakout sessions for its own users conference. Even during this period, GE continued to send a key but limited group of members of the services and sales teams to attend the WTUI conferences and meet with the users.

After a few years, and right after the conclusion of another successful Western Turbine conference, some of the WTUI board members (including Jon Kimble and Jim Hinrichs) approached GE to talk about improving GE's visibility and support of the WTUI conference. This was an opportunity for both groups to speak fruitfully about their future together.

Since then the two organizations have continued working closely with each other to find ways that GE and WTUI can best support end-users. This close cooperation now includes GE booths at WTUI staffed by numerous GE technical and product experts, and GE product-line-specific materials and presentations given to end-users and authorized service providers during WTUI.

At the conclusion of GE's own 2014 Americas User Conference in Orlando, the company announced the date and location for the 25th annual Western Turbine Users conference, and further suggested that the customers attend that valuable session clearly a sign of good cooperation.

Madhu Madhavan and Mike Pipes, GE Power, with Gil Badeer, Tayo Montgomery, Rick Hook, Preetham Balasubramanyam, and Kumar Khemchandani

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