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2Q/2009
$15

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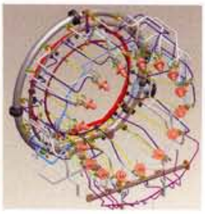
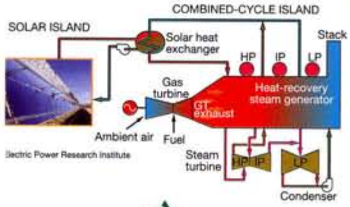


Saluting the Class of 2008/2009

2009 Pacesetter Plant Award






Exclusive User Group Coverage

CTOTF Coverage begins on p 2

7EA Users Group Coverage begins on p 28

Celebrating 60 years of commercial power production by gas turbines

The first industrial engine, a 3.5-MW GE machine, began operating in a combined-cycle configuration at Oklahoma Gas & Electric Co's Belle Isle Station in June 1949 148

INDEPENDENT VOICE OF THE GAS-TURBINE-BASED GENERATION SECTOR

Class *of* 2008/2009

Arvah B Hopkins Generating

Tallahassee, Fla

City of Tallahassee—Your Own Utilities

Combined-cycle repowering reduces fuel cost, decreases emissions

The decision to convert Unit 2 at the Arvah B Hopkins Generating Station, a 230-MW (summer net rating) gas/No. 6 oil-fired conventional steam/electric plant installed in 1977, to combined cycle was based on economics and good sense. The City of Tallahassee, Florida's capital, knew its investment would reduce customers' energy bills over time, which is particularly important because the municipal utility's customers are its owners, and most vote.

Analyses conducted by Sargent & Lundy (S&L), Chicago, the city's engineer for power-generation facilities, indicated that the project would significantly reduce unit heat rate and the utility's annual fuel bill. In fact, the numbers were so compelling, the City Commission voted in October 2005 to move up the planned conversion by two years and have the combined-cycle unit in service before the summer 2008 peak.

Important to note is that the City Commission did not see fossil fuels and a supply-side solution as the city's only energy options moving forward (Sidebar 1). It also invested in an aggressive demand-side management program and made commitments to purchase both power from a biomass-fired project under development and pipeline quality gas derived from biomass.

S&L's work indicated that the Hopkins-2 steam turbine would accommodate installation of two F-class gas turbines (GTs)/triple-pressure heat-recovery steam generators (HRSGs), so it developed a two-phase plan. First phase would be a 1 × 1 combined cycle (Fig 1), the second phase would convert that to a 2 × 1 arrangement. A supplementary-fired HRSG was selected (Sidebar 2), with duct firing considered "peaking capability."

The city mandated that the repowered unit retain the original unit's ability to operate on both gas and liquid fuel to assure production reliability. There was no regulatory driver for this philosophy, just a concern that the state was highly dependent on natural gas and if supplies were curtailed for any reason, the city still could provide power to its customers by burning oil.

1. Downstream of the gas turbine is the bypass stack and the heat-recovery steam generator for the repowered Hopkins Unit 2

The numbers: A 1 × 1 combined cycle without supplementary firing would develop a nominal 233 MW in the summer at a net heat rate of about 7370 Btu/kWh. Duct burners could boost output to 296 MW, but with an accompanying heat-rate penalty (7780 Btu/kWh). The unfired 2 × 1 configuration offered double the 1 × 1 capacity at a better heat rate (7123 Btu/kWh).

The Hopkins 1 × 1 combined cycle began operating in mid 2008 as planned. Repowering and capacity additions since 2000 have increased the utility's total summer firm capability by 138 MW to 805 MW. The results of investing in new generation have been impressive, as the following numbers comparing 2009 data to that from 1991 attest:

- Capacity, 490 MW in 1991 has been increased by 64%.
- Energy production, 1479 GWh in 1991, is projected for 2654 GWh in 2009, an increase of 79%.
- The utility's aggregate heat rate, 11,287 Btu/kWh in 1991, has been reduced by 28% to 8051 Btu/kWh.
- Increased reliance on GTs fueled by natural gas has reduced Tallahassee's CO_2 intensity to 989 lb/MWh (2008 data), which the city notes is better than what neighboring utilities are achieving at this time, and better than most generating fleets in the country.

The repowered Unit 2 has run well since being declared commercial, according to Manager of Power Production Robert E


McGarrah


Singh


Sheehan

McGarrah, Plant Manager Triveni Singh, and Assistant Plant Manager Clark K Sheehan. It met all expectations regarding performance and environmental goals. Additionally, the unit was completed without any lost-time accidents and came in at about 8% under the $156-million budget.

Engineering, construction

Construction permits were received in November 2006; major work began on a fast track the following February after pile placement was complete. S&L's experience on previous repowering projects enabled Project Manager Bock Yee's team to take advantage of lessons learned and help guide the project to a successful completion.

Two general contractors were prequalified for the repowering effort by the city's electric utility staff and asked how they would structure a fast-track contract. The utility extracted the best points from each and developed an RFP (request for proposal). BE&K Inc, Birmingham, was selected by the city as the general contractor.

BE&K's contract was not fixed-price because of extreme volatility in both prices and availability of labor and materials at the time. Construction man-hour budgets were developed during the project with overruns and savings shared between the parties. Materials and quipment purchased by BE&K was a pass-through.

The city assumed responsibility for construction management, commissioning, and startup, with Sargent & Lundy providing technical and field support. The city bought all major long-lead-time components directly from the manufacturers based on technical specifications developed by S&L. The city evaluated the bids for this equipment.

Virtually every construction project has at least one lesson it doesn't want to relearn and Hopkins was no different. Its "fly in the ointment" was having the contractor buy balance-of-plant (BOP) engineered equipment—such as condensate booster pumps, air compressors, performance gas heater, etc—to facilitate the purchasing process.

Delays in purchasing this equipment dictated "just-in-time" engineering because (1) S&L needed final equipment specs to finish its work and (2) construction had to proceed before engineering was complete in order to meet the schedule. In the end, mechanical completion was six weeks late.

However, the repowered unit started on schedule. One reason: The city's experienced employees—including some from the Purdom combined cycle—and a few well-selected direct hires, did checkouts/troubleshooting as individual systems were installed. This effort, plus the use of "in-house" operators having first-

2. Circulating-water piping looking out to the cooling tower at the upper right of the left-hand photo; new concrete pipe at right attaches to a special spool piece to connect to the final section of FRP pipe near the condenser

hand familiarity with the equipment to commission the unit, helped recover the time lost because of the delayed mechanical completion and still meet the commercial operations target of June 1, 2008.

S&L's Yee stressed that prior experience in both powerplant design and repowering work were critical to the project's success. Such background was invaluable for:

- Developing the overall repowering approach and scope.
- Managing all the interfaces with the existing plant. For example, knowing what controls, systems, and equipment to reuse, modify, relocate, and abandon in place. There is no "what to do list" for you to follow in a handbook. Solutions vary from site to site because of differences in design criteria, margins, etc.
- Knowing when to bring in an OEM to review and evaluate equipment you plan on reusing, and what inspections and analyses the manufacturer should perform.

Yee then shared three examples of important interface areas that required modifications for reuse and what was done:

1. Controls. The original Hopkins 2 was designed with a conventional cascading bypass system and equipped with non-modulating steam-turbine intercept valves. It would have been too expensive to replace these valves with ones capable of modulating. Thus this system could not be used for turbine startup in the same manner as a typical bypass system designed for a new combined cycle.

Here's how the repowered Hopkins is started: The cascading bypass system warms up steam piping initially. Prior to steam roll, high-pressure and cold-reheat bypass steam are diverted to the HP sky vent and the reheater is evacuated.

Controls are arranged this way because the non-modulating intercept valves could not control overspeed if reheat pressure were to increase during the steam roll. Cold reheat steam is admitted to the reheater during the turbine roll at a controlled and increasing rate dictated by turbine acceleration and speed control. Control system modifications were made to accommodate the various startup modes required.

2. Condenser. Heat-rejection capability of the original condenser was evaluated for use in the repowered configuration. Keep in mind that extractions for the feedwater heaters, now abandoned in place, had to be capped, increasing flow to the condenser. Engineers said the existing condenser was adequate for the duty, but that a few modifications were required to accommodate repowering. They included:

- Redistribution of the heat source to eliminate hot spots.
- Rerouting of steam-turbine low-point drains.
- Replacing the first feedwater heater in the condenser neck with the bypass diffuser.

3. Steam turbine was evaluated to determine what modifications and/or operating limits were required to assure its suitability for the repowered plant. In sum, 13 areas were studied, including these:

- Verify mechanical integrity and permissible operating limits, considering all loads.
- Define temperature limits of all turbine components, including design limitations.
- Determine the maximum flow through all turbine sections to the condenser—this to verify the capability of the unit to handle the repowered steam flow with feedwater-heater extraction nozzles capped.
- Define the startup requirements, procedures, and operational limits of the repowered turbine—including ramp limits for cold, warm, and hot starts.

1. Tallahassee's generation assets

The City of Tallahassee issued municipal bonds in September 1902 to build its first electric light plant. Less than two years later it issued bonds to expand that facility. Today the vertically integrated utility has an installed summer firm capability of 805 MW—625 MW of that commissioned in the new millennium—and 11 MW of low-head hydro capability. The city serves more than 110,000 customers in a 221-mi^2 service territory. Tallahassee ranks fourth among municipal electric utilities in Florida and 26th in the US in terms of sales.

The utility has three generating stations, which are profiled below:

- **Arvah B Hopkins Generating Station, 504 MW**
  - Unit 1, conventional steam (1971), 76 MW
  - Unit 2, 1 × 1 7FA-powered combined cycle (2009), 300 MW
  - CT1, W191 simple cycle (1970), 12 MW
  - CT2, W251 simple cycle (1972), 24 MW
  - CT3, LM6000 simple cycle (2005), 46 MW
  - CT4, LM6000 simple cycle (2005), 46 MW
- **Sam O Purdom Generating Station, 301 MW**
  - Unit 7, conventional steam (1966), 48 MW
  - Unit 8, 1 × 1 7FA-powered combined cycle (2000), 233 MW
  - CT1, W171 simple cycle (1963), 10 MW
  - CT2, W171 simple cycle (1964), 10 MW
- **C H Corn Power Plant, 11 MW**
  - Unit 1, run-of-river hydro (1985), 4 MW
  - Unit 2, run-of-river hydro (1985), 4 MW
  - Unit 3, run-of-river hydro (1986), 3 MW

Tallahassee has five interconnections with the grid:

- One 230-kV link to The Southern Company
- One 230-kV link to Progress Energy Florida
- Two 115-kV links to Progress Energy Florida
- One 69-kV link to Progress Energy Florida

2. Principal equipment, Unit 2A, A B Hopkins Generating Station

Commercial operating date: June 2008
EPC contractor: BE&K Inc
Owner's engineer: Sargent & Lundy
Type of plant: Combined cycle

Key personnel

Manager of power production: Robert E McGarrah
Plant manager: Triveni Singh
Asst plant manager: Clark K Sheehan
Plant engineers: Dave Fatkin, Cyrinda DeMontmollin

Gas turbine

Manufacturer: GE Energy
Number of machines: 1
Model: 7FA+e (7241)
Control system: Mark VI
Combustion system: DLN 2.6
Fuel: Dual fuel (natural gas and distillate)
Water injection for NO_x control? Yes (when firing oil)
Water injection for power augmentation? No
Generator, type: Hydrogen-cooled
Manufacturer: GE Energy
GSU: Hyundai Heavy Industries Co Ltd
Air inlet house: Braden Manufacturing LLC
Air filters: GE Altair
Inlet-air cooling system, type: Evap cooler

HRSG

Manufacturer: Nooter/Eriksen Inc
Control system: Emerson Process Management (Ovation)
Attemperator: CCI-Control Components Inc
Duct burner: John Zink Co
SCR: Vector Systems Inc
Catalyst supplier: Cormetech Inc
Steam-turbine bypass valve/desuperheater: Dresser Inc (Masoneilan)

Water treatment

HRSG internal treatment, type: Coordinated phosphate
Chemical supplier: Nalco Co
Reverse osmosis installed? No
Demineralizer installed? Yes
Manufacturer: Siemens Water Technologies
Cooling-water chemicals: Nalco Co

Steam turbine

Manufacturer: Westinghouse Electric Corp (existing)
Generator, type: Hydrogen-cooled
Manufacturer: Westinghouse Electric Corp (existing)
GSU: Westinghouse Electric Corp (existing)

Balance of plant

DCS, type: Ovation
Manufacturer: Emerson Process Management
Condenser, type: Water-cooled
Manufacturer: Westinghouse Electric Corp (existing)
Wet cooling tower: Hamon-Custodis (existing)
Boiler-feed pumps: Flowserve Corp
Boiler-feed-pump drives: Voith Turbo Inc
Condensate pumps: Existing
Condensate booster pumps: ITT Goulds Pumps
Booster-pump drives: Voith Turbo Inc
Circulating-water pumps: Johnson Pump, an SPX brand (Existing)

Other project highlights

Circulating-water piping. One of the first items on the agenda at the project kick-off meeting concerned existing FRP (fiberglass-reinforced plastic) circulating-water pipe. It ran under a plant road that, although not used much since the facility began operating in the early 1970s, would see much more traffic during repowering construction and afterward. Plus, the road (and the piping) would have to support much heavier loads than it did previously.

City engineers had identified some ovaling and delamination of the FRP pipe and were concerned about its long-term life. The utility charged Sargent & Lundy with replacing the pipes running from the cooling tower to the plant and from the plant to the tower with ones made of concrete (Fig 2).

Doesn't sound like a big deal, but little does until you have to do it and the job must be of a high quality. S&L had to develop procedures for fixing that portion of the pipe buried in the plant foundation as well as for the manufacture of a special spool piece that would join the FRP and concrete sections. A special outage was taken in spring 2007 to replace the circulating-water system piping.

In fall 2007, a 10-week outage was needed to overhaul the steam turbine and to modify that machine as necessary for combined-cycle service. The third and final outage required to complete the repowering project lasted four months, from February 2008 until June.

Bypass stack. Fig 1 shows a bypass stack installed just ahead of the HRSG to permit simple-cycle operation in the unlikely event of a steam turbine/generator failure. Supplied by Braden Manufacturing LLC, Tulsa, it does not have a damper of the type typically used in bypass stacks.

Rather, a solid steel plate in the bypass stack directs hot gas to the HRSG during normal operation. In an emergency, the plate would be removed from the stack and used to block gas flow to the transition duct at the front of the HRSG. About a week's work would be involved in switching the position of the low-leakage "blank flange."

P91 piping. All large main-steam and hot-reheat pipe is made of P91; cold-reheat pipe is carbon steel. High-temperature steam valves are made of P22 and were delivered to the field with P91 transition pieces. The difficult P22-to-P91 weld was made in a shop to permit tight control of the weld process and associated pre- and post-weld heat treatment. All field welds were P91 to P91. Sargent & Lundy is developing a long-term P91 monitoring plan.

Steam blow was directed through the HRSG's water and steam circuits and steam piping at low pressure and continuously. The low-pressure continuous blow was said to have been very effective.

Fuel-oil system. The existing fuel-oil system was repurposed with some effort and upgrades. For example, the city's oil tanks (total of 270,000 bbl of capacity or about an 18-day supply), previously used for storing No. 6 fuel oil, were cleaned to white metal as the GE spec requires. Metal liners were installed at the bottoms of the tanks and a secondary containment was built around the tanks to meet Florida's aboveground storage-tank rules.

Spare parts. Tallahassee's utility signed a 12-yr LTSA (long-term service agreement) with GE for the new 7FA and then extended the Purdom LTSA so it will terminate at about the same time as Hopkins'. All hot-gas-path parts are interchangeable between the units and the city owns its spares, with GE refurbishing them under the LTSA. This was the most economical option for the city. CCJ