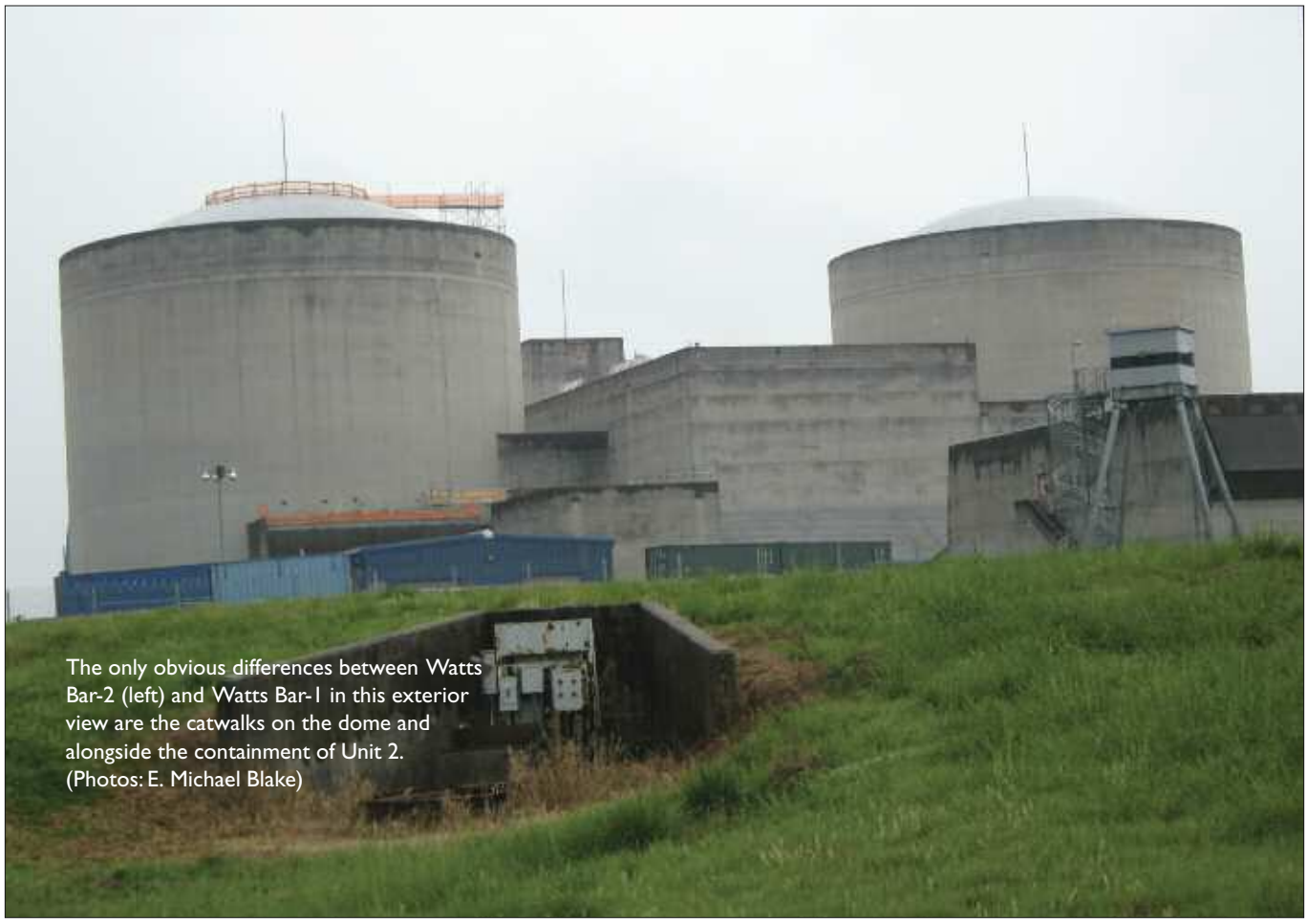

The only obvious differences between Watts Bar-2 (left) and Watts Bar-1 in this exterior view are the catwalks on the dome and alongside the containment of Unit 2. (Photos: E. Michael Blake)

The last of the old, the first of the new

BY E. MICHAEL BLAKE

The Tennessee Valley Authority is working to finish what may be the last reactor of its generation to be built in the United States, while Southern Nuclear has begun substantive work on what may be the country's first new-design nuclear power plant.

On April 20, Watts Bar-1, which shares a control room with the as yet unfinished Watts Bar-2, was on line at full power, and the part of the control room devoted to that reactor was fully staffed by reactor operators and other shift personnel. The control room is divided by a heavy curtain suspended from a rod along the ceiling, and on the other side, workers carried out various tasks related to the installation of equipment to be used when Unit 2 goes on line, perhaps in less than three years. The curtain allows the Unit 1 operators to keep their focus where it belongs as work on Unit 2 is under way on the other side.

Masoud Bajestani, the Tennessee Valley Authority's vice president for Watts Bar-2, said that the current separation of the two units' control room areas involves more than a noise-reduction curtain. A Faraday cage has been built to reduce the effects of electromagnetic and radio frequency interference (EMI-RFI) produced by welding, grinding, and other construction work on the Unit 2 side. "The EMI-RFI could actually interfere with the signal we see on Unit 1," Bajestani said. "We look at all the work that we are doing in the control room to make sure that we minimize distraction on Unit 1."

And so it is almost everywhere at TVA's Watts Bar plant, near Spring City, Tenn., as Unit 1 is expected to operate normally while Unit 2 is finished and put into service.

In contrast to the close quarters of Watts Bar, Southern Nuclear's Vogtle plant, near Waynesboro, Ga., has abundant elbow room for its own project, the preparation of the site for the construction of two new reactors. Vogtle-1 and -2 are a few hundred meters from the rectangular holes that Southern and its lead contractor, the Shaw Group, have dug down to the blue bluff marl that will underpin Vogtle-3 and -4, Westinghouse-design AP1000 pressurized water reactors.

On April 19, the excavations clearly differed from one another. The Unit 3 hole already contained about an 8-foot depth of the backfill that will eventually fill in the 90-foot-deep excavation to bring it up to grade level. The Unit 4 hole was still empty, showing its marl floor. Work was continuing at the originally intended pace, even though Southern has learned that the amount of acceptable backfill material from the excavation will not be enough. The company is recovering backfill material from other parts of the site and is seeking the Nuclear Regulatory Commission's approval of a plan to bring in acceptable material from off site.

And so it can be said that after a gap of more than a decade, power reactor construction is taking place in the United States. Watts Bar-2 represents the last of the first generation of reactors (with a possible future exception acknowledged below), on

The Watts Bar-2 control room will maintain continuity with the controls and procedures in effect for Unit 1. It may have been possible to convert Unit 2 entirely to digital instrumentation and controls, but TVA prefers that Unit 2 be operable in the same way as Unit 1.

the footprint established for the reactor decades ago, which contributes to the air of intense activity. Not only is there a construction permit in effect, but much of the work is being done inside the existing structures of the containment building and turbine hall. Where either the replacement or in-place refurbishment of structures, systems, or components is taking place, the available space (especially in the already compact ice-condenser containment) is reduced even further by scaffolds and other temporary structures. Numerous tasks are going on at once, performed by teams led by the project's lead contractor, Bechtel. This is also the case in the turbine building, but it is less obvious because of the greater available space. (This reporter missed out by a few minutes on seeing and photographing a crane lift of one of the Unit 2 moisture separator reheaters. Win some, lose some.)

At Vogtle, there is much less activity—all of it within the constraints of the limited work authorization (LWA) issued by the NRC last August, along with the early site permit (ESP)—and it is spread out over a bigger area. There may not be anything inherently exciting about holes being dug and then filled in, but some of the other work going on at the site may quicken the pulse of a new-reactor proponent. The foundation has been poured for the facility where the AP1000 modules are to be received, inspected, and in some cases assembled into larger modules, and work has begun on the facility's walls and infrastructure. By the time this issue of *Nuclear News* is published, the installation of recirculating water piping may have begun in the Unit 3 excavation. This piping will connect the reactor with the cooling tower, for which foundation work is scheduled to begin this summer.

This article's focus on Watts Bar-2 as the last of the first generation of power reactors, and Vogtle-3 and -4 as the first of new, may be excessively dramatic, and possibly not even accurate. But because there is committed, physical work taking place at both locations, we felt that it was worthwhile to look at them in person.

For the record, we will acknowledge that it is possible that TVA might follow up Watts Bar-2 by finishing one of the two Bellefonte reactors in Alabama, which were in advanced stages of construction when the project was suspended in the 1980s. The Bellefonte site is also the subject of a combined construction and operating license (COL) application by the NuStart consortium for two AP1000s. As a federal agency, TVA must prepare an environmental impact statement (EIS) for any new generating capacity, separately from the EIS developed by the NRC for the licensing process. Last year, TVA declared that the options in the EIS would be the completion of one partially built reactor, the construction of one new reactor, or no reactors at all at Bellefonte. TVA's board of directors may reach a decision this summer on which option to pursue.

While Watts Bar-2, and the refurbishment of Browns Ferry-1 before it, involved work on reactors that are fairly well known (Watts Bar-2 was essentially a replicate of Unit 1 when work began in the 1970s, and Browns Ferry-1 had operated for more than 10 years before its 22-year outage), Bellefonte-1 and -2 are unlike any other reactor in operation anywhere. They are the only Babcock & Wilcox PWRs with a capacity greater than 1000 MWe in the United States that weren't canceled before completion. (One such reactor–sometimes referred to as Model 205 for the number of fuel assemblies in the core—was built in Germany, jointly with Brown Boveri and Company. This reactor, Mülheim-Kärlich, was closed

in the late 1980s after about a year of commercial operation.) TVA's decision regarding Bellefonte may come down to whether its experience with Browns Ferry and Watts Bar, and the equipment in place at Bellefonte, makes completion seem more attractive than starting over as one of more than a dozen AP1000s planned worldwide.

It is also possible that other COL applications could lead to the operation of new power reactors before Vogtle's does. The licensing process delineated in 10 CFR Part 52 is being used for the first time on more than a dozen applications simultaneously, so it might be unwise to count out South Texas, Calvert Cliffs, and other projects as candidates to be first to the finish line. (The schedule for North Anna-3, which has moved farther through the NRC's technical reviews than any other COL application, will be revised because of Dominion Generation's decision to switch reactor models from the ESBWR to the US-APWR; see page 34 of this issue).

With all that being said, the work taking place at Watts Bar-2 and Vogtle-3 and -4 points in the direction of the operation of power reactors that have never before operated. These are the places where power reactor construction is happening in the United States, and—despite the continuing activity of other projects—they will likely remain the *only* places for the rest of this year, and perhaps all of next year.

The same, only different

Replication has its advantages. To some extent, if you make Unit 2 look and work like Unit 1, you're well on the way to smooth long-term operation. This means, however, that you have to make some accommodations. Watts Bar-1 has analog instrumentation and controls, and so will Watts Bar-2. Any attempt to shift the fundamental reactor safety systems of either reactor to digital I&C will have to wait. In the near term, however, this will make the joint control room of the two units a seamless whole, and will extend to two reactors the procedures and practices now used for one.

In one sense, replication has made the job of completing Unit 2 more difficult, because when Unit 1 needed a spare or replacement, often the quickest and easiest solution was to take it from Unit 2. And sometimes Watts Bar-2 items were shipped to TVA's Sequoyah PWRs, whose design closely overlaps the Watts Bar reactors.

Bajestani said that the decision whether to replace or refurbish an item has two main drivers. One is whether parts for refurbishment are available; if they aren't, new equipment is ordered. The other is whether replacing parts would cost more than replacing the entire item. Bajestani gave examples of the parts that might have to be changed out to refurbish safety-related motor-operated valves: terminal blocks, torque switches, limit switches, and motors. He said that a business case was made to replace the valves rather than to try to refurbish them. Roughly 3000 valves are being replaced on Unit 2, about 1700 of which have been delivered.

The next large-scale activity involves the receipt (in June) and installation (in July or August) of the three low-pressure turbines. By that time, essentially all of the major equipment for Watts Bar-2 will be on site. The project is on schedule for fuel loading in April 2012. The goals are not just completion and startup, but successful operation at a level comparable to that of the rest of the industry. Bajestani said that TVA is looking at lessons learned from its work on Browns Ferry-1, and from the industry in general, "to make sure that when we close the generator breaker and go for the first cycle of operation, we're going to have reliable, safe operation of Watts Bar Unit 2." He said that he expects high reliability and capacity factor right from the first cycle.

Not everything has gone perfectly smoothly. An NRC inspection completed at the end of March identified two violations. One was for the lack of measures to protect safety-related cables from physical damage, and the other for the failure to include all required information in procurement documents for safety-related seismic Category I conduit supports. Both violations were assessed as Severity Level IV (the lowest and least significant) and entered into TVA's corrective action program, so the NRC is treating them as "non-cited" violations.

One reason to suspect that TVA might eventually finish one partially built reactor at Bellefonte (if not both, under a different

Inside the Watts Bar-2 containment, work proceeds simultaneously in several areas, in close quarters. The reactor vessel upper head, with control rod drive tubes in place above it, is shown in the background, surrounded by scaffolding. In the foreground, partly obscured, is the open cylinder of the reactor vessel.

EIS) is the continuity of TVA's reactor restart effort, from Browns Ferry-1 through Watts Bar-2. Bajestani has worked both projects, as have many others. With eight years already devoted to the effort, and with a commitment to at least two to three more years, TVA has a *de facto* long-term organization in place for the operation of unused nuclear assets. It might make sense to keep this organization, and the lessons it has learned, in place to spend the next decade finishing first one, and then the other, of the existing Bellefonte reactors.

Asked whether he is confident that the experience from Browns Ferry-1 and Watts Bar-2 would carry over well to Bellefonte, Bajestani declined to speculate, noting that any decision on Bellefonte is to be made by the TVA board. Asked whether the experience would at least be useful at Bellefonte, he said, "The information we've learned from Browns Ferry and Watts Bar is going to help to build any future nuclear plants."

Browns Ferry-1 shares a control room with Browns Ferry-2, so the situation in the Watts Bar control room is nothing new for Bajestani. If he and his team do move on to Bellefonte, they won't have to deal with sharing a control room with an operating reactor. At least not for the first of the two.

Backfill and beyond

The AP1000 design calls for the placement of the nuclear island's foundation 40 feet below grade level. At Vogtle, in the area where Southern plans to build Units 3 and 4, there is hard rock (the blue bluff marl) about 90 feet below grade. Southern has chosen to excavate to the marl, place backfill up to the foundation level, and then continue filling the rest of the way to grade.

The material acceptable for backfill is referred to as "Category 1" soil, which through testing and other characterization has been found to have consistent strength and settlement properties and qualities that would ensure the stability of the structures built in and on it in the event of an earthquake. Category 1 backfill is sandy, with enough fines to produce a dense, quartz-based substance. Soil with a clay content high enough to exhibit plastic behavior when wet is unsuitable. The material that has been excavated so far at the Vogtle site includes both sandy Category 1 soil and more clay-laden soil, so not all of it can be plowed back into the holes. This is one reason that Southern is looking for more backfill sources, on site and elsewhere.

This reporter observed that the Category 1 material is reddish, and the piles of soil set aside as unsuitable for backfill are tan. There is more to the selection process than distinguishing one color from another, however. In addition to visual tests, laboratory and in-place compaction tests are also performed. Density tests are done to confirm that the soil has compacted properly, and the speed of vibration travel through the soil is also measured.

Southern has asked the NRC for permission to use other backfill sources, including some from outside the plant property. In the May 6 *Federal Register,* the NRC announced Southern's application for an ESP amendment and proposed a determination of no significant hazards. This meant that although the NRC staff did not see any problems with the proposal, the agency was obligated to take public comments through May 20. In an April 6 presentation, Southern told the NRC that at the current rate of work, the confirmed Category 1 backfill might be exhausted as early as June. Southern personnel told *Nuclear News* that they did not expect that backfill work will be slowed down by the need to obtain approvals for material from other sources.

The excavations are terraced every 30 feet of altitude, mainly for erosion control while the angled slopes remain exposed. A

The Vogtle-3 excavation contained about 8 feet of backfill at the time of this photo (April 19). The slopes surrounding the excavation are terraced every 30 feet of height, with ramps to allow equipment to enter and leave.

On April 19, backfilling had not yet begun for Vogtle-4. The structures on the blue bluff marl measure the vertical motion of the rock; with the 90-foot depth of dirt removed, the marl had risen measurably, and it was expected to lower again once the backfill was placed. Units 1 and 2, both in operation at the time, are in the background.

dewatering system draws water out of both excavations and into a retention pond, for later use in dust control. Reuse is practiced on much of the site; the concrete that was removed when old support buildings for Units 1 and 2 were cleared from the excavation zones will be crushed into aggregate for roadbeds, among other things.

On its own, and outside the LWA, Southern is building an operations training facility for Units 3 and 4. Nearly all other work is being led by Shaw, as its many trailers and working vehicles attest.

Dave McKinney, Southern's vice president of nuclear construction, told *NN* that the need for additional backfill sources arose after excavation, when it was determined that the quality of the soil was not what it had been believed to be based on earlier geological studies. The additional weight of the AP1000 design as a result of structural additions to the shield building, however, did not change the quantity or nature of the required backfill.

Once the fill has reached what McKinney referred to as elevation 180, mudmats will be placed for the nuclear islands. (The Vogtle site is 220 feet above sea level, so elevation 180 corresponds to 40 feet below grade.) At this level, foundations can be set for the turbine buildings and, between Units 3 and 4, the heavy-lift crane that is being engineered and manufactured by Bigge Industries (the company's name, appropriately enough, is pronounced "biggie"). Perhaps later this year, the crane will be brought to the site by truck as separate components and assembled in place. Also at this level, the circulating water pipes leading to the cooling towers can be placed. McKinney said that enough Category 1 backfill already exists on site to fill both excavations to elevation 180.

Asked whether modular construction may be nearing a practical limit as far as the ability to lift and control items of this weight, McKinney said that he doesn't think the limit is being reached yet, but going very far beyond the range of an AP1000 module—which tops out around 1100 tons—might not be practical.

McKinney said that Southern is closely following the construction of the AP1000s at the Sanmen site in China. "We're sending folks over there to observe most of the major milestones," he said, such as the first module lifts, "or placement of the containment bottom, or some of the rings for containment." Southern is also applying the lessons learned by Westinghouse and Shaw from the work in China, so that the company can perform readiness reviews for each milestone component at Vogtle.

Despite a possible setback in the rate recovery process for Vogtle (a state court ruling in May requesting that the Public Service Commission reconsider an earlier decision), Southern is aiming to maintain site work continuously from here on. A second LWA has been requested for the installation of reinforcing steel, sumps, drain lines, and other items embedded in the nuclear island foundation base slab, and for the placement of concrete for the slab, and it may go into effect in time to allow this work to immediately follow on the first LWA.

The COL might be issued in late 2011 or early 2012, perhaps immediately following on the second LWA. Southern appears to be the only COL applicant that has been able to make the LWA opportunity work. Both Progress Energy (for Levy County) and Florida Power & Light Company (for Turkey Point) have withdrawn their LWA applications, deciding that the effort required to get through the approval process would not, for them, deliver sufficient benefits in the amount or kind of work that

The foundation has been completed for the module assembly facility at Vogtle. Work on the building's other structures was just beginning.

could be done prior to COL issuance.

Just as the Vogtle work could continue nonstop, Southern may be able to carry the work on further, perhaps taking it to another site (as TVA has done, from Browns Ferry to Watts Bar). Southern has notified the NRC that it plans to apply for another COL, for an as-yet-unspecified greenfield site, probably in Alabama or Georgia. The NRC has stated that it expects this application in 2011, but more recently Southern has said that it would not be submitted until 2012 or later.

Vogtle has kept the NRC's construction inspection activity occupied. As it has done with Watts Bar, the NRC recently issued an inspection report on Vogtle, and the result was not spotless. The May 4 report found that Southern had, in fact, used backfill from a source that was not specified in the safety analysis report (SAR). The material itself was Category 1, but its use would only have been allowed through an amendment to the SAR. The NRC determined this to be a minor violation (Severity Level IV), and Southern has applied for the necessary amendment.

Also subject to NRC oversight are the inspections, tests, analyses, and acceptance criteria (ITAAC) that Southern must carry out (and that the NRC must verify as having been completed successfully) before a project with a COL can be approved for fuel loading, startup, and operation. Because some of the work allowed under the first Vogtle LWA is subject to ITAACs, Southern and the NRC will soon begin the first climb up the ITAAC learning curve, with every other 10 CFR Part 52 reactor project looking on.

Terra incognita

Until electricity is produced by a new reactor in the United States, it may be wise to repeat the old mantra: This has never been done before. No reactor has been licensed under 10 CFR Part 52. No completely new reactor has entered service since Watts Bar -1, in 1996. Despite all of the advance work that is already under way, nobody really knows what it will take to get the NRC's approval of ITAACs (and to what extent topics in an early ITAAC will have to be revisited later), and how permission to load fuel and to start up will be granted without a second evidentiary hearing.

For Watts Bar-2, the course seems fairly clear. This is 10 CFR Part 50 licensing, so a second-step hearing for a traditional operating license lies ahead (perhaps next spring; the final NRC documentation is scheduled to be completed in January). The admitted contentions have to do with the omission from the EIS of TVA's compliance with federal permits—mainly an interagency agreement on contaminated sediments in Watts Bar Reservoir and an expired pollution discharge permit—and with the adequacy of TVA's assessment of potential aquatic impacts, such as the effects of thermal discharge on fish. The latter item may get to the issue of whether both reactors can operate at full power for extended periods of time with acceptable environmental impacts. Within the context of the hearing, impacts from Unit 1 operating by itself could not be considered unacceptable.

Attorneys for TVA have stated that they expect to request that at least one of the contentions, and perhaps both, be dismissed as moot, based on further information from TVA. On May 6, the attorney for the intervenor informed the Atomic Safety and Licensing Board that the intervenor will not oppose the dismissal of the contention on permit compliance. TVA personnel have expressed confidence to *NN* that whether the remaining contention is dismissed or litigated, Watts Bar-2 will be licensed and put into service.

One contention has been admitted in the Vogtle proceeding. In theory, if Southern prevails in the contested hearing—and if there is no impediment in the mandatory hearing, which is not adversarial—the COL should lead to startup as long as all ITAAC requirements are satisfied. As some new-reactor projects in neighboring states have been delayed—the twin AP1000 plants at Lee, in South Carolina, and Levy and Turkey Point, in Florida, now have startup dates after 2020—there might be more overall demand in the region for Vogtle. With work already taking place on site, and with strong local and state support, utility commitment, and a federal loan guarantee, Vogtle is certainly, at this time, the most likely project with a new reactor design to progress to commercial operation. A pessimist could therefore assert that if it doesn't work here, it won't work anywhere. NN