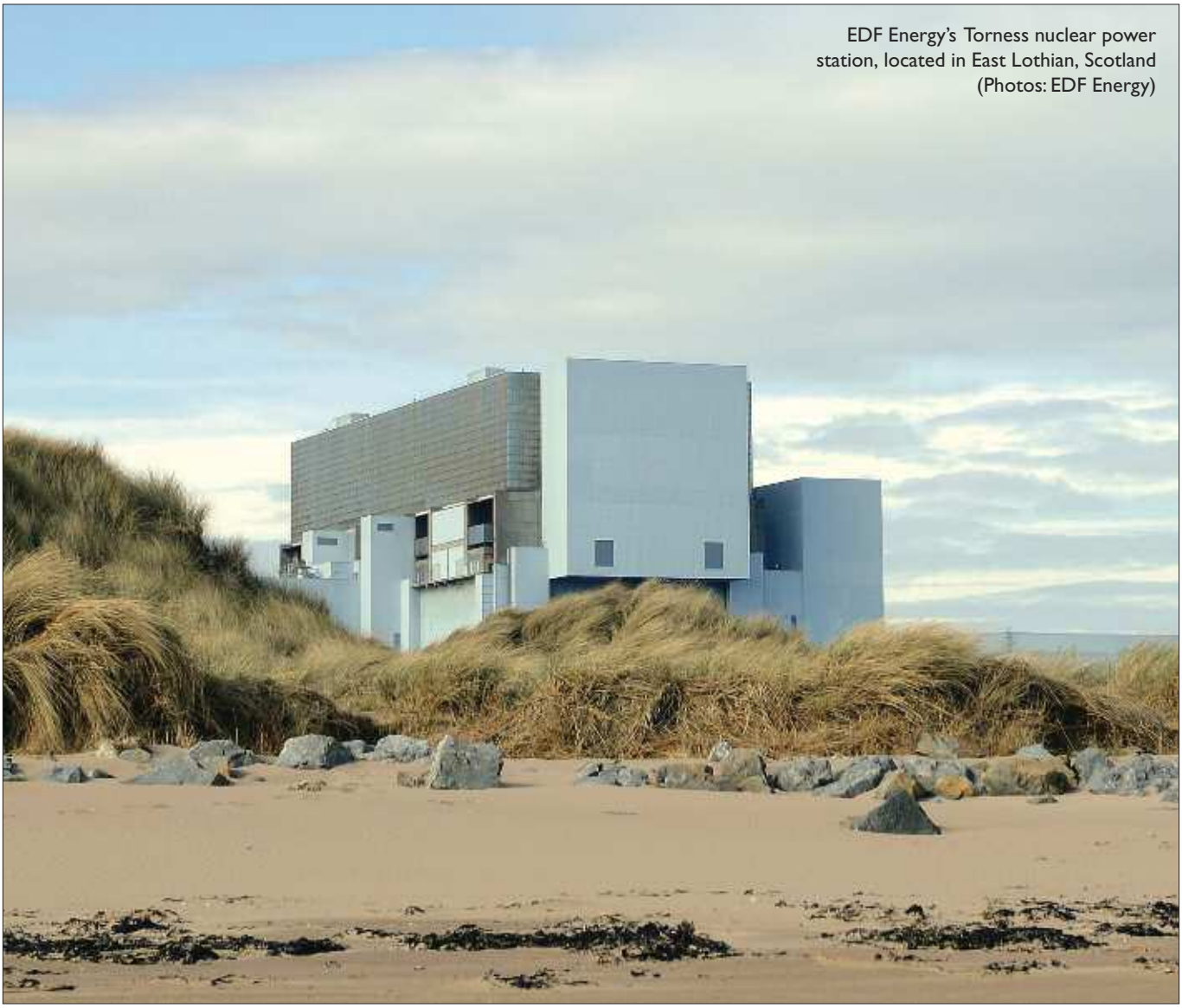


EDF Energy's Torness nuclear power station, located in East Lothian, Scotland (Photos: EDF Energy)

Torness tackles biggest-ever outage

By Dick Kovan

Unit 1 at Scotland's Torness plant undertook its 10th and largest outage following two years of meticulous planning.

The Torness-1 advanced gas-cooled reactor (AGR) was taken off line on February 2 for a statutory inspection outage, which is required every three years under the plant's nuclear site license.

McAllister

The focus of an AGR statutory outage is inspection, maintenance, and testing, while a number of improvement projects are carried out at the same time. A refueling operation, which involves the replacement of only a few fuel elements, is done at the end of the outage. This latest outage, explained Ross McAllister, technical and safety support manager at the EDF Energy plant, is the most extensive in the plant's history.

The two Torness reactors, which are among the youngest AGRs in EDF Energy's nuclear fleet, have been operating commercially for some 25 years. Unit 1 is rated at 600 MWe (net), and Unit 2 at 605 MWe. As of August 2013, the station had generated about 200 TWh of electricity since it was connected to the grid in 1988.

AGRs are designed for on-load refueling, a process in which used fuel stringers—each a string of short fuel assemblies inserted into a reactor fuel channel, of which there are about 330—are removed and replaced with new ones. Refueling at Torness-1 takes place every five weeks. During each refueling, an average of 8–10 fuel stringers are exchanged, an operation that is done under reduced reactor load but with the reactor still at power. Refueling carried out during outages involves the same number of stringers as the usual refueling operations, McAllister said.

Outage scope

The large number of additional activities carried out in the 2014 outage is reflected in the level of investment, which at around £34 million (about $56 million), is nearly double the £19 million (about $31 million) cost of normal "core outage work." The other £15

million (about $25 million) of investment includes major equipment replacement, required at least in part to deal with normal aging and other life-cycle effects, McAllister explained. The plant is also taking the opportunity to do some significant modernization and other improvement work. In total, more than 13,000 separate pieces of work were scheduled for this outage, which at this writing was still under way.

Graphite inspection

Graphite inspection is a major part of an AGR statutory outage and is vital to supporting the safety case for continued operation. The activities undertaken during such an inspection include the following:

- The use of a specialized camera to visually inspect the channels for degradation and any other issues regarding the condition of the graphite, particularly defects.
- The deployment of feeler gauges and other types of probes to measure features such as the ovality of the channels, the level of tilt of the graphite bricks, and the channel bore.
- The removal of small samples of the graphite for analysis, which provides a greater understanding of the progress of graphite deterioration and other effects over its life cycle.

Previously, the graphite inspection work had to be conducted at a late stage in the outage, as the reactor must be cooled down and depressurized, the CO_2 discharged, and the air circulated before the inspections could begin. Following the inspections, the reactor would then have to be recharged with CO_2. As AGRs age and the irradiated graphite deteriorates, more information is needed about the graphite's condition and the processes taking place within the graphite to build the safety case. An expanded channel inspection program has been introduced to gather more information. Because additional inspections would be expected to stretch the outage duration, it was deemed necessary to optimize the work to keep outage time to a minimum. Under the new optimized operation, the channel inspection program is now carried out in a depressurized CO_2 atmosphere, allowing access much earlier in the outage and without having to discharge and then recharge the CO_2.

To plan and carry out this new inspection program, about 170 procedures were written, numerous drawings were created, and many plant modifications were introduced. A large number of planning changes were also drawn up, along with all the safety-case work that underpins the procedures. According to McAllister, the new procedure has worked very well.

Other key outage projects

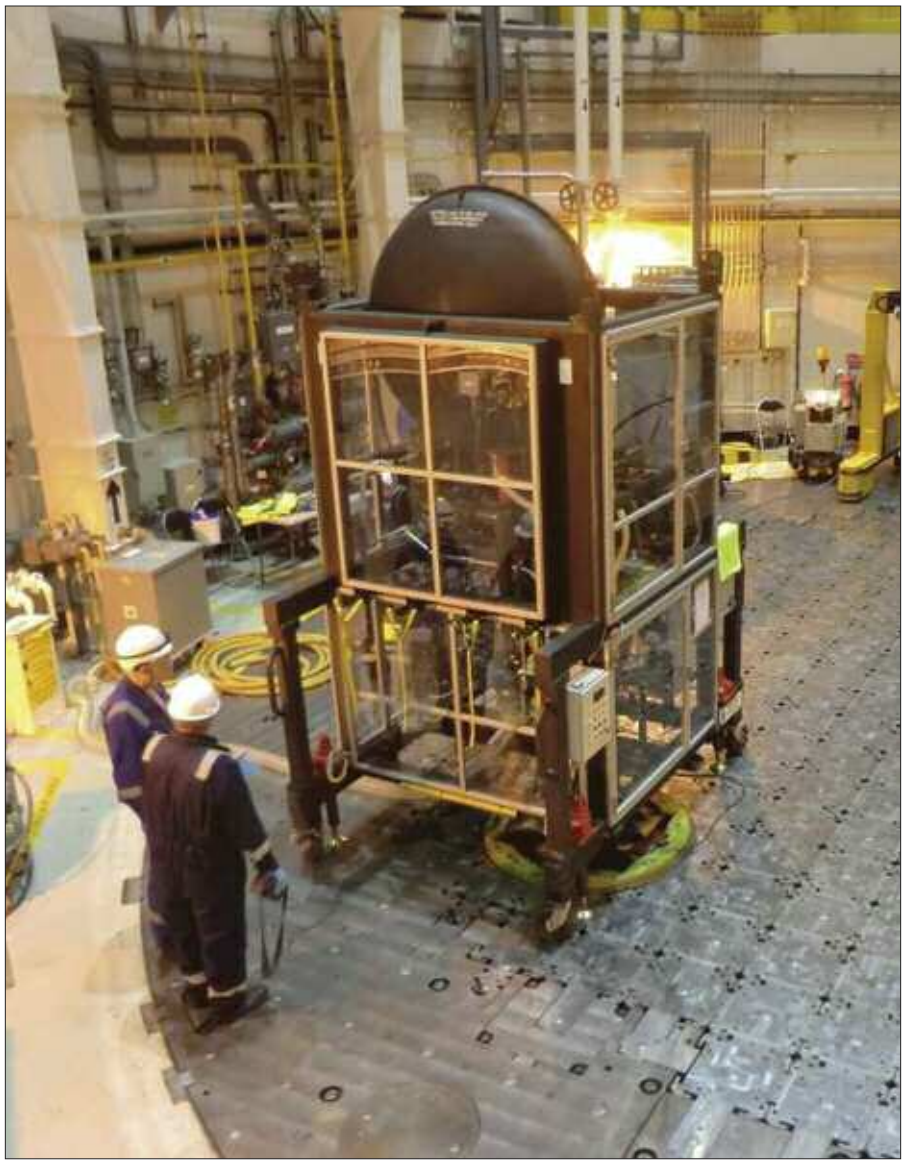
Another major project being carried out at Unit 1, and that had already been completed in the previous outage at Unit 2, is the replacement of all three phases of the unit's generator transformer. This task had to be done because of the quality of the generator oil used in the 1980s and 1990s, which caused problems with insulation and other components. In order to secure good future performance, the decision was made to replace the transformer phases now. Each phase weighs around 250 metric tons, and removing them required precision engineering.

The plant engaged a number of specialist contractors to handle this project, including one whose usual business involves moving oil rigs and similar-sized items. For them, these transformers are relatively small. Although the job was completed overnight, "as if it was an everyday activity," according to McAllister, the success of the operation was due to the assessment, design work, and planning. These massive units are now sitting in a laydown area next to the site.

Another major outage activity involved the replacement of the variable frequency drives for the gas circulators that force the CO_2 through the core. When the plant is coming off line, it is vital to be able to adjust the circulator speed, and it was decided that this outage was the time to replace the existing drives with more modern and efficient ones. This is the first such replacement implemented in the EDF Energy fleet. Also, breakers that had been identified as having reliability and maintenance issues were replaced with a new design. The turbine and generator rotors were also replaced.

Plant improvement options

In determining optional work to be done during an outage—and the investment needed to do that work—areas deemed high



The graphite core channels in an advanced gas-cooled reactor are inspected by removing fuel assemblies from the top of the reactor and lowering inspection equipment down into the empty fuel channel. The New In Core Inspection Equipment (NICIE) tool allows for video inspection of the channel, looking for cracks in the graphite blocks and measuring both the bore profile and tilt of the channel, which check for swelling in the graphite.

Torness Target 3

Target 1 — Three safety indicators at 0

Have no significant nuclear, industrial, or environmental safety events through the effective targeting of minor events. This supports "zero harm" and being a leader in sustainability and is achieved through having high-performing people.

Target 2 — Less than 3 percent unplanned losses

Deliver an unplanned capability loss factor of less than 3 percent. This supports our commitment to deliver a strong financial performance.

Target 3 — Three-year breaker-to-breaker run

Be the first AGR to deliver a safe three-year breaker-to-breaker run. This demonstrates our commitment to lead the way in nuclear power generation and supports Torness being the first choice for customers.

Torness-1's transformer bushings are lowered to the ground outside the Unit 1 reactor building.

priority, such as reducing reactor trips, are considered. As a learning organization, McAllister said, international operating experience and that of EDF Energy's own fleet are also used to identify areas in which to improve equipment reliability. These activities are reflected in the larger work scope of this outage.

To make these decisions, a risk-informed approach is used. McAllister made clear that this approach informs decision making; it does not drive it. As a tool to facilitate this approach, the company has developed a risk program to collect a range of relevant risk information covering, for example, operating experience, changes to the plant, and anything else that could increase risk, whether it presents a physical, commercial, reputational, or nuclear safety risk. This provides an idea as to where the biggest risks lie and what it would cost to mitigate them.

One area that received particular attention for this outage was the amount of maintenance work that had to be done at the plant, and a decision was made to invest in easing the burden on maintenance teams. For example, in the conventional plant, a lot of time was spent maintaining certain air-operated valves. These are to be replaced with a new, improved design to avoid future maintenance work.

Outage goals

One feature that sets AGRs apart from water reactors is that theoretically, an AGR can run for three years between statutory outages without being taken off line. Torness-1 once ran for over two years without shutting down. A three-year breaker-to-breaker run is now one of the targets in the station's new overall goal—called Torness Target 3—which sets three ambitious targets to be achieved by 2016 (see accompanying box). A statement from the plant noted that Unit 1's 2014 outage is a key milestone to achieving these targets. Also, according to the statement, "By working together as one team and challenging each other to meet high standards," the plant aims to deliver an outage that "propels us towards these targets."

Although life extension is not now a goal for the plant, which is licensed to operate until 2023, when decisions are being made concerning investments, such as replacing major components, the potential life of the reactor is an important consideration. A major life-limiting feature for AGRs is the deterioration of the graphite core, which cannot be replaced. Any decision to extend the plant's life—assuming that the graphite is in good condition—would be a commercial one, McAllister said.

Outage planning and organization

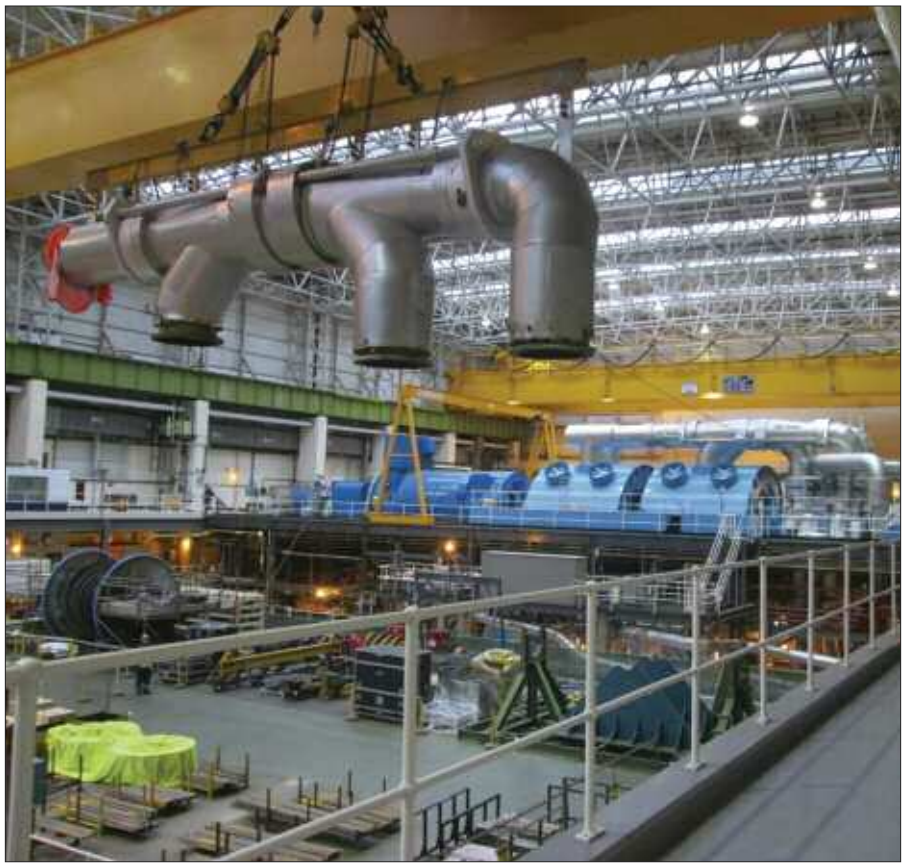
The planning of these major outages starts two years out with a pre-outage mile-

stone plan that guides and drives the planning process.

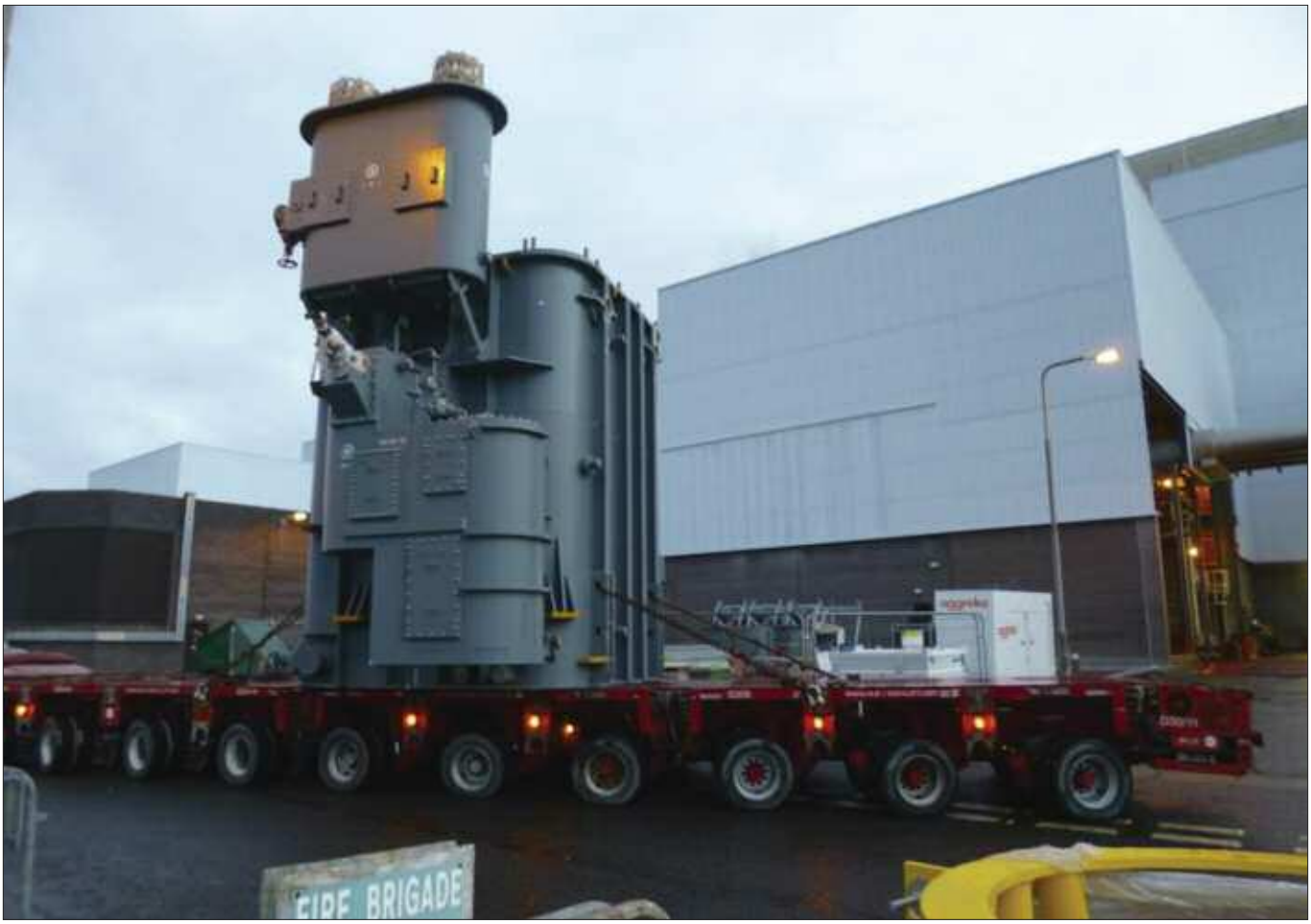
The plant's outage department is headed by a strategic outage manager, as well as an outage manager who deals with the operational, day-to-day activities. An outage management team led by the strategic outage manager consists of about 19 people, including plant and other EDF Energy staff, and staff of the main partner contractors. They include engineers, planners, work specifiers, and administrative staff. The outage is seen as a cross-functional activity in which all team members are held accountable for their own areas and for helping each other deliver a successful outage, McAllister said.

To support outage goals, in addition to a strategic outage review board at the plant, a regional outage review board provides higher-level oversight by fleet managers and chief nuclear officers. There is also a fleet outage department that looks at outage optimization across the fleet.

To provide further support for normal operation and for outages, the company continuously collects lessons-learned information before, during, and after an outage. This information is accumulated in a database to help identify issues of concern and to resolve them or to make improvements. A corrective action program encourages



The 30-metric-ton low-pressure steam crossover pipe is removed from the Torness-1 turbine.



The old transformer is transported away from the reactor building.

staff to submit condition reports, which help capture low-level issues and identify trends in areas such as equipment reliability. These are then analyzed and worked through with the company's engineers. Every year, about 8,000 condition reports are recorded, indicating where improvements are needed, as well as noting good practices. Trending of this data is done in order to learn from experience and to improve performance during each outage, McAllister said.

Relations with contractor partners

For outage activities, the plant boasts a strong partnership relationship with its contractors. "We have our big six contract partners [see list in accompanying box], and we absolutely see a successful outage delivery driven by these key contract partners. It's about collaboration," McAllister said.

He referred to the outage safety team, which is made up of EDF Energy staff, as well as staff from the contract partners, who all have exactly the same status and are committed to the same goals. "That is about working together, maintaining a positive attitude while challenging each other to achieve the right results," McAllister said.

A major consideration of any outage is the efficient mobilization of the contract workforce. This has been a particularly long and busy outage, with 1,600 people on-site over every 24-hour period. And having a major outage in winter, which is unusual, required that a winter readiness plan be in place. Although it turned out to be a nearly snowless period, plans had to be in place in case people were snowbound. Among the facilities that were prepared for such an emergency were an overflow parking facility with overhead lighting; semi-temporary accommodations with well-equipped changing facilities; and extended operating hours of the canteens. The plant engaged with shops, restaurants, and other services in the area to ensure that contractor personnel have adequate local amenities during the outage.

In the United Kingdom, contract staff tend to go from site to site. EDF Energy values their vital contributions to the success of its outages and provides them with good care and support. A lot of effort is also placed in setting a tone of high professional standards, starting on the first day a contractor arrives on-site. There is a one-stop shop just off the site where contractors park their cars and go through the induction process. They are provided training, which includes setting out the standards and expectations for the site. "We want them to get the right impression of our plant from when they drive up the access road," McAllister said.

Local suppliers are able to take a share of the work, worth tens of thousands of pounds to the local economy. Paul Winkle, director of the Torness station, said, "We are impressed by the high standards of the [local] companies we work with and the quality of their workmanship. These companies will work alongside specialist firms from across the world who are leaders in their field." NN

Outage contract partners at Torness

Cape
Access and insulation

Alstom
Turbine

Doosan Babcock
Mechanical and boiler services

Workplace Solutions
Facilities management

Weir Power and Industrial
Pumps and valves

Cavendish
Nuclear services