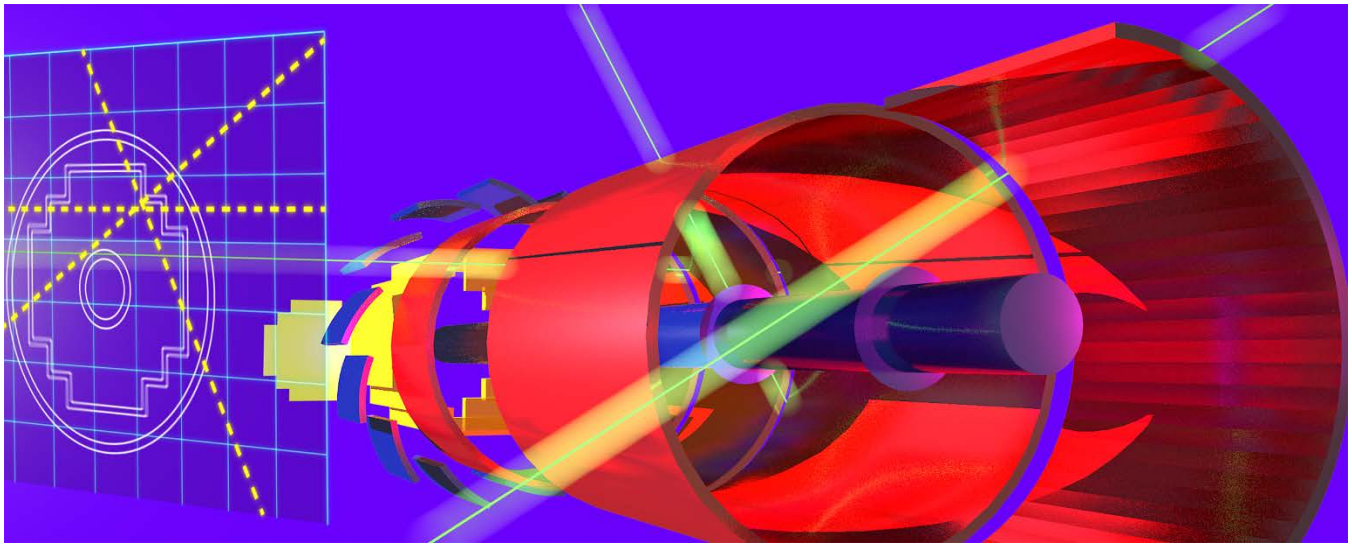
‘Push a Button and the Work Gets Done’



EPRI Examines Robotics and Automation for Nuclear Plant Decommissioning

By Brent Barker

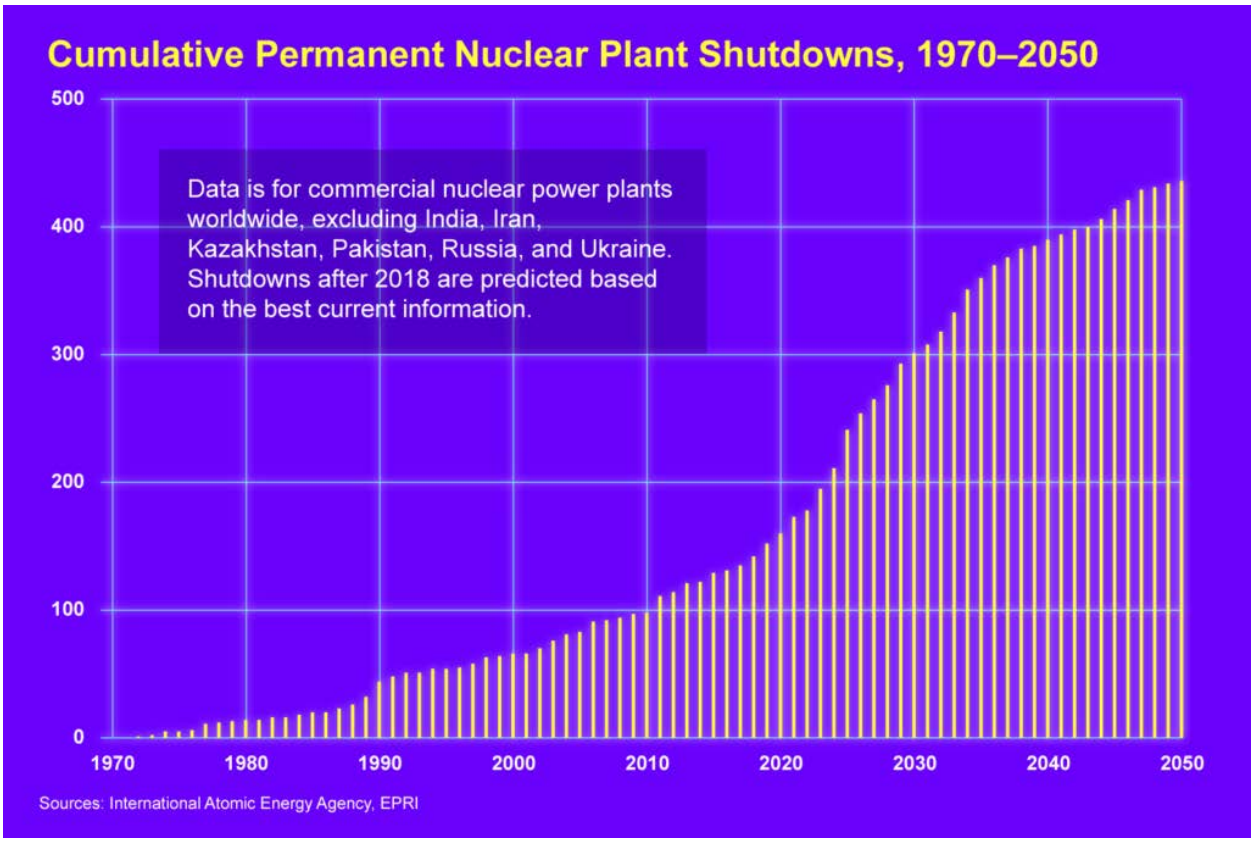
The Resident Farmer Scenario describes the ideal endpoint of a fully decommissioned nuclear plant site when it is sold to new owners. The structures have been removed and radiation reduced so that a family can reside year-round, breathe the air, till the soil, grow and eat crops, and drink the groundwater without hazard. The U.S. Nuclear Regulatory Commission’s (NRC) radiation dose threshold for this scenario—25 millirem per year per person—is less than 10% of the average American’s annual exposure. This endpoint is achievable for many plants given the right set of decommissioning technologies and techniques.

Decommissioning procedures today are precise, effective, and safe but highly labor-intensive, typically taking 10 years at a cost of roughly $80 million per year for each plant. There’s increasing interest among plant owners, operators, and regulators in accelerating the process through automation and robotics without sacrificing safety.

Decommissioning work is expanding significantly worldwide as many plants approach the end of their license in countries that do not permit extensions. Some countries are mandating early plant retirement, while in others market pressures are driving plants to close—with some single-unit facilities unable to compete with lower cost natural gas and renewable generation.

Of the 111 nuclear plants that have been shut down globally, only 13 have been completely decommissioned, and 38 are being dismantled. Sixty have yet to begin decommissioning. Some of these have been placed in safe storage for decades until adequate funding is available for decommissioning. Often, units are put in safe storage when they share sites with units that remain in operation. This is because it’s more efficient to decommission all the units at once.

Based on current announced energy policies, as many as 10 or more plants may be permanently shut down per year in each of the next 10 years. The global decommissioning queue is expected to grow to more than 200 plants at a total cost of roughly $160 billion (see graphic).



Ranking Key Tasks to Reduce Time and Cost

EPRI's Decommissioning Program is focusing on the use of technology to reduce the time and cost of decommissioning while maintaining safety. "Several years ago, we assembled experts to assess all the major tasks in decommissioning," said EPRI Technical Executive Rick Reid. "For each of the 54 tasks, we asked them where to focus R&D. We explored questions such as, can you use a robot instead of a human being to perform this task? If so, what are the benefits? Can the task be automated? How much time would that save? While most of the tasks do not warrant the use of robotics or automation, we found that several tasks do and offer significant potential savings in time and cost."

"I believe that we're going to find real advantages with automation," said Reid. "We currently use semi-robotic systems for many tasks, with skilled operators directing them. Since a lot of this work is predictable and programmable, we can automate it. Ideally, an operator pushes a button and the work gets done. That's how we can complete tasks faster and with less radiation exposure to the operators."

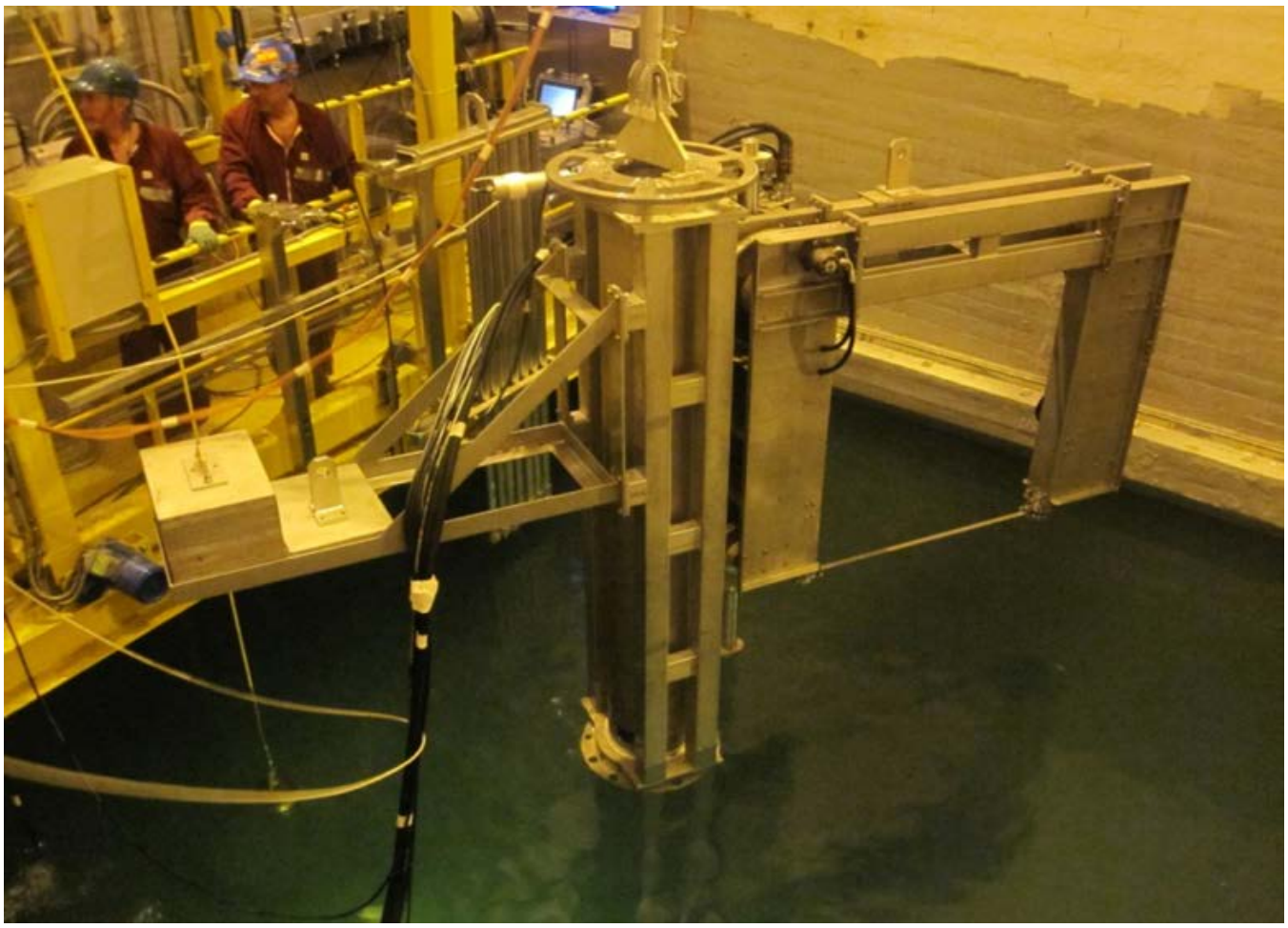
Among the several tasks that offer the greatest potential benefit from automation, Reid and EPRI Principal Technical Leader Rich McGrath are investigating two: the segmentation of a reactor's internal components (one of the first tasks in decommissioning) and the site characterization survey (one of the last tasks). Both of these are critical path tasks.

Cutting Reactor Materials for Packaging

Early in decommissioning, the spent nuclear fuel is removed from the plant's reactor pressure vessel, leaving a framework of two-and-a-half-inch-thick, highly irradiated stainless steel plates that must be cut up and packaged in a disposal container.

With the current approach, the framework is submerged in a pool of water. On a bridge above, technicians operate an underwater camera system and cutting tool, following a precise cutting plan and protocol so that the pieces can be moved and packed efficiently into an underwater disposal container.

"This takes about a year, so the operators are getting a fair amount of radiation exposure," said Reid. Although this exposure is monitored and well within regulatory limits, cutting reactor materials typically is one of the tasks that results in the most exposure during decommissioning.



At the Jose Cabrera Nuclear Power Station, workers on a bridge use remote control to lower a band saw into a spent fuel pool containing the reactor's internal components. The saw will make pre-determined vertical or horizontal cuts. EPRI is developing a system to automate this cutting process so that workers do not need to be present.

From Reid's perspective, this task is a fit for semi-automation. "Rather than stationing someone on the bridge using what's essentially a joystick, we could position someone remotely, watching what is happening on a screen and intervening if necessary."

This requires a precise map of the structure and precise cutting and packaging plans so that the pieces nest together tightly in the container. "A computer could be used to make the cuts and complete the task," said McGrath. "Technology available today can 'look' at the component underwater, determine exactly where to cut to create the right puzzle piece for the container, and execute the cut."

Cutting is slow. Most is performed mechanically, with disc saws, band saws, and shears.

"We're looking at faster technologies, including laser cutting, which essentially vaporizes the material," said McGrath. EPRI is evaluating the cutting rate of an underwater fiber laser. Another technology, the arc saw, has shown significantly faster cutting rates relative to mechanical cutting.

Additional testing, scale-up, and demonstration of these processes will be critical for adoption by an industry that subjects new technologies to rigorous vetting.

Site Characterization Survey

The site characterization survey takes a year or longer. "You have to show that radioactivity is below allowable levels throughout the site, which could range from tens to hundreds of acres," said Reid. "If you leave any buildings in place, you have to evaluate all the surfaces. It is a tremendous amount of work."

"I was at Connecticut Yankee during the decommissioning," said McGrath. "About five years before completion, we started the survey with the outlying land. As the plant was getting cleaned up, we moved closer in. It can take a year or more just to survey the buildings."

In the plant area, most survey work is done by hand, requiring a great deal of equipment. Technicians scan walls with handheld radiation meters, and others use meters attached to extenders or mounted on boom lifts. "At one plant, the decommissioning team built a scaffolding to the top of the containment building, and people climbed up and scanned the surface with handheld meters," said McGrath.

Opportunities for automation are numerous. "The technology is there. Imagine a mobile robot, like a golf cart or a small tractor, surveying the empty land with a radiation meter and using a global positioning system to trace an exact path," said McGrath. "Drones can be used to reach inaccessible areas."

"Because you know what needs to be done and where, these surveys can be easily programmed on a grid," said Reid. "You push a button, and the work gets done, faster and more safely."

EPRI is engineering the systems for both cutting reactor components and surveying sites. The next steps are working with fabricators on prototypes, conducting laboratory and plant demonstrations, and transferring to industry.

Reid is optimistic that automation and robotics will reduce the time and cost of decommissioning while improving worker safety. "The process now averages about 10 years. As companies get more experience and new technologies are brought on board, it's likely they'll get this down to eight years. If you really execute these things well, you can probably get it to six years. That's significant when you consider that every year saved provides millions of dollars in potential savings."

International Decommissioning Collaboration

Stakeholders in several countries are seeking collaborative R&D opportunities to improve decommissioning technologies and techniques. “In particular, companies in France are interested in pooling resources and ideas,” said McGrath. “The equipment is very expensive, and you want to make sure it works well before you put it into a radioactive field application.”

Recently, SHARE—an international group whose members include research organizations, utilities, waste disposal site operators, and the International Atomic Energy Agency—has formulated a roadmap for eight technology categories and made preliminary assignments for each. “EPRI is likely to be involved in all of them,” said McGrath.

For each technology category, SHARE team members will identify the areas with the greatest potential for improvement. These will be developed as collaborative research projects.

“We’re very excited about the potential for SHARE,” said Reid. “By sharing resources and information, we can make great progress and avoid duplicating efforts.”

Key EPRI Technical Experts

Rick Reid, Rich McGrath