SMRs meet ESG

Water conservation benefits of small and advanced reactors

By Nadia Glucksberg, Jay Peters, and Dawn Santoianni

The electric utility industry has set ambitious environmental, social, and governance (ESG) goals, with most aiming to achieve carbon neutrality by midcentury by reducing greenhouse gas emissions. Nuclear power can be a key technology in the clean energy portfolio to reach this goal, and small modular reactors can aid the industry's efforts in meeting ESG goals through protection and conservation of water resources.

ESG and the role of nuclear power

ESG identifies a set of principles for a company's role and behavior in safeguarding the environment; enhancing relationships with employees, customers, suppliers, and the communities in which it operates; and board oversight of risks, political giving, and transparency. ESG performance is increasingly becoming a focus of investors, including those managing mutual funds and pension funds, insurers, and regulators. Standards for reporting on ESG issues are being developed by financial regulators. For example, in 2021 the European Commission introduced the Corporate Sustainability Reporting Directive, which requires companies to report in compliance with European sustainability standards.[1] In the United States, the Securities and Exchange Commission (SEC) proposed a mandatory climate disclosure rule in March 2022 that would require public companies to disclose greenhouse gas emissions, including:

- Scope 1 emissions from direct production.
- Scope 2 emissions from purchased energy.
- Scope 3 emissions (for larger companies) associated with upstream and downstream activities in their value chain.

The SEC rule would also require companies to report on climate-related physical and transition risks.[2] Consequently, ESG disclosures and performance are playing an increasingly important role in the ability for companies to raise capital.

In addition to aiming to reduce carbon footprint, utility ESG strategies address important water stewardship goals, including reducing water use associated with electric generation, managing discharges, and improving water quality. For both active and decommissioning nuclear plants, groundwater impacts from tritium and other, nonradiological constituents have made headlines over the past 20-plus years. Although groundwater impacts are generally limited, do not affect public water supplies, and are generally managed via discharge through permitted and monitored pathways, the costs of investigations and remediation and the erosion of public confidence have been documented across the fleets. Active plants have invested resources to better understand existing groundwater and surface water conditions and potential impacts. Once those plants transition to decontamination and decommissioning (D&D), the nonradiological constituents in groundwater are often regulated,

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with documented impacts from diesel fuel, lube oil, and more recently per- and polyfluoroalkyl substances (PFAS). With the existing nuclear fleet providing about half of the carbon-free electricity in the U.S., the question becomes, what replaces these units as they retire to meet future climate goals? The average nuclear unit in the U.S. is about 40 years old, and many are nearing the end of their original 40-year license term or are already operating under a 20-year license renewal term.[3]

Filling the capacity gap

In 2022, 14.9 gigawatts of coal-fired electric generating capacity are slated for retirement.[4] More than 51 GW of coal-fired capacity are expected to retire by 2027, and another 23 GW are expected to go off line in 2028.[5]

There are two primary issues affecting what replaces those coal units. First, as more and more intermittent renewables are interconnected to the power grid, the reliability services provided by existing coal capacity must be replaced. Second, this replacement capacity must be able to be dispatched to follow load and quickly ramp up and down as electric demand and renewables output fluctuates. Because of the grid-balancing attributes of coal and the lower capacity factor of solar and wind, a one-for-one replacement with renewables alone would not ensure grid reliability. Further, global supply chain disruptions for solar photovoltaic panels have recently caused delays in the planned retirement of some coal units.

Conventional nuclear power plants (pressurized water reactors and boiling water reactors) have the capacity to fill the gap in electrical generation created by retiring coal plants, and conventional nuclear strongly aligns with ESG goals. For example, life-cycle carbon dioxide emissions per kilowatt-hour for nuclear power are the lowest among power generation options, and no emissions of particulate matter, nitrogen oxide, or sulfur dioxide occur at the point of generation.[6]

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Fewer construction materials are used per kWh of energy produced from nuclear, compared with materials used for wind and solar.[7] Although waste management has historically been cited as an environmental problem associated with nuclear power, the quantity of waste produced by nuclear power is small, compared with other power generation methods. While large numbers of solar photovoltaic panels and wind turbines have not gone out of service yet, the end-of-life management remains an open issue due to the current scarcity of recycling options. Finally, modern uranium mining methods are highly regulated (more so than those associated with mining for rare earth metals used to produce solar photovoltaic panels and lithium-ion batteries) and typically use *in situ* extraction techniques, which are associated with a lower carbon footprint and less land use disruptions.

SMRs and ESG goals

Advanced nuclear technologies, including SMRs and advanced reactors, can provide scalable capability to serve fluctuating electrical demand and are uniquely positioned to provide flexible, zero-carbon energy. However, SMRs and advanced reactors further support ESG goals with a reduced footprint for construction (compared with conventional nuclear power) and positive effects on water resources and social responsibility, as outlined below.

Environmental protection of water resources

Although nuclear power has zero emissions and is a clean, reliable, and environmentally responsible source of power, conventional nuclear power plants have a public stigma associated with high-profile accidents and historic impacts on groundwater. These perceived downsides would be eliminated if SMRs are used in the future. SMRs may have advantages over PWRs and BWRs related to surface water temperatures and groundwater quality.

Surface water: Temperature. In PWRs and BWRs, noncontact cooling water is circulated and returned to the source, but an increase in water temperature created by the cooling process can have an effect on the ecological community in the water body that receives the cooling water. An example of the potential impacts from temperature was identified during the D&D of the Connecticut Yankee plant. When that plant was still in operation, southern cottonwood trees thrived in the warmer microclimate along the discharge canal. They are a protected species in Connecticut, as they represented one of the northernmost occurrences of that particular tree. Since the plant has shut down and the discharge waters are no longer providing a microclimate after the D&D, the trees remain but likely will not thrive, as no additional protective measures were required by state agencies. These impacts can be seen as positive or negative but clearly show that the temperature of the discharge water does affect the local ecological systems both within and around the receiving waters.

Groundwater: Tritium and nonradiological releases to groundwater. After the identification of a tritium plume that extended off-site for the Braidwood plant in Will County, Ill.,[8] the industry undertook recommendations under the NEI 07-07 initiative to develop groundwater monitoring networks for all active plants in the U.S. This led to the installation of more wells, hydrological characterization and testing, and identification of tritium impacts to groundwater. Most of these detections did not lead to unacceptable conditions, but the costs to the utilities and impact on public confidence led to millions of dollars spent for off-site disposal of water.

SMRs use far less or no cooling water for energy production. Lower requirements for cooling water translates to fewer (if any) impacts on surface water and elimination of potential impacts on groundwater quality. When coupled with advances in analytical testing methods that can detect lower concentrations of chemical constituents and public and regulatory interest in emerging contaminants impacting water resources, the ability for SMRs to use less water translates to less potential for impacts to environmental media.

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In summary, SMRs will reduce the impacts to the hydrological cycle, thereby advancing attainment of ESG goals.

Climate impacts to water resources

As climate change exacerbates water scarcity and quality issues, advanced nuclear reactors and SMRs can help utilities advance their ESG goals by reducing water use and effluent discharges associated with power generation.

In many areas of the U.S. and the world, drought is becoming more severe, further constraining water availability for fossil energy, hydropower generation, and pumped storage. Consequently, conservation of groundwater and protection of groundwater and surface water quality will become increasingly important ESG metrics.

SMRs use little to no water for cooling, helping conserve groundwater aquifer levels. This also means that SMRs can be deployed in areas where water scarcity is an existing or projected concern, particularly in areas where water rights become a limitation to development.

Social responsibility and economic development

A current trend in the U.S. has been to prematurely shut down and decommission conventional nuclear plants due to economic pressures. During D&D planning, these sites typically retain their switchyards to continue to support the electric grid. Unfortunately, the land on which those plants sit likely will not be redeveloped for public use until the Greater-than-Class-C waste and spent fuel are removed.

Because of the existing intact grid infrastructure and ancillary equipment, SMRs can be sited at retiring coal or nuclear power plants. Importantly, these plants are often the largest taxpayers in their counties, so building replacement generation on-site can support utility "just transition" ESG goals. As the plants undergo D&D, building SMRs preserves the

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community tax base. Furthermore, siting SMRs at existing power generation facilities can preserve local jobs. Although operation of SMRs requires specialized training, job retraining can move an existing workforce from operation of a retiring fossil fuel plant or nuclear plant to operation of an SMR. Typically, nuclear power plant employment commands higher wages than other types of power generation.

The future of clean energy

A future clean energy system will require replacement capacity necessitated by the retiring coal fleet, greater need for flexibility to balance intermittent resources, and technologies that can be deployed in regions that are already experiencing water stress from climate change. As demand for water is increasing to serve a growing global population, protection of groundwater and surface water resources is increasingly critical and will likely emerge as a significant ESG goal in the coming decade. Advanced nuclear reactors and SMRs can provide efficient, flexible, and reliable energy with zero carbon emissions and negligible impacts to hydrogeological and hydrological cycles and therefore can play a key role in enabling utilities to meet ESG goals.

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