Nuclear Issues Study Guide

Contributions of Nuclear Power to GHG-free Power

The power sector is the world's largest carbon dioxide emitter, contributing more than 40% of the global greenhouse gas (GHG) emissions. GHG emissions must fall to mitigate climate change; that can only happen if we increase production from low carbon sources. By 2050 increases in total demand for electricity in the U.S. could be as low as zero or as high as 15% above the 2022 level according to the Annual Energy Outlook 2023 of the U.S. Energy Information Administration.

That report states that it is technically feasible to rely on a mix of energy sources to meet both the predicted demand for electricity in 2050 and also net-zero climate goals. Solar and wind energy sources will provide over 50% of supply with substantial funding at the federal and state levels. Existing nuclear energy will continue to provide electricity with plants in operation today whose useful lives have been extended 20 to 40 years beyond their initial licenses. The balance of supply will come largely from natural gas and from coal at a much lower extent than in the past.

Greenhouse gas-free energy sources —nuclear, hydropower, wind, solar, and more— are currently responsible for approximately 40% of the nation's electricity supply. Wind and solar generation are growing rapidly because of declining costs relative to other sources. Between 2009 and 2021, the cost of solar dropped 90% and wind 72%. However, wind and solar cease to produce power when the wind does not blow and the sun does not shine; they are "variable" energy producers.

Nuclear and hydropower provide almost two-thirds of the clean electricity generation in the U.S. They are "baseload" sources, meaning they can supply energy continuously. To enable consumers to have an adequate supply of electricity at all times, a "baseload" source is required. Baseload power generation can be produced from renewable (geothermal, hydropower, heat, biomass, biogas) or non-renewable resources such as nuclear or fossil-fuel.

There are several other issues that must be considered by utility companies when choosing the energy sources on which they will depend. The capacity factor is the measure of how often a power plant runs over a specific period of time. A plant with a capacity factor of 100% is producing power all of the time. In 2021 the capacity factor for nuclear energy was 92.7%. The capacity factor for natural gas was 54.4%, hydropower 37.1%, wind 34.6%, and for solar it was 24.6%. Nuclear plants have had fewer and shorter refueling and maintenance outages and fewer unplanned outages than other facilities.

An issue of variable energy sources is the impact on the grid. Grid operators require wind and solar generators to curtail production to reduce energy output when power lines don't have enough capacity to deliver available energy. They must also curtail production when generation exceeds the demand.

Even renewable energy sources have a carbon footprint due to the solar panel waste and old turbine blades. Over the course of its life-cycle, a nuclear power plant produces about the same amount of carbon dioxide-equivalent emissions per unit of electricity as wind, and one-third of the emissions per unit of electricity when compared with solar. Licensing extensions for currently operating nuclear power plants would reduce per unit emissions further.

Nuclear Regulatory Commission licenses to operate are initially for 40 years but may be extended in increments of 20 years if the reactor is operating safely and if requested by the state utility commission. Of the 92 US nuclear reactors operating in 2020, 88 have received an extension of 20 years on the initial 40-year license.

Renewable Energy Challenges

While some scholars propose that the U.S. can become 100% reliant on renewable energy sources in the foreseeable future, everyone acknowledges that a number of technical and non-technical challenges to renewable energy growth must be addressed. One of the issues, the diurnal mismatch problem, has apparently been solved. It concerns the need to balance supply and demand over a 24-hour period because peak demand occurs at night but supply of solar and wind energy is mostly generated during the day. Battery storage systems are key to solving this problem. A study by the DOE National Renewable Energy Laboratory and the DOE Office of Energy Efficiency and Renewable Energy concludes that battery technology is currently sufficient to achieve up to 80% of electricity demand using renewable energy sources, however, the carbon footprint and mining considerations must be evaluated.

Deterrents to Nuclear Energy Expansion and Effective Remedies

Unresolved issues from the past leave some members of the public viewing nuclear power with distrust of the technology and its management. There is a history of damage to the environment and to people associated with uranium mining. Damage from mining has been significantly reduced using leaching to extract uranium *in situ*; however, the legacy of distrust remains.

There are also challenges associated with disposition of spent fuel from nuclear power because the Federal government has been unable to achieve a national program for permanent spent fuel disposition. Recently, the Department of Energy has embarked on an effort to resolve the problem through consent-based siting, an approach to siting facilities that focuses on the needs and concerns of people and communities.

Opponents of nuclear energy cite concerns about the industry as a result of the Three Mile Island, Fukushima, and Chernobyl accidents and the potential for war-related damage like that at Zaporizhzhia in Ukraine. They also complain about lack of transparency in decision-making.

Decommissioning of closed facilities is complex. Under one approach, the plant is immediately dismantled with removal or decontamination of radioactive materials. Under the other approach, the facility is maintained and monitored, allowing radioactivity to decay until the plant is dismantled and the property decontaminated. Of the 11 sites where decommissioning was complete in October 2022, only three had no fuel left on the site.

Nuclear power accounts for about 20% of the nation's electricity production. It has declined slightly over the past decade because of plants being retired early and limited construction of new plants due to the high capital cost and relatively high operating costs. Other countries have deployed nuclear facilities within five to six years, but the lead time in the U.S. has been much longer and relatively high operating costs compared with natural gas have led to nuclear plants being shut down early.

Evaluation of Advanced Nuclear Reactor Concepts with Enhanced Safety features and Efficiency with Related Implementation Status

All of the U.S. commercial reactors and most of the commercial reactors worldwide are Light Water Reactors (LWRs), a genre that originated with naval submarine reactors in the early 1950s. There are some new LWR reactors under construction and a number of non-LWR research, experimental, and special purpose reactors of various types in operation both in the U.S. and worldwide. While the looming losses due to retirement of the existing fleet of LWR reactors could be replaced with new LWR reactors, new technological developments hold promise to eliminate many of the disadvantages of the old LWR technology. Eighteen nations have active programs to develop advanced nuclear reactors based on these new technologies.

The Intergovernmental Panel on Climate Change (IPCC) is not relying heavily on expanding nuclear power to combat climate change; although it acknowledges its potential for carbon free electric power, it cites uncertainties in cost and construction time, lack of public acceptance, lack of permanent waste disposal, and proliferation potential (IPCC 2022-III, pp 438-439, and 639-641). Nevertheless, during the current COP 28 deliberations 22 countries including the U.S. have signed up to the goal of tripling global nuclear energy capacity by 2050. Richard Meserve, former chair of the Nuclear Regulatory Commission, speaking about advanced nuclear reactors, has described climate change as a huge challenge and has indicated that there is no tool that we should exclude in addressing the situation.