LWVNM Nuclear Issues Study
Task 1 Report

Contributions of Nuclear Power to Greenhouse Gas-Free Power

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Task 1. Summarize the current contribution nuclear energy provides as both a baseload and a greenhouse gas-free (GHG-free) source for domestic/international energy production.

The power sector is the largest carbon dioxide emitter, making up more than 40% of the global emissions, followed by transport and industry sectors, which each produce around 25% of global emissions (IEA, 2021a). Some models forecast total electricity demand will increase by 250% between 2020 and 2050, while energy efficiency improves at a rate of 4% per year. (1) As electricity demand continues to rise, greenhouse gas (GHG) emissions must fall if we are to mitigate climate change, and we must switch to cleaner sources to reduce air pollution. This will require large increases of all low-carbon energy sources, of which nuclear is an important part.

GHG-Free Energy Sources

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; nevertheless, nuclear and hydropower provide almost two-thirds of the clean electricity generation and are the primary source of the clean electricity baseload. Nuclear plants, in particular, regularly operate for more than 90% of the year and can provide electricity in extreme situations when other resources may not be available.

Current sources of power-system flexibility, including storage, are already helping to integrate variable renewable energy. Though all plants age and eventually are closed, the retirement of sources of clean generation increases the amount of new capacity needed to reach 100%, increasing costs and deployment challenges in some cases. In the near term, ensuring that the current fleet of nuclear reactors and hydropower facilities continues to operate will reduce new deployment needs; over time, this will also entail refurbishing aging wind, solar, and other renewable energy assets, with a core focus on plants otherwise at risk of retirement. (2)

GHG-Free Variable/Renewable Energy Sources

Solar

Solar energy panels that can convert the power of the sun to electrical energy have existed for several decades, but dramatic cost reductions and rapid market growth for residential installations has made this an option for utilities over the past 10 years. Photovoltaic panels can be installed as arrays of surface mounted units or on rooftops to convert solar energy to electrical power to be used locally or fed to the existing electrical power grid for use by others. The technology is relatively mature and has relatively low capital and maintenance costs. The time to implement a solar system is generally the shortest of all GHG-Free energy technologies and can be implemented in about one to three months. Larger arrays may require additional time to verify compatibility with grid interface needs but can be implemented in about a year unless modifications to the grid connection are not standard.

Wind

Harnessing the power of the wind and converting it to electrical power is another technology that has become more prevalent and visible over the past decade. This technology is being installed in many areas of the country as clusters of windmill structures. Except for marine and off-grid homestead uses, this technology is not installed on residences or in higher density urban settings and has a higher capital cost than solar arrays. The systems also require a dedicated connection to the electrical power grid, but can be installed on land used for compatible purposes such as agriculture or ranching.

Baseload Energy Sources

The current international energy mix includes both Baseload and Renewable/Variable Energy Sources. Baseload power sources operate continuously to meet the minimum level of power demand at all times. Baseload plants are usually large-scale and are key components of an efficient electric grid. They produce power at a constant rate and are not designed to respond to peak demands or emergencies. Baseload power generation can be produced from both renewable (geothermal, hydropower, heat, biomass, biogas, where available) or non-renewable resources (nuclear or fossil-fuel).

- Clean Baseload Energy –Although wind and solar generation is increasing, nuclear and hydropower provide almost 2/3 of clean electricity generation and are the primary sources of clean electricity serving as the baseload. (Alternate baseload sources are fossil-fuel generated).
- Clean Variable/Renewable Energy may harness energy from natural sources that are continually replenished, for example, from the sun (solar energy), the wind (wind energy), plants (bioenergy), rainfall (hydropower), or even the ocean. (3)

GHG-Free Baseload Energy Sources

Hydro

Conversion of water flow to electrical energy, regionally available, has been pursued for almost a century as a component of river management and engineered flood control structures. This technology has been utilized as part of large-scale public works projects and relatively modest diversion structures on smaller watercourses. The technology relies on differences in water elevation to create a hydraulic force that can be converted to electrical energy through turbines or similar wheels that convert pressure to rotating generator systems. The technology can be effective for even small elevation or flow regimes and operate as long as the water flow is sufficient to generate hydraulic pressure.

Nuclear
Use of nuclear fission as a clean energy technology has been pursued in the U.S. since the advent of nuclear research and development, starting with large scale power plant design and construction during the 1960s. This technology has multiple variations depending on the design and configuration of the power block that converts the power of the fission reaction to steam for conversion to electrical energy, the types of fuel utilized, and the scale of the systems. Most U.S. power plants generate from 500 to 1500 gigawatts of power, and many locations include multiple generating plants using common support and infrastructure systems. The designs and operating layouts of nuclear power stations are specific to the design of the plant, use of cooling water sources, and other considerations, and the systems have evolved with time to reflect industry experience and efficiencies. Nuclear power has contributed about 10% of US domestic energy supplies during 2023 and has declined slightly over the past decade because of plants being retired early and limited construction of new plants.

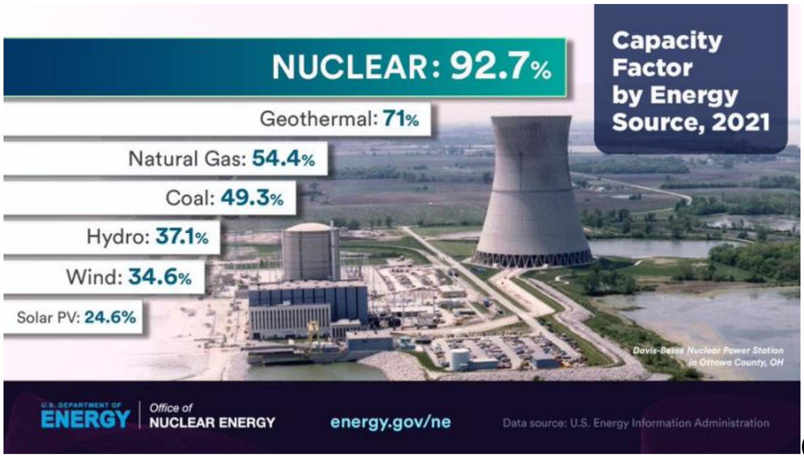
Nuclear energy supplies approximately 10% of the world's electricity and is the world's fourth largest source of electricity, following coal, gas and hydroelectricity, which supply approximately 38%, 23%, and 16% of the world's electricity, respectively (4). Nuclear energy, therefore, is the world's second largest source of non-emitting electricity, following hydroelectricity, and the largest source of non-emitting electricity in the group of Organisation for Economic Co-operation and Development (OECD) countries. In regions that are not rich in hydroelectric potential, nuclear is generally the most significant non-emitting option for electricity generation. (5).

The capital cost to develop new nuclear plants has increased dramatically over the past several decades, and this has reduced the interest of most utilities in pursuing new stations. The high capital cost and relatively high operating costs make nuclear power considerably more expensive than other technologies, and many utilities have elected to retire plants rather than pursue license extension that would allow them to remain in use. The development schedule for new nuclear power stations is long relative to other technologies. 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.

Factors Affecting Energy Delivery

Although both baseload and variable/renewable energy sources may contribute to GHG-free power availability, additional considerations regarding contributions of each must include the capacity factor and grid-level impacts.

Capacity Factor
The capacity factor is the measure of how often a power plant runs over a specific period of time. It's expressed as a percentage and calculated by dividing the actual unit electricity output by the maximum possible output. This ratio is important because it indicates how fully a unit's capacity is used. A plant with a capacity factor of 100% is producing power all of the time. Nuclear plants have had fewer and shorter refueling and maintenance outages and less unplanned outages. (6)



(7)

Grid-Level Impacts
Grid impacts from Variable GHG-Free Energy Sources may result in curtailment. Grid operators require wind and solar generators to curtail production to reduce energy output below the levels they would have otherwise produced during periods of:

- Congestion, when power lines don't have enough capacity to deliver available energy, and
- Oversupply, when generation exceeds customer electricity demand.

Carbon Footprint of Various Energy Sources

The International Renewable Energy Agency predicts that we'll have to deal with a cumulative 78 million metric tons of antiquated solar panel waste and tens of millions of tons of old turbine blades by 2050. Domestic nuclear energy comparison to wind and solar generation regarding carbon footprint and lifecycle emissions were recently addressed by US DOE Assistant Secretary for Office of Nuclear Energy Dr. Kathryn Huff: "Nuclear power plants produce no greenhouse gas emissions during operation, and over the course of its life-cycle, nuclear 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." (8)

Additional domestic reductions to GHG emissions may be realized by licensing extensions to currently operating nuclear power plants. The initial NRC licensing period for domestic nuclear reactors is 40 years. Pacific Northwest National Laboratory Earth Scientist Son H. Kim calculated that, without adding any new capacity, 60-year to 80-year extensions for existing nuclear reactors could contribute to an approximate reduction of 0.4 gigatons of carbon emissions per year by 2050. Taking it one step further, the total cumulative difference in carbon-dioxide emissions between 2020 and 2100 with lifetime extensions of existing plants and the inauguration of new nuclear plants could reach 57 gigatons of carbon emissions per year. The International Energy Agency reported U.S. carbon emissions in 2022 were 4.7 gigatons. Kim says that means nuclear energy could save about 12 years of carbon emissions. (9)

The UN Intergovernmental Panel on Climate Change indicated that the world's total renewable energy (e.g., solar, wind, bioenergy) will be insufficient to meet global energy needs: The energy from these sources exceeds the world's current and future energy needs many times. But that does not mean that renewable sources will provide all energy in future low-carbon energy systems as geographic availability is a major constraint. All low-carbon energy sources have other implications for people and countries, some of which are desirable, for example, reducing air pollution or making it easy to provide electricity in remote locations, and some of which are undesirable, for example decreasing biodiversity or mining of minerals to produce low emissions technologies." (3)

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