Nuclear Energy

Executive Summary

The Missouri Nuclear Clean Power Act (HB 1684 in the 2022 regular session) allows electric corporations to charge ratepayers for the cost of building clean baseload generating plants (specifically new nuclear-fueled facilities) or renewable source generating facilities rated at 200 megawatts or more (including wind, hydropower, solar power, landfill methane, biomass, or any other renewable source of power that does not produce significant carbon emissions) before they are operational. This repeals Section 393.135, RSMo which prohibits electrical corporations from charging for non-operational properties, including construction and financing.

Highlights

- Currently, 9% of Missouri's electricity generation comes from renewable sources, and 11% of Missouri's electricity generation comes from its single nuclear power plant, the Callaway Nuclear Generating Station.
- Nuclear energy could be used as a carbon-free energy source to provide consistent, baseload energy, as Missouri increases use of intermittent renewable energy such as solar and wind power.
- Disadvantages of nuclear power include problems with long-term waste storage, public perception of safety, and excess costs during construction.

Limitations

- New nuclear reactors may improve economic viability and safety, but this technology is still developing.
- There is no long-term national plan for the storage of spent nuclear fuel.

Research Background

Renewable and Nuclear Energy in Missouri

Renewable energy is energy that comes from a source that is naturally replenishing.[1] Major types of renewable energy include solar, wind, hydropower, geothermal, and biomass. Several challenges exist when attempting to shift to renewable forms of energy. They can suffer from intermittency (solar and wind), dependence on geography (hydropower and geothermal), or scalability issues (biomass).[2,3] Nuclear power is a carbon-free energy source that is reliable at a large scale and can be produced almost anywhere on Earth. Nuclear power does rely on a fuel source, however, and thus is not considered to be a renewable energy source. Uranium and plutonium can both be used as nuclear fuels but currently the United States does not use

plutonium.[4] A report by the Nuclear Energy Agency and the International Atomic Energy Agency predicts that there is enough uranium for nuclear fuel for over 250 more years.[5]

Missouri currently generates most of its electricity from fossil fuels, primarily from coal. A large portion of this coal (>90%) is imported from out-of-state.[6] The Callaway Nuclear Generating Station is currently Missouri's only nuclear power plant and in 2020 generated 11% of the state's net electricity.[7] It has been in operation since 1984. Renewable energy sources (including hydroelectric, solar, wind, and biomass) generate approximately 9% of Missouri's electricity. Of the renewable energy sources, wind energy is responsible for more than half the energy generation, followed by hydroelectric energy. Notably, electricity generation from solar energy has tripled since 2014.[7] Solar energy production is predicted to continue growing nationwide in the years to come.[8]

Intermittent and Firm Energy Sources

Traditional electricity generation sources have been classified based on their costs per energy produced and how often they are called on to meet demand (aka "load"). "Baseload" power sources serve to meet the minimum electricity demands on a grid experienced over a span of time. Nuclear energy fits into this category. Other sources serve to respond to changing electricity demand, and have been classified as "load-following" or "peaking" resources.

The penetration of intermittent wind and solar into the energy market challenges the traditional categorizations of energy sources.[9] This has led some researchers to develop new categorizations of energy producing technologies. "Firm" energy sources are described as those that are able to reliably produce electricity to meet demand during any season for long durations. Nuclear power, hydroelectricity, coal, and natural gas fit into the "firm" category.

One study investigated the role of firm energy sources with low-carbon output, such as nuclear energy and natural gas with carbon capture and sequestration, in conjunction with other renewable and conventional fossil fuels in electricity generation and different decarbonization goals.[9] They investigated nearly 1,000 scenarios, accounting for different potential future costs for renewable and other energy technologies, different CO_2 emissions targets down to zero emissions, the impact of flexible electricity demand scheduling, and various long-distance transmission capacities. The researchers found that low-carbon, firm energy sources consistently lowered the price of electricity in the scenarios that were evaluated. In fully decarbonized scenarios, electricity costs decreased by 10-62%.

Nuclear Energy Safety Concerns

<u>Nuclear Energy Accidents</u>

While catastrophic nuclear reactor accidents such as the Fukushima and Chernobyl disasters do occur, the overall mortality rate per terawatt-hour (TWh) of nuclear energy is 0.07.[10,11] As reference, the mortality rate per TWh for coal is 24.62, natural gas is 2.82, solar is 0.02, and wind

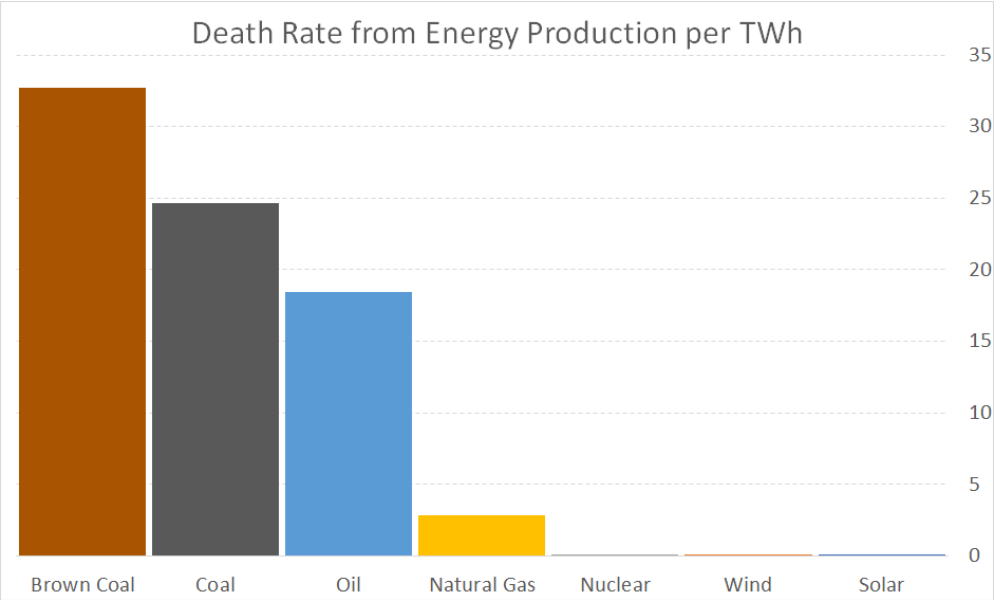

Figure 1. Death rate per terawatt-hour due to energy production by different energy sources. Figure made using data from references 10 and 11.

is 0.04 (Fig. 1). These mortality rates account for deaths due to accidents and also increases in mortality due to air pollution.

Because of the long lasting nature of radiation, nuclear reactor accidents have long-term ecological effects. Radioactive strontium and caesium will continue to remain in the vicinity of the Chernobyl nuclear power plant for decades.[12] Plutonium and americium will persist for thousands of years, though their human exposure is low. There is evidence that several species in the area have experienced mutations that impact their ability to survive.[13]

Regulations for nuclear reactors are updated after tragic events occur. After the most recent major nuclear accident at Fukushima, Japan, the U.S. Nuclear Regulatory Commission updated regulations for plants to include plans for more rare and extreme events.[14]

Spent Nuclear Fuel

Spent nuclear fuel is still highly radioactive and dangerous to humans. The radioactivity of nuclear materials naturally reduces overtime via a process called radioactive decay, but radioactive waste can still be dangerous to humans for thousands of years. Therefore, proper disposal of waste is essential.[15]

All U.S. nuclear reactors store spent fuel in concrete reinforced pools that serve to cool the fuel and act as a radiation shield.[16,17] After 5-10 years, the fuel is moved to a dry cask made of steel and concrete designed to cool the fuel and shield the radiation. As of 2019, approximately 86,000 metric tons of spent fuel is stored on-site at reactor facilities.[17] Currently there is no long-term plan for storage of spent nuclear fuel in the United States.[18,19] Partly as a result, 13 states

currently have restrictions on the construction of new nuclear energy facilities, with the majority awaiting identification of high-level waste disposal, although three states (Montana, Kentucky, and Wisconsin) have lifted restrictions in the last 6 years.[20]

Economic Viability of Nuclear Energy

Recent expansion in electricity generation from natural gas has led to lower electricity prices.[21] In combination with weak growth in electricity demand, electricity production from nuclear power plants has become less competitive, leading to closures and challenges in financing to build new plants.[21-23] Additionally, construction costs for many nuclear reactors become more expensive than initially estimated, with an average increase in cost of 117% (for comparison, hydroelectric is 71%, wind 8% and solar 1%).[24] One alternative to large nuclear reactors is the development of small, modular reactors which may require less upfront costs; however, this technology is still developing.[25]

The U.S. currently has 93 nuclear reactors. Twelve have shut down since 2013.[22] The Watts Bar Unit 2 reactor in Tennessee began operation in 2016 and was the first new reactor in nearly two decades.[21] Small single reactor plants that produce less than 1,000 megawatts in restructured energy markets are the most vulnerable to closure.[23,26] In most restructured markets, electricity is sold on a competitive market. In traditional markets, public utilities commissions exert oversight and regulatory authority over investor-owned utilities' rates.

State Legislation Related to Nuclear Energy

Thirteen states have restrictions on nuclear energy. Most of these states have conditions for the construction of a nuclear facility, including requiring a plan for the disposal of spent nuclear fuel, approval by the state legislature, or approval by voters.[27] Minnesota adopted an outright ban on the construction of new facilities, and New York adopted a ban in a limited area of the state.

The National Conference of State Legislatures compiled a list of policies which support nuclear energy generation.[28] Illinois and New York have both approved policies that would give zero emissions credits to nuclear plants based on megawatts of carbon-free electricity generated. Twenty-nine states and the District of Columbia have mandated renewable portfolio standards (RPS) which specify that a portion of a utility's electricity generation must come from carbon-free or low-carbon sources. These policies incentivize electricity generation with reduced carbon generation, such as nuclear energy. Missouri has a RPS (RSMo 393.1030) that mandates that electric utilities must generate at least 15% of their electricity from renewable sources. Florida, Georgia, and South Carolina have implemented policies related to advanced cost recovery. These policies allow utilities to collect costs for construction projects before they are finished. This is similar to the proposed Missouri Nuclear Clean Power Act (HB 1684).

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