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Opinion

The Current State of Nuclear Electrical Power in the United States

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Opinion

Although nuclear energy currently provides about 20% of U.S. electric power and over half of the nation's carbon free electricity, the ability of U.S. nuclear power plants to meet increasing demands for electricity and sustain the U.S. life style or even maintain the present one-fifth of US electrical demand is problematic and doubtful. A Union of Concerned Scientists (UCS) report finds that over one-third of the current fleet of 98 licensed nuclear power plants in the United States (65 PWRs and 33 BWRs) will or could be closed within the next decade. Sixty-six of these plants will not be profitable for continued operation by their plant owners. These closures may occur even before expiration of the plants U.S. Government issued NRC License.

Meanwhile, the U.S. and world demand for base-load electrical power will continue to escalate. Google now consumes more electrical power than San Francisco, and the advent of electrification of the U.S. vehicular fleet will impose even greater demands upon the U.S. electrical power sector. The average Chinese resident now consumes 3 kW(e) [kiloWatt(electric)] while a U.S. resident uses about 10 kW(e) on a 24hr/7day basis while an African use only 0.5 kW(e). Finally, over 1 billion people on the planet are without any electricity today. These electrical power consumption rates will greatly increase in the future, principally sustained by the further use of coal and natural gas as the primary energy source. Globally, this increase will result in massive increases in greenhouse gases and exacerbate globally warming. There is no scientific doubt that this unmitigated human action is threatening the earth's biosphere, resulting in marked increase in glacial water loss, raising ocean levels that threatening coastal populations, severe weather disruptions, increase incidence of hurricanes, wild fires, and widespread flooding. This uncontained biological stress of the planet's sensitive ecosystem is absolute and growing.

There are numerous reasons for the reversal of the optimistic projections for U.S. nuclear electrical power growth made in the 1970's and 1980's. It was projected that nuclear generated electrical power would be the primary driver of the U.S. electrical economy in the 21st century and would provide most U.S. base load electrical power without greenhouse gas emissions. Now with real threats to the viability of U.S. nuclear capacity, natural gas must meet U.S. needs. U.S. renewables will provide some relief, but the unconditional requirement for assured 24/7 base-load electrical power is imperative. Fortunately, natural gas imposes only about one-half of the greenhouse gases associated with the combustion of coal, but most developing nations will rely on coal to meet their future electrical power needs.

Some of the issues that suppress U.S. nuclear plant sustainment and future development include the current abundance of cheap, natural gas for fossil fueled electrical plants; the rapid government approval and licensing of natural gas plants in contrast to the decade-long and often contentious path for nuclear plant licensing. Other reasons include much lower construction cost and rapid natural gas plant construction, and finally the fear and opposition to nuclear plants because of the accidents at nuclear plants, especially the Russian Chernobyl Plant on 26 April 1986 and the Fukushima Accident.

On 11 March 2011 the largest subsea bed earthquake ever recorded in Japan (a 9.0 to 9.1 Richter magnitude seismic event) caused a devastating tsunami to crash onto the Japanese coastline, causing thousands of deaths and injuries (not nuclear radiation related) and no fewer than three meltdowns at the Fukushima nuclear plant, in addition to hydrogen-air explosions and the release of radioactive material. This event forged a lasting, distrust of the safety of nuclear energy throughout Japan and across the globe. Six reactors at the Fukushima Daiichi site are currently being dismantled as part of a cleanup process that will take decades to complete and is further complicated by technological challenges, public fear and residual radioactive waste including tritium that is seeping into coastal water adjacent to the plant sites. Soberly, a similar ~9 Richter magnitude seismic event occurring along the ~800mile coastal San Andreas Fault in southern California would kill millions of residents and incur $trillions of property damage. Assured and confirmed safety for any nuclear electrical plant sited along the San Andreas Fault zone is obvious and harrowing.

Currently, the large, multibillion-dollar U.S. nuclear plants such as the ~1 GW(e) (GigaWatt) Westinghouse, AP1000 plant now under construction in South Carolina is over budget and greatly delayed in licensing and construction. Installations of these large nuclear plants incur escalating costs and mounting legal obstacles for siting. Typically, these delays result in decades of extended construction time with attendant, cost escalation. Furthermore, when these plants must shutdown for refueling, adequate base load backup on the order of a GW(e) is required.

In view of this ominous situation confronting the U.S. nuclear power plant fleet, could a new type of nuclear power plant be designed and built with operation and safety guaranteed by the basic laws of thermodynamics, engineering and physics? The world's civil aviation sector has developed a large fleet of commercial aircraft that are reliable, safe, factory built, dependable and broadly accepted by the public for worldwide passenger transportation. Could a smaller, robust nuclear electric plant generating a ~100 MegaWatt(e) of electrical power on demand with assured safety and reliability be developed. These small nuclear plants could be assembled in specialized factories by trained, certified personnel and rigorously tested and certified for siting in the U.S.?

These plants must conform to the highest, international standards for safety and operation. Indeed, a nuclear power electrical plant that satisfied all international standards and expectation for safe operation under all environmental conditions that we expect and have achieved for air transportation. Such plants would resolve and effectively eliminate public anxiety over safety concerns, generate less waste and possibly even burnup existing nuclear waste inventories. Finally, such plants could reduce operating costs and be commercially competitive with solar and wind farm electric plants.

A U.S. DOE Small Modular Reactor (SMR) Program, in cooperation with the U.S. nuclear industry, focuses on developing and supporting SMRs that are safe and robust and incorporate past operating experience of all U.S. and International nuclear power plants. The Program has two components: (1) support the design finalization and licensing of first-mover SMR designs and (2) conduct research, development, and demonstration activities supporting the deployment of advanced SMR designs. The DOE program is closely coordinated with the US NRC development of licensing and regulation standards for SMR nuclear plants. Both DOE and NRC are actively investigating a numerous number of SMR plant concepts and designs.

In January 2018 NRC announced that NuScale's SMR incorporates novel safety design features that eliminates the NRC Class-1E Regulatory standard set for the design of safety-related nuclear power plant electrical systems. In the NRC Safety Evaluation Report, the NRC approved NuScale's "Safety Classification of Passive Nuclear Power Plant Electrical Systems" Licensing Topical Report, in which NuScale established how its design is safe without reliance on any safety-related electrical power. It was the loss of onsite cooling capability that precipitated the Fukushima Accident. The NRC has now limited its regulatory approval solely to Nu Scale's design. The U.S. NRC is expected to certify NuScale's current SMR design. The NuScale's first customer, Utah Associated Municipal Power Systems (UAMPS), is planning the deployment of a 12-module SMR plant complex in Idaho for testing and certification slated for operation by mid-2020s based on certified design.

The NuScale SMR is an advanced light-water reactor (LWR). Each module is a self-contained unit that operates independently within multi-module configuration. Up to 12 modules can be monitored and operated from single control room. Each reactor module measures 65 feet tall and 9 feet in diameter. The reactor and containment vessel operate inside a water-filled pool that is built below grade. Reactor operates using principles of natural circulation and no pumps are required to circulate coolant water through reactor. The thermodynamic operating system uses natural convection to heat the coolant and generate electrical power on demand. These advanced NuScale SMRs offer many advantages such as relatively small size, controlled and certified factory construction, reduced capital investment, ability to be sited in locations not possible for larger nuclear plants, and provisions for incremental power operation for duty cycles and modular additions. Such SMRs could offer the essential safety, safeguards, reliability, security and nonproliferation demanded in the 21st Century for future U.S. Nuclear Power Plants.

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