American Nuclear Society

# Nuclear Technology's Critical Role in the World's Future Clean Energy Supply

## Background Information, Position Statement 43

### Historical and Current Non-Electric Applications

There are more than 70 nuclear power reactors operating in 11 countries that generate not only electricity, but also heat and energy for district heating, for industrial processes, and for desalination.[1] Nuclear reactors have been used for non-electric applications since the early development of nuclear power. For example, in 1956 the Calder Hall plant in the United Kingdom provided not only electricity but also heat to a nearby fuel processing plant. In 1963, the Agesta nuclear power plant in Sweden provided hot water for district heating to the suburb of Stockholm. In 1972, the Aktau BN350 fast reactor in Kazakhstan was used to provide electricity and heat for a seawater desalination plant that supplied 120,000 cubic meters of fresh water per day to the city of Aktau. Starting in the late 1970's, steam from the Bruce nuclear power plant in Canada was diverted to a steam system which provided energy for heavy water production as well as industrial and agricultural users.[2]

The recovery and utilization of low-grade or waste heat from nuclear power plants can help to lower their combined generation cost and environmental impact. Waste heat can also be recycled to make additional electricity, improving the overall efficiency of nuclear power plants, or can be repurposed for other applications. The reuse of waste heat not only provides direct economic benefit, but also an indirect benefit by reducing the amount of thermal pollution (waste heat rejected directly to the environment).

While excess heat from nuclear power plants has been repurposed since the 1950s, the heat provided by these nuclear reactors has been primarily limited to district heating for close-in towns and villages, as well as heat for fishery farms and agricultural greenhouses. To achieve the objective of a higher contribution by clean energy sources, it is essential that the use of nuclear heat and power expand within a wider spectrum of applications. This can be accomplished through repurposing existing large reactors or designing co-generation facilities.

### Nuclear Plants Can Help Meet our Growing Need for Desalination

Desalination is the process that removes dissolved minerals from seawater or brackish water. The technologies currently in use for desalination require significant amounts of energy, either as low-temperature process heat or electricity.

---

[1] https://www.iaea.org/topics/non-electric-applications/nuclear-desalination

[2] "Bruce Power: Site History". Canadian Nuclear Workers' Council (CNWC). 2009. Archived from the original on 27 May 2011. Retrieved 27 March 2011.

Desalination projects will become increasingly important given the growing world population and already existing local shortages of fresh water. In 2017, it was estimated that 10% of the world's population does not have access the most basic quality drinking water.[3] Water-borne diseases result in more than 3.4 million deaths each year.[4] This situation is likely to deteriorate in the future because of increasing population, commercialization, and industrialization, particularly in arid and semiarid regions, and because of the cost of tapping new water reservoirs. According to the World Health Organization, by 2025 about half the world's population will be living in water-stressed areas. In many areas, the rate of water usage already exceeds the rate of replenishment, and in the United States, severe water shortages have already occurred in some regions, e.g., California, Florida, and Texas.

Nuclear reactors have already been used for desalination in several countries. In total, more than 200 reactor-years of operating experience with nuclear desalination have been accumulated worldwide.[1] The Aktau nuclear desalination plant in Kazakhstan has already demonstrated the commercial aspects of nuclear desalination. Eight nuclear reactors coupled to desalination projects (to provide make up water for the nuclear power plants) are currently in operation in Japan. Furthermore, India, the Republic of Korea, Canada, Pakistan, and the U.S. have completed demonstration desalination plants utilizing heat from nuclear reactors. India successfully developed Low-Temperature Evaporation (LTE) desalination technology based on the utilization of waste heat from the nuclear research reactor CIRUS in Trombay, to produce 30 cubic meters of fresh water per day. While multi-stage flash desalination (MSF) proves to be the simplest and most reliable of the major desalination processes, a significant drawback is its higher energy consumption when compared to multi-effect distillation (MED) and reverse osmosis. This disadvantage may be overcome with the processes utilizing the waste heat of high temperature gas-cooled reactors (HTGRs). For example, the Japan Atomic Energy Agency has designed a High-Temperature Reactor called the GTHTR300 which could use waste heat to produce fresh water through MSF desalination.[5] In the southwest of the U.S., where solar energy is abundant, but water is a limited resource, nuclear plants could be repurposed for desalination when solar energy is available.

## More Efficient Hydrogen Generation

Hydrogen and hydrogen-rich fuels are expected to become valuable energy carriers with applications in the industry and transportation sectors, which together accounted for 60% of U.S. energy consumption in 2018.[6] At present, most hydrogen (about 95%) is produced by steam reforming of methane with process heat provided by the combustion of some of the methane. If this were done utilizing nuclear derived process heat, it would result in a substantial reduction in the consumption of methane and a decrease in the amount of carbon dioxide generated per unit

[3] https://washdata.org/sites/default/files/documents/reports/2019-07/jmp-2019-wash-households.pdf

[4] https://www.who.int/water_sanitation_health/takingcharge.html

[5] http://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx

[6] https://www.eia.gov/energyexplained/use-of-energy/

of hydrogen produced. Hydrogen production through nuclear-assisted steam reforming of methane is viewed by many as an intermediate step to large-scale, nuclear-driven hydrogen production from water. Hydrogen may be produced from water by electrolysis or thermochemical cycles using nuclear energy. Electrolysis requires electrical energy as input and can be performed at any temperature, but it is considerably more efficient at higher temperatures. Thermochemical cycles, involving various recycled reactants, require process heat as input and require relatively high temperatures. In Illinois, where wind energy is abundant, nuclear operators are considering repurposing energy from a nuclear reactor to produce hydrogen for fuel-cell vehicles, steelmaking, or ammonia production. The U.S. DOE is collaborating with several companies under the H2@Scale initiative. H2@Scale was launched "to enable affordable and reliable large-scale hydrogen generation, transport, storage, and utilization in the United States across multiple sectors."[8]

## Alternative Applications for Small Modular Reactors (SMRs) and Advanced Reactors

Most of the current alternative applications are somewhat limited because they are coupled to large water-cooled reactors with lower operating temperatures. In the future, both small modular and advanced nuclear power reactors could be attractive energy sources for alternative applications. Small modular reactors are especially suitable for remote areas with limited infrastructure. Canada is researching deployment of small modular reactors to remote locations that will not only provide power, but also produce hydrogen to serve as a clean fuel for transportation and heating. Advanced reactors provide unique features, such as higher temperatures and thermodynamic efficiencies.[7] Once high-temperature reactors become available, the spectrum of applications can be broadened to additional methods of hydrogen production, coal gasification, synthetic fuel production, and other industrial petrochemical applications.

Communications & Outreach Department
555 North Kensington Ave.
La Grange Park, IL 60526-5592

708-352-6611 telephone

outreach@ans.org e-mail
www.ans.org

[7] Advanced Reactors (ANS-35-2018). http://cdn.ans.org/pi/ps/docs/ps35.pdf
[8] DOE Announces $40 Million in Finding for 29 Projects to Advnace H2@Scale, https://www.energy.gov/articles/department-energy-announces-40-million-funding-29-projects-advance-h2scale