Application of Nuclear Technology to Water Desalination

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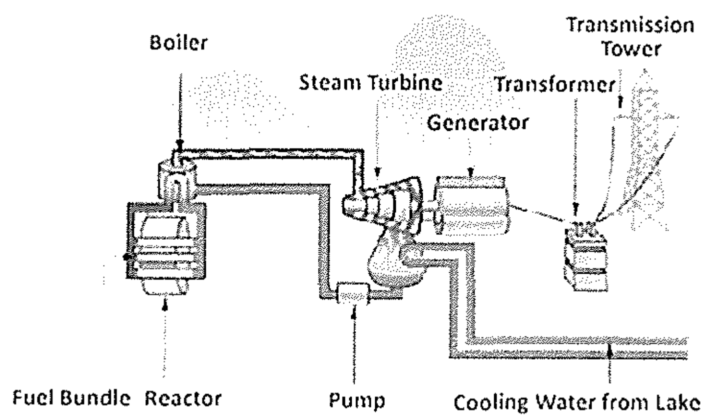
"If a person doesn't drink clean water they will be dead in less than three days. That's why water is the most valuable commodity there is" (White, 2009). In the modern world, one of the most pressing issues is the scarcity of water, and this problem is certainly not going to dwindle over time. Granted, there is an abundance of water, but it is the lack of drinkable, or potable, water that is the problem. Progress towards a solution must start immediately because approximately one fifth of the world's population lives without sufficient drinking water, and since the world population is growing, but the supply of water is not, the need for water is going to increase. Potable water is in such small supply because freshwater sources are limited. Water from uncontaminated freshwater aquifers and streams is suitable for human consumption, but groundwater and seawater contain salt and minerals which are unfit for drinking or even watering crops. However, unsuitable water can be desalinated, thereby creating potable water (Khamis, 2011). Using heat and electricity from nuclear reactors to power water desalination plants is a practical, environmentally friendly, and economical technique that will help solve the water scarcity crisis.

Currently, there are three prominent methods used to desalinate water: reverse osmosis (RO), multi-stage flash (MSF), and multi-effect distillation (MED). At the beginning of the RO process, seawater is separated from freshwater by a semipermeable membrane. Naturally, pure water would flow from the side low in concentration of salt to the side high in concentration of salt. However, by pressurizing the side with seawater, this natural tendency is overcome, so that pure water flows out of the seawater side and into the freshwater side (International Atomic Energy Agency [IAEA], 2007). This pressure is provided by electric pumps (Khamis, 2011).

The MSF and MED processes involve heating seawater and condensing the steam, which is comprised of only pure water (IAEA, 2007).

Despite the presence of desalination methods, potable water scarcity remains a threat. This is because all three methods face the same constraint; they require a great deal of energy (Khamis, 2011). One possible solution to this problem is using the heat produced during the process of creating nuclear energy to power desalination processes. Heat is produced in nuclear reactors when neutrons collide with uranium atoms, splitting the atoms and releasing heat energy stored in chemical bonds. The energy heats up water, which converts into steam, and it is this steam that spins steam turbines, creating electricity for public use (How a Nuclear Reactor Works, 2010). However, the steam or electricity can also be used to power desalination.



As the diagram above (How a Nuclear Reactor Works, 2010) shows, the water in the boiler is connected to the steam turbines that turn to create electricity. However, at that stage some of the steam can be diverted to steam turbines that power MSF or MED desalination units. Also, electricity that has passed through the transformer can be directed to a desalination plant and used to power RO pressure pumps. Both techniques produce electricity and potable water simultaneously. Furthermore, the proportion of energy used to meet public electricity needs to the energy used for desalination can be set to appropriately reflect the public demand for electricity at any given time. According to Khamis (2011), "the feasibility of integrated nuclear desalination plants has been proven with over 150 reactor-years of experience, chiefly in Kazakhstan, India and Japan."

For example, in Kazakhstan, a BN-350 fast reactor was combined with ten MED units. Sixty percent of the reactor's power was enough to allow the MED units to produce 80,000 m^3/day of potable water for over 27 years. Another instance of success is in India, where a hybrid of RO and MSF units was integrated with two nuclear reactors, and it produced 6,300 m^3/day of potable water. In addition, in Japan, ten desalination units linked with nuclear reactors have produced 14,000 m^3/day of potable water for 100 reactor-years (Khamis, 2011).

The practical reasons for using nuclear power are evident. Heat is produced by nuclear reactors, and the structure of a nuclear reactor is ideally suited to integration with desalination plants. However, other possibilities must be considered. After all, since coal, natural gas, and wind can create electricity, they are also capable of powering water desalination. Green World Water™ is a joint venture by Alternate Energy Holdings, Inc. (AEHI) and the China National Nuclear Corporation. The Chinese corporation produces nuclear reactors combined with desalination plants, and AEHI makes them commercially available (Wayne, 2010).

1100 MWe System	Cost of Plant (approx)	Daily Water Amount	Water price per cubic meter (with cost of fuel)	Expected Lifespan	Additional Energy Output	Yearly Carbon Emissions
Coal Powered	$4 billion	400,000m^3	$2.00	40 years	0	6 million tonnes
Natural Gas Powered	$3 billion	400,000m^3	$7.30	30 years	0	3 million tonnes
Wind Powered	$6 billion	45,000m^3	$12.50	20 years	0	Carbon Credits
Green World Water™	$3 billion	400,000m^3	$0.35	60 years	700 MWe	Carbon Credits

The above table (Green World Water™, 2010) compares the capabilities of coal, natural gas, wind, and Green World Water™. Green World Water™ is tied with natural gas as the least expensive plant to construct. It produces the same amount of potable water each day as coal and natural gas, but at a far smaller cost per cubic meter. Additionally, Green World Water™ has the longest lifespan by far and is the only unit that produces energy along with the potable water. It also is an environmentally friendly choice, since nuclear reactors don't emit greenhouse gases (Green World Water™, 2010).

Green World Water™ demonstrates some of the economic advantages of nuclear desalination, but there is another aspect that gives the nuclear method an edge. The uranium used in nuclear reactors is a naturally occurring element, so it is mined and then packed into fuel pellets. Because "a single 1.65 cm nuclear fuel pellet can produce the same amount of energy as 807 kilograms of coal, 677 litres of oil, or 476 cubic metres of natural gas" (How a Nuclear Reactor Works, 2010), these plants are the least expensive method of desalinating water. This is especially true in current times because fossil fuels are extremely high in price.

Widespread use of Green World Water™, as well as other nuclear desalination plants, could help reduce the water scarcity crisis in an efficient and economical manner, while at the same time preserving the environment. AEHI is paving the way; Don Gillispie, the founder of Green World Water™, stated that he will be engaging in discussions with around thirty nations about the possibilities of selling these units to them (Wayne, 2010). More developments are sure to come as other revolutionaries begin to truly grasp the role nuclear desalination could play in ending water scarcity.

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