Union of Concerned Scientists

Nuclear Power and Water

FACT SHEET

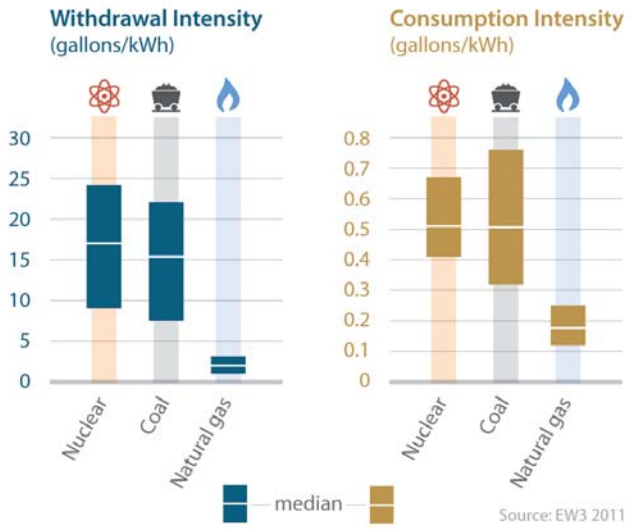
QUICK FACTS ON NUCLEAR POWER GENERATION AND WATER USE

The United States produces roughly 4 trillion kilowatt hours of electricity annually, 90 percent of which is generated by thermoelectric power plants.[i] Plants fueled by coal, natural gas, oil, nuclear fission, and some renewable energy technologies boil water to produce steam, which then turns a turbine to generate electricity. After it passes through the turbine, more water is needed to cool the steam back into water to reuse for generation; this steam-cooling step accounts for virtually all of the water used in most power plants. Nuclear fission is the most water intensive method of the principal thermoelectric generation options in terms of the amount of water withdrawn from sources. In 2008, nuclear power plants withdrew 8 times as much freshwater as natural gas plants per unit of energy produced, and up to 11 percent more than the average coal plant. [ii]

Water use in cooling systems

Nuclear power plants are about 33 percent efficient, which means that for every three units of thermal energy generated by the reactor core, one unit of electrical energy goes out to the grid and two units of waste heat go out into the environment through cooling systems. [iii] Of the 104 nuclear reactors in the United States, 35 are boiling water reactors (BWR) and 69 are pressurized water reactors (PWR). About 60 percent of these nuclear power systems use recirculating cooling; the remainder use once-through cooling.[iv]

Variations in Water-Use Intensity across the Fleet



Turning the Corner on Global Warming Emissions. July 28, 2004. Among power plants using freshwater for cooling in 2008, nuclear power plants used more water per unit of electricity produced. The average nuclear plant withdrew nearly eight times as much freshwater as the average natural gas plants, and 11 percent more than the average coal plant. Nuclear plants also consumed three times as much freshwater as natural gas per unit of energy produced, and about 4 percent more freshwater than coal plants. Sources: EW3 2011 Report.

Once-through cooling

Since a large nuclear power plant that utilizes a once-through cooling system may withdraw 800 million to 1 billion gallons of water a day, these plants are usually built next to rivers, lakes, or oceans.[v] As the name implies, once-through cooling uses water a single time to cool and condense steam produced for electricity generation. Water produced from the condensed steam is reused in the generation process, but the water used for cooling is discharged back into the lake, river or ocean, with a temperature increase of up to 30 degrees.[vi]

The temperature increase in the bodies of water can have serious adverse effects on aquatic life. Warm water holds less oxygen than cold water, thus discharge from once-through cooling systems can create a "temperature squeeze" that elevates the metabolic rate for fish.[vii] Additionally, suction pipes that are used to intake water can draw plankton, eggs and larvae into the plant's machinery, while larger organisms can be trapped against the protective screens of the pipes. Blocked intake screens have led to temporary shut downs and NRC fines at a number of plants.

Recirculating cooling

While once-through cooling systems withdraw 25,000 to 60,000 gallons of water for each megawatt-hour of electricity produced, recirculating cooling systems, also known as closed-cycle cooling systems, withdraw only 800 to 2,600 gallons per megawatt-hour and are used when nearby water sources lack sufficient volume to allow once-through cooling. After water is withdrawn from a source to cool steam, it is then cooled and pumped back into the condenser for reuse. Though plants with closed cycle cooling systems withdraw far less water than once-through cooling systems, they consume (through evaporation) about 600-800 gallons per megawatt-hour, roughly half the amount they withdraw.

Other water uses for nuclear power

While cooling systems account for the vast amount of water withdrawn by nuclear power plants, fuel extraction and refining have also impacted water sources. Uranium fuel extraction, for example, requires 45-150 gallons of water per megawatt-hour of electricity produced and uranium mining has contaminated surface or ground water sources in at least 14 states.[viii] Additionally, nuclear power plants intake water to cool service equipment, such as chillers for air conditioning units or lubricating oil coolers for the main turbine. Service water system flow rates can range from 13,500 to 52,000 gallons per minute depending on the season and the power plant.[ix]

Nuclear power in a warming world

Water cooling systems can also pose significant problems from an economic standpoint. When water is warmed, either by plant discharge or ambient temperatures, cooling requires even more water and power plants operate less efficiently. Moreover, if water cannot be cooled, it can neither be recirculated nor returned to the river, lake or ocean without threatening aquatic life. Therefore, during hot summers or heat waves, the problem compounds: during times of extreme heat, nuclear power plants operate less efficiently and are dually under the stress of increased electricity demand from air conditioning use. When cooling systems cannot operate, power plants are forced to shut down or reduce output. The combination of high electricity demand and reduced output can result in higher energy prices for ratepayers. Droughts can have a similar effect as heat waves, limiting the amount of water available for cooling.

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[i] U.S. Energy Information Administration. *Electricity in the United States,* 2009.
[ii] Averyt, et al. *Freshwater use by U.S. Power Plants: Electricity's Thirst for a Precious Resource.* Union of Concerned Scientists, EW3, 2011.
[iii] Lochbaum, David. *Got Water?* Union of Concerned Scientists, 2007.
[iv] Union of Concerned Scientists. *How it Works: Water for Nuclear,* 2010.
[v] Palo Verde nuclear power station buys treated wastewater to use in its recirculating cooling system. It is the only nuclear power station not located near a body of water.
[vi] UCS. 2007.
[vii] UCS,EW3. 2011.
[viii] UCS. EW3. 2011.
[ix] UCS. 2007.

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