SMR Nuclear Technology Pty Ltd Fact Sheet
Cooling Water for Nuclear Power Plants

The main cooling water requirement for nuclear power plants is condenser cooling water for plants that use a steam turbine to generate electricity. The exhaust steam from the turbine is condensed back into water to be recirculated to the nuclear reactor. As in any electrical generation plant that uses a steam turbine, including all coal-fired power stations, this requires separate condenser cooling water supplies. Unlike the water supplied to a boiler in a coal-fired power station or to the steam generator in a nuclear power plant, condenser cooling water does not have to be high quality and seawater/lake/river/recycled water is commonly used.

There are three condenser cooling arrangements

Direct once through cooling

Water is taken from a lake, river or the sea, passes through the condenser and is discharged back into the original water source, but at a point where it will not immediately recirculate. There are usually environment limits on the temperature of the water being returned.
Direct cooling **withdraws** more water than other condenser cooling methods but the water **consumption** is smaller. If the water source is a lake, they will be some small evaporation losses.

Examples of withdrawal rates:
UK Environmental Agency report[1]:
Westinghouse PWR, AP-1000, 1117 MWe, 57,000 l/s = 183,706 l/MWh
Framatome PWR, EPR, 1,600 MWe, 72,000l/s = 162,000 l/MWh

NREL report[2]
Nuclear range 95,000 – 227,000 l/MWh

A 300 MWe SMR with direct cooling would withdraw ~ 14,000 litres/sec.

Indirect cooling with cooling towers

The condenser cooling water is circulated through cooling towers which discharge the heat to the air, both directly and through evaporation. This is the plume of condensed water vapour that is seen rising from a cooling tower. Tower cooling **withdraws** less water but **consumes** more.

Examples of consumption
UK 1,600 MWe, 2,000 l/s

NREL supercritical coal 1730 – 2250 l/s
Nuclear range 380 – 1,500 l/s

Towers can be natural draft (chimney effect) or mechanical draft using large fans.

[1] https://assets.publishing.service.gov.uk/media/5a7c7688ed915d6969f450b2/scho0610bsot-e-e.pdf

[2] https://wwwnrel.gov/docs/fy11osti/50900.pdf

The 20 MW (thermal) OPAL research reactor at Lucas Heights, Sydney uses tower cooling. This reactor does not generate electricity and the 20 MW of heat produced in the reactor is dissipated in the tower cooling system. The system has five counter flow forced draft cooling towers with a wet basin and 3 x 50% cooling pumps. Flow rate is 4,400 l/s per pump. Heat transfer to the atmosphere is by variable speed cooling fans.

Dry cooling

The condenser cooling water flows through a large radiator in a closed circuit. Fans blow air through the radiator removing the heat. Water **consumption** is very low as there is no water loss through evaporation. Dry cooling increases the house load (electricity required to operate the plant) because of the fans and hence decreases the electrical output slightly. Dry cooling also increases the cost of the cooling system.

The largest coal-fired unit in Australia uses dry cooling. Kogan Creek[3], QLD, 750 MWe supercritical located on the Western Downs consumes only 80 l/MWh, about 5% of a typical Australian coal-fired power station.
The giant radiator has 48 fans, each 9m diameter.

Milmerran, QLD, 2 x 426 MWe supercritical coal also uses dry cooling with a consumption of ~150 l/MWh.

The proposed NuScale SMR 6 x 77 MWe plant to be sited at Idaho National Laboratories was designed to have dry cooling, reducing water usage by 90%[4] and decreasing power output by 5-7%.

Summary

- When there are abundant cooling water supplies or adequate supplies without too restrictive environmental limitations, direct cooling is the most efficient and least cost option.
- Indirect cooling using wet cooling towers is an option when water supplies are restricted.
- Dry cooling is a more expensive and less efficient option, but enables power plants to be situated practically anywhere

Many of the advanced Small Modular Reactors and microreactors under development now do not use a steam turbine and will not require significant cooling water supplies.

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[3] https://www.csenergy.com.au/news/blog/the-giant-radiator-keeping-kogan-creek-cool

[4] https://world-nuclear.org/information-library/current-and-future-generation/cooling-power-plants