FACT SHEET
JULY 2022

FOOD & WATER WATCH

# Thirsty Fossil Fuels: Potential for Huge Water Savings by Switching to Renewables

**As water resources across the United States experience historic stress thanks to perpetual megadroughts and other climate change impacts, the unsustainable relationship between water and fossil fuel electricity generation is even more apparent. While all forms of energy production require water at some point in their life cycle, fossil fuels use an exorbitant amount compared to renewables such as wind and solar.[1]**

In 2015, thermal power plant cooling accounted for 40 percent of all water withdrawn in the United States.[2] From 2000 to 2015, there were 18 instances where, due to insufficient or high-temperature water supplies needed for the cooling process, coal plants were unable to generate electricity.[3] It is clear that fossil fuel technologies will not be able to meet future energy demands and will continue to compete with other uses in the face of an increasingly volatile water supply. This underscores the need for a swift transition to a renewable electricity grid, which can cut lifecycle water use by up to 99 percent.

Food & Water Watch found:

- If California replaced fossil fuel and nuclear electricity production with 100 percent renewable energy sources like solar photovoltaic (PV) and wind, the state could save 82 million cubic meters of water annually. This is a 98 percent reduction from current levels consumed for fossil fuel and nuclear electrical generation.
- Similarly, California's water withdrawals could be reduced by over 99 percent while producing the same amount of energy — amounting to nearly 6.3 billion cubic meters of water. That is equivalent to 2.5 million Olympic swimming pools of water.[4]
- Similar water savings are possible at the national level, with more than a 99 percent decrease in water consumption and withdrawal by replacing fossil fuels and nuclear with wind and solar PV.
- Nationally, over two-thirds of water used in electrical generation for cooling comes from freshwater sources. Shifting to 100 percent renewable energy would free up enormous amounts of freshwater for truly beneficial purposes.

## Fossil Fuels' Enormous Water Footprint

The main use of water in the electricity generation process occurs in the cooling process for thermoelectric power plants; these are power plants that produce electricity by heating water to produce steam, which then passes through a turbine to generate electricity.[5] Further, the majority of electricity produced in the United States comes from water-cooled systems,[6] which employ two main methods.[7] **Once-through cooling systems**, as the name indicates, withdraw water, circulate it through the heat exchangers, and then return it to a body of water at a higher temperature. **Recirculation cooling systems,** in contrast, let the circulated water cool before reusing it in the same process.[8]

These two methods use water in different ways. Once-through cooling systems are a type of **water withdrawal**, where water is used before returning it to its original source. However, this water is discharged at a higher temperature, which can lead to thermal pollution. Thermal pollution harms aquatic life by decreasing levels of dissolved oxygen and increasing metabolic rates of aquatic animals, causing food shortages and migration to more suitable habitats.[9]

In contrast, recirculating cooling systems are a type of **water consumption**, where water is not returned to its original source after use. Other examples of water consumption include agricultural uses, where water evaporates in fields, is transpired by crops or is consumed by livestock. Recirculation systems may withdraw much less water than once-through systems but do not return it to the source.[10]

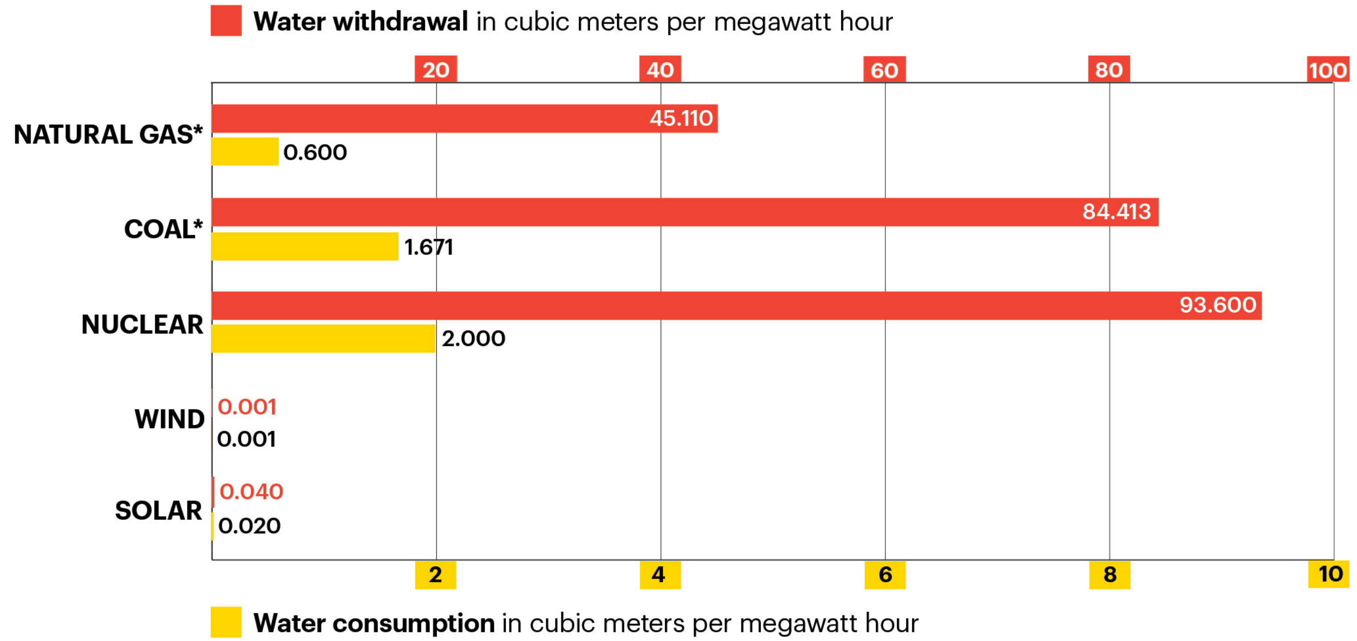
Some thermoelectric power plants use dry cooling systems, which decrease water dependence by around 95 percent.[11] However, dry cooling systems are more costly and require more energy to operate than wet systems, thereby decreasing overall power plant efficiency.[12] This highlights a trade-off between increased carbon emissions and water use that is unique to fossil fuel electricity production.

While cooling systems account for the vast majority of water use in fossil fuel electricity generation, upstream processes such as mining and hydraulic fracturing (fracking) are also water intensive. Upstream water consumption accounts for 30 percent of the total water consumption of coal-fired electricity. For natural gas, fracking increased the upstream water consumption from 11 percent of total natural gas water consumption in 2013 to 19 percent in 2016.[13] The water intensity of fracking and other upstream fossil fuel processes – which fuel climate change, leading to more severe droughts and stress on water resources – highlights the incompatibility of fossil fuels with a sustainable electric grid, in terms of both water usage and carbon pollution.[14]

## Shifting to Renewables Could Eliminate 99 Percent of Water Used in Fossil Fuel Electrical Generation

While fossil fuel and nuclear electricity production involve water-intensive operations (both at the plant level and upstream from the plant), this is not the case for many forms of renewable energy — including wind and solar PV. Multiple studies have found that lifecycle water consumption and withdrawal for wind and solar PV are significantly lower than water intensity for fossil fuels such as coal and natural gas, and even for nuclear (see Figure 1).[15] Importantly, wind and solar PV generation requires very little water use to maintain, unlike thermoelectric power plants.[16] This means that the water needed to operate wind turbines, solar panels and related infrastructure does not increase much as electricity generation from these technologies increases. The same cannot be said for fossil fuel and nuclear electricity generation.[17]

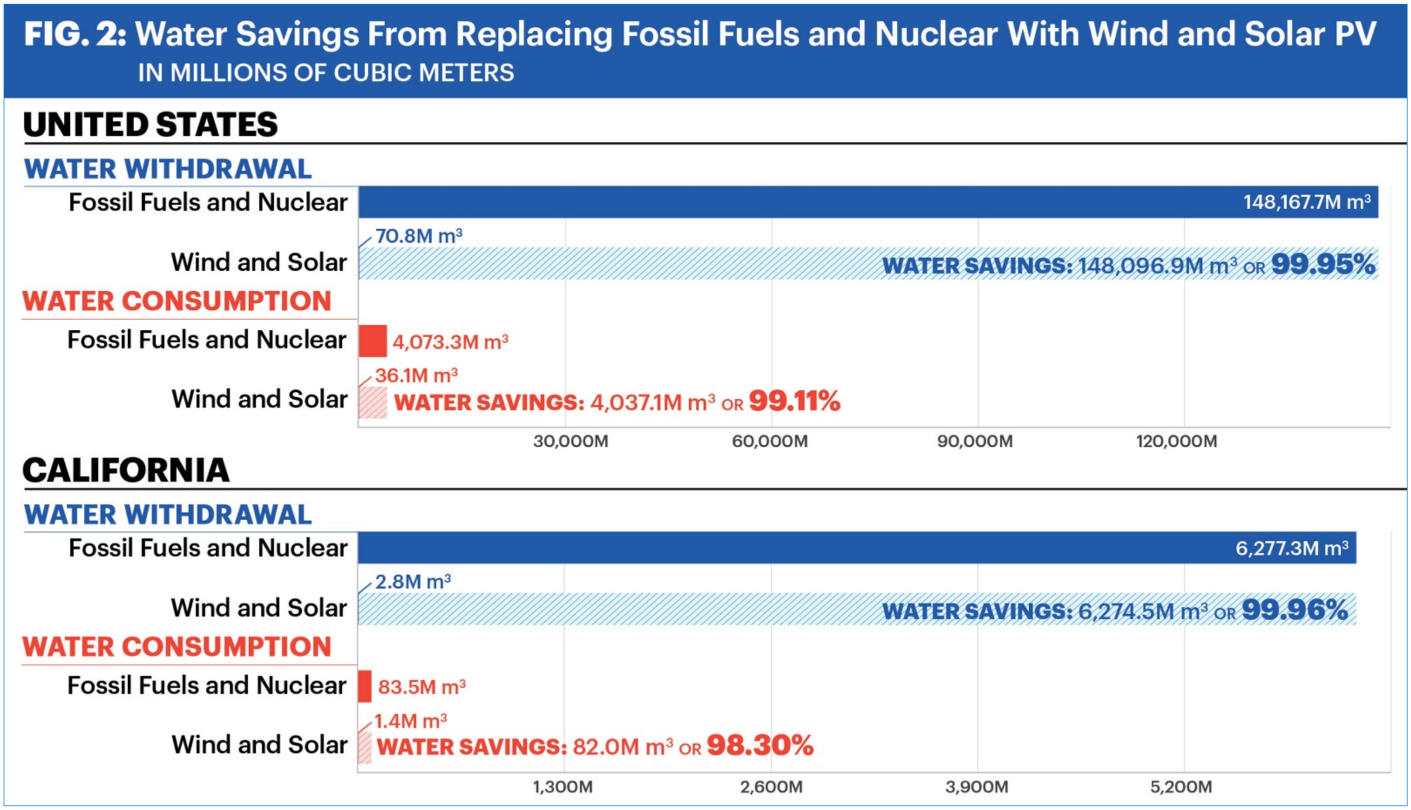
**FIG. 1: Lifecycle Water Consumption and Withdrawal Intensities by Energy Technology**




*Average of once-through and recirculation cooling systems*

DATA SOURCE: Food & Water Watch (FWW) analysis of Kondash et al. (2019)

As shown in Figure 2 on page 4, there is massive potential water savings in the United States by replacing fossil fuel and nuclear electricity generation with wind and solar PV. At a national scale, this transition could decrease water consumption by over 99 percent (4 billion cubic meters per year). It would also virtually eliminate water withdrawals for electricity generation. In California, the switch from fossil fuels and nuclear to wind and solar PV could decrease water consumption by 98 percent (82 million cubic meters per year) and also virtually eliminate water withdrawals (see Methodology on page 5).




DATA SOURCE: Food & Water Watch analysis; see Methodology for more information

At a national scale, for once-through cooling systems, freshwater makes up over 70 percent of the total withdrawals and virtually all of the consumption (99.6 percent); for recirculating cooling systems, freshwater accounts for 89 percent of both consumption and withdrawals (see Methodology). Switching to renewables would preserve freshwater for truly beneficial uses such as residential consumption and small- and medium-scale agriculture, a vital lifeline for areas currently facing water shortages such as the western United States.

## Conclusion and Recommendations

The fossil fuel industry pushes a number of false solutions to greenwash its dirty systems, including dry cooling power plants and carbon capture and storage (CCS).[18] Switching to dry cooling systems at power plants would decrease water dependency but sacrifice efficiency, in turn increasing the emissions from burning coal and natural gas.[19] Carbon capture also fails this trade-off, by not only failing to decrease carbon emissions but also significantly increasing lifecycle water usage.[20] Both systems simply lock in fossil fuel production for decades to come. Further, as natural gas production from shale resources is proposed to increase over the next few decades, water needed upstream for this electricity generation will also increase.[21]

We must transition from fossil fuels immediately not only to cut carbon emissions but also to safeguard our water resources, which are becoming scarcer and more volatile as climate change progresses and megadroughts persist.[22] In the United States, in the months of February and

August 2015, 27 percent and 46 percent of power plants were unable to secure freshwater for cooling, respectively.[23]

In addition, transitioning to renewable energy generation has positive impacts on nearby water ecosystems. In California, the adoption of solar and wind energy improves resilience to droughts and groundwater sustainability, which in turn maintains sustainable levels of groundwater.[24] In Canada, a study found that renewable energy expansion would decrease both surface and ground water demand and free these water resources up for other uses.[25] These additional benefits hammer home the need to immediately transition away from fossil fuel-based electricity generation to renewable energy for the health and safety of people and water resources everywhere.

## Methodology

The potential water savings scenarios are calculated using: 1) the real 2020 fossil fuel and nuclear energy mix[26] and 2) a counterfactual wind and solar PV energy ratio derived from Mark Jacobson's roadmap for fully renewable energy generation by 2050 for the United States and California.[27] Both scenarios use the 2020 fossil fuel and nuclear generation value as the full energy generation for the current and hypothetical renewable generation mixes. Therefore, the counterfactual examples used to calculate potential water savings with a fully renewable grid are not meant to make claims about generation capacity, as total energy generation is held constant throughout.

These calculations use only the energy generation sources reported in Kondash et al. (2019), in order to allow for lifecycle water intensity values for all energy sources in the calculations.[28] These sources are coal, natural gas, nuclear, wind, and solar PV. This means that the water savings percentages in this report only take into account energy generated from these sources. So, a 99 percent decrease in water withdrawal does not take into account non-fossil fuel and nuclear water usage.

As Kondash et al. report water intensity levels for coal and natural gas by cooling system, we calculated the amount of energy produced utilizing different cooling systems using data for the United States from the U.S. Energy Information Administration (EIA) and for California from the California Energy Commission.[29] The data for water quality in thermoelectric power plant cooling come from U.S. Geological Survey data from 2015.[30] Exact calculations for water quality usage in the current 2020 scenario were not produced; rather, the water quality calculations were meant to provide context for understanding where these calculated water savings may come from given past water quality usage in thermoelectric power plant cooling.

# Endnotes


1 Meldrum, James et al. "Life cycle water use for electricity generation: A review and harmonization of literature estimates." *Environmental Research Letters.* Vol. 8. March 12, 2013 at 1 and 14.

2 Kondash, Andrew J. et al. "Quantification of the water-use reduction associated with the transition from coal to natural gas in the US electricity sector." *Environmental Research Letters.* Vol. 14. December 4, 2019 at 1.

3 *Ibid*.

4 Fédération Internationale de Natation (FINA). "FINA Facilities Rules 2017-2021." September 22, 2017 at 7 and 8.

5 U.S. Department of Energy (DOE). "The Water-Energy Nexus: Challenges and Opportunities." June 2014 at vii. Available at https://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf; Hoff, Sara. U.S. DOE. Energy Information Administration (EIA). "EIA tool compares individual power plants' generation, cooling water use, and emissions." Today in Energy. June 5, 2019. Available at https://www.eia.gov/todayinenergy/detail.php?id=39732.

6 Kondash et al. (2019) at 1.

7 U.S. DOE (2014).

8 Kenny, Joan F. et al. U.S. Department of the Interior. U.S. Geological Survey. "Estimated use of water in the United States in 2005." Circular 1344. 2009 at 48. Available at https://pubs.usgs.gov/circ/1344/pdf/c1344.pdf.

9 Raptis, Catherine E. et al. "Global thermal pollution of rivers from thermoelectric power plants." *Environmental Research Letters.* October 12, 2016 at 1 to 2; Fleischli, Steve and Becky Hayat. Natural Resources Defense Council. "Power Plant Cooling and Associated Impacts: The Need to Modernize U.S. Power Plants and Protect Our Water Resources and Aquatic Ecosystems." IC:14-04-C. April 2014 at 7. Available at https://www.nrdc.org/sites/default/files/power-plant-cooling-IB.pdf.

10 Dorjets, Vlad. U.S. DOE. EIA. "Many newer power plants have cooling systems that reuse water." Today in Energy. February 11, 2014. Available at https://www.eia.gov/todayinenergy/detail.php?id=14971.

11 Kondash et al. (2019) at 7.

12 Suparna, Ray. U.S. DOE. EIA. "Some U.S. electricity generating plants use dry cooling." Today in Energy. August 29, 2018. Available at https://www.eia.gov/todayinenergy/detail.php?id=36773.

13 Kondash et al. (2019) at 5.

14 *Ibid.* at Abstract.

15 Meldrum et al. (2013); Kondash et al. (2019); Grubert, Emily and Kelly T. Sanders. "Water Use in the United States Energy System: A National Assessment and Unit Process Inventory of Water Consumption and Withdrawals." *Environmental Science and Technology.* Vol. 52, Iss. 11. May 8, 2018.

16 Meldrum et al. (2013) at 14.

17 *Ibid*.

18 Food & Water Watch (FWW). "The Case Against Carbon Capture: False Claims and New Pollution." March 2020.

19 Kondash et al. (2019) at 7.

20 Ou, Yang et al. "Life cycle water use of coal- and natural-gas-fired power plants with and without carbon capture and storage." *International Journal of Greenhouse Gas Control*. Vol. 44. January 2014 at Abstract; FWW (2020).

21 Kondash et al. (2019) at 6; U.S. DOE. EIA. Office of Energy Analysis. "Annual Energy Outlook 2022 (AEO2022)." March 2022 at 39. Available at https://www.eia.gov/outlooks/aeo/pdf/AEO2022_ChartLibrary_full.pdf.

22 Stevenson, Samantha et al. "Twenty-first century hydroclimate: A continually changing baseline, with more frequent extremes." PNAS. Vol. 119, No. 12. January 2022 at 1.

23 Lee, Uisung et al. "Regional and seasonal water stress analysis of United States thermoelectricity." *Journal of Cleaner Production.* Vol. 270. June 1, 2020 at Abstract.

24 He, Xiaogang et al. "Solar and wind energy enhances drought resilience and groundwater sustainability." *Nature Communications.* November 6, 2019 at Abstract.

25 Wu, Lina et al. "Dynamics of water-energy-food nexus interactions with climate change and policy options." *Environmental Research Communications.* Vol. 4. January 27, 2022 at Abstract.

26 U.S. DOE. EIA. "Table 1.1. Total Electric Power Industry Summary Statistics, 2020 and 2019." Electric Power Annual. October 29, 2021. Available at https://www.eia.gov/electricity/annual/html/epa_01_01.html; California Energy Commission. "2020 Total System Electric Generation." Available at https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2020-total-system-electric-generation. Accessed May 2022.

27 Jacobson, Mark Z. et al. "100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World." *Joule.* September 6, 2017 at 24. Available at https://web.stanford.edu/group/efmh/jacobson/Articles/I/CountriesWWS.pdf; Jacobson, Mark Z. "Zero Air Pollution and Zero Carbon From All Energy Without Blackouts at Low Cost in California." Stanford University. December 7, 2021 at 4. Available at http://web.stanford.edu/group/efmh/jacobson/Articles/I/21-USStates-PDFs/21-WWS-California.pdf.

28 Kondash et al. (2019) at 8.

29 U.S. DOE. EIA. "Table 9.3. Quantity and Net Summer Capacity of Operable Cooling Systems, by Energy Source and Cooling System Type, 2010-2022." Electric Power Annual. October 29, 2021. Available at https://www.eia.gov/electricity/annual/html/epa_09_03.html; Electric Power Research Institute. Prepared for California Energy Commission. "Comparison of Alternate Cooling Technologies for California Power Plants Economic, Environmental and Other Tradeoffs." 500-02-079F. February 2002. Available at https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-1167.pdf.

30 Harris, Melissa A. and Timothy H. Diehl. U.S. Department of the Interior. U.S. Geological Survey. "Water withdrawal and consumption estimates for thermoelectric power plants in the United States, 2015 (ver. 1.1, February 2021)." Revised February 4, 2021. Available at https://doi.org/10.5066/P9V0T04B.


info@fwwatch.org
202.683.2500 (DC)
510.922.0720 (CA)
foodandwaterwatch.org



FOOD& WATER WATCH