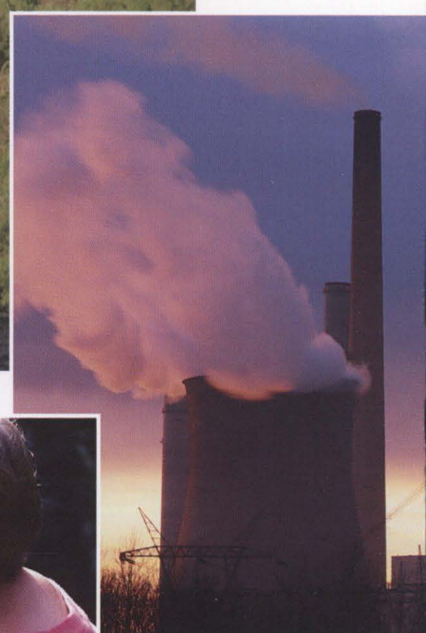
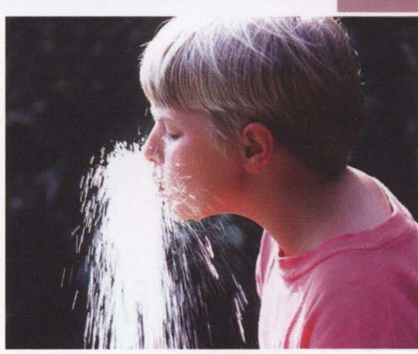
The Last Straw
Water Use by Power Plants in the Arid West

Hewlett Foundation
Energy Series





Clean Air Task Force

The Land and Water Fund of the Rockies

The Energy Foundation
The Hewlett Foundation

April 2003

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The Land and Water Fund of the Rockies *uses law, economics, and policy analysis to protect land and water resources, protect essential habitats for plants and animals and ensure that energy demands are met in environmentally sound and sustainable ways.*

CLEAN AIR TASK FORCE

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This report was prepared as part of the Hewlett Foundation Energy Series, a joint project of the Hewlett Foundation and the Energy Foundation.

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The Last Straw: Water Use by Power Plants in the Arid West

Introduction and Summary

JENNY HAGER, DENVER, CO

Power plants are widely recognized as major sources of air pollutants that damage human health and the environment. Less well recognized is their impact on water, both as large users and polluters. Coal and gas steam-generating electric plants in the eight-state Interior West currently withdraw over 650 million gallons every day.[1] This is a lot of water. Over the course of a year, this same volume meets the municipal demands of almost four million people, the equivalent of six or seven cities the size of Albuquerque, Denver or Tucson.

Water in the West is becoming increasingly valuable for a multitude of uses, especially in light of widespread drought conditions. As a result, western communities are reassessing how to best use this vital resource. Fortunately, there are many practical opportunities to significantly reduce both water use and water quality impacts from power generation.

Although agriculture is the largest water user in the West, power production can have a large impact on water supply and water quality in specific locations, especially in river basins that are already over-extended with other water uses. Also recent drought conditions give rise to power reliability concerns. In areas that rely on hydropower – the case in much of the West – drought serves a double whammy. With less water, less hydro power is available, placing larger demand on steam generation plants, which also must contend with a more limited water supply.

This report examines the close relationship between power generation and water, including water use effects on competing uses, water quality and power system reliability. The report sets out an action agenda that, if implemented, can minimize the impacts from water used for power generation and help to ensure power system reliability, conserve scarce water resources, and protect rivers, streams and groundwater from unnecessary discharges.

Although many water use issues described herein apply to power plants across the US, the focus of this report is on eight Interior Western states – Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

This report is timely for several reasons:

- Many proposed new power plants could adversely impact the quality and quantity of Western waters.
- The region is in the midst of a serious drought that has heightened public concern about how limited water resources should best be allocated.
- The Environmental Protection Agency is reviewing regulations on cooling water intake structures at power plants. If EPA adopts strong regulations, there could be a significant impact in power plant water use.

In sum, the time is ripe for a more comprehensive understanding of the full relationship between power generation and water use.

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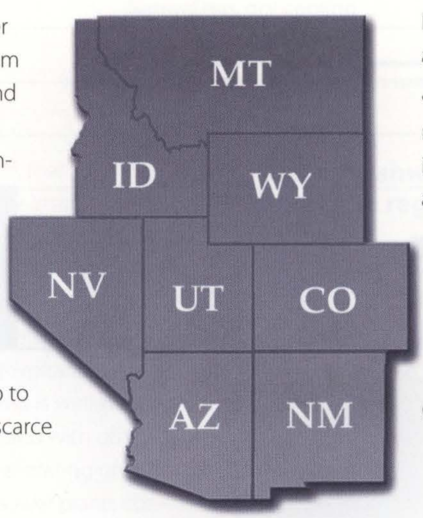

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Water use, a growing issue

In 2000, coal and gas steam-generating electric plants in this eight-state region withdrew over 650 million gallons of water per day,[2] totaling over 728,000 acre-feet each year. That is enough water for the annual needs of at least 3.64 million people; enough water to cover a football field with a column of water 138 miles high!

In response to the California energy shortage in 2000 and growing electricity demands, there is pressure to build many new power plants throughout the region. Almost 39,000 MW of new generation capacity have been proposed for the Interior West. If all of that capacity were to be developed, additional water demand could be as much as 270 million gallons per day – an increase of over 40 percent from existing levels.[3] This is water that would otherwise be available to meet the needs of over 1.4 million new people, or three times the population of present-day Albuquerque. Under a more likely scenario, perhaps only 16,800 MW would be built. If the majority of these new plants consume fossil fuels and use conventional cooling technologies, this would still require the withdrawal of an additional 116 million gallons of water per day (18 percent increase) from water sources, many of which are already overstressed.[4]

Water "diverted" or "withdrawn" refers to water removed from streams, groundwater or other sources. Much of this water is "consumed" through use. The remainder returns to the local surface or groundwater system and is available for subsequent use downstream of its discharge.

Figure 1 gives a state-by-state breakdown of water withdrawals in the region.[5] Seventy-five percent of water for power plants comes from surface waters (mostly rivers), and 20 percent comes from groundwater.[6] Groundwater is the dominant water source in Arizona, meets about half of the water needs for electricity production in Nevada, 17 percent in New Mexico, and just over 10 percent in Colorado.[7]

Figure 1 –
Annual water withdrawal at fossil fuel plants in 2000

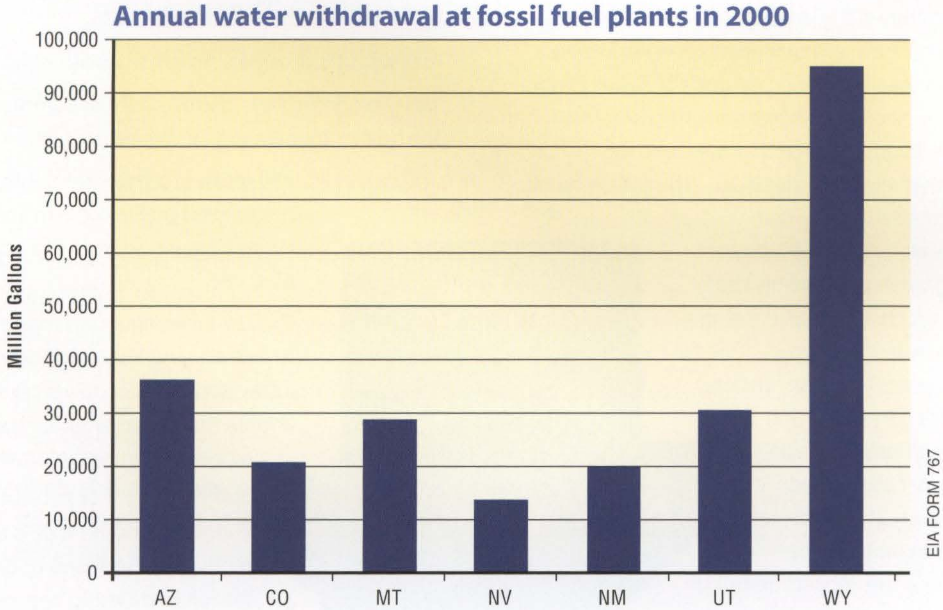
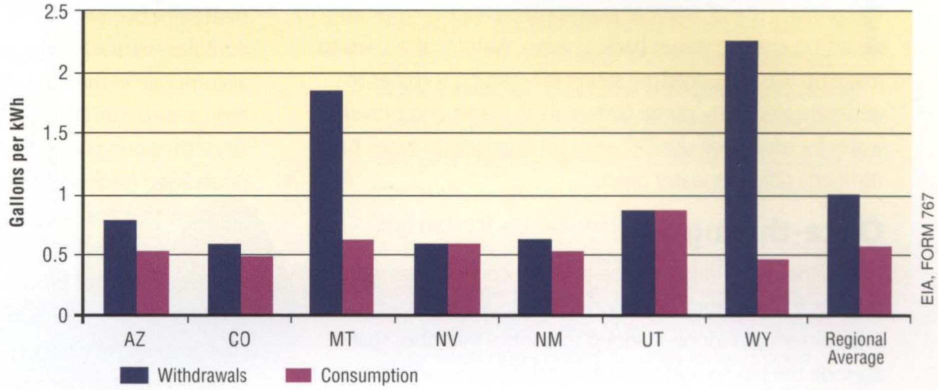


Figure 2 reveals the water consumption and withdrawals per kWh by state and, in effect, shows the water demands of different cooling systems. In states where withdrawal is much larger than consumption, once-through systems are more common. Where withdrawals and consumption are nearly the same, recirculating systems are used more frequently.[8]

Figure 2 –

Regional water withdrawals and consumption at fossil plants in 2000



Coal plants use greatest amount of water in region

Water demand varies by fuel type and technology. As seen in Figure 3, steam plants have the highest demand. Combined cycled gas plants produce more energy per unit of fuel. This increased efficiency means reduced cooling requirements and therefore a lower demand for water. Additionally, combined cycle plants get about two-thirds of their power from the gas turbine, which generates energy without using steam, and as a result does not have the same requirement for cooling water.

Figure 3 –

Cooling water withdrawal and consumption in gal/kWh at fossil plants [9,10,11]

Plant & Cooling System	Withdrawal (cooling & process)	Consumption (cooling)
Steam		
Once-through	20 - 50	~.3
Re-circulating	.3 - .8	.24 - .64
Dry cooling	~.04	0
Combined Cycle		
Natural gas, once through	7.5 - 20	~.1
Natural gas, re-circulating	~.23	~.18
Natural gas, dry cooling	~.04	0
Coal, re-circulating	~.38*	~.2

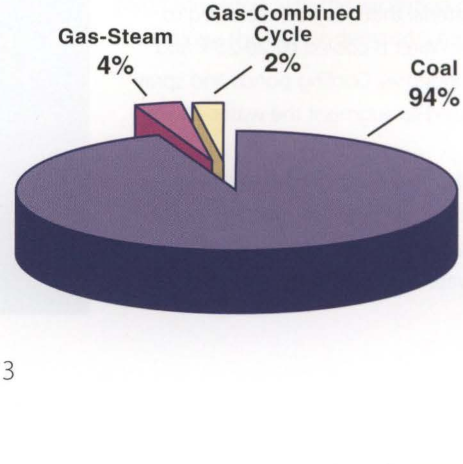
* includes gasification process water

Figure 4 shows coal plants as the dominant fossil-fuel consumer in the region – using 335 of the 355 million gallons of water consumed each day.

The good news is that since the 1970s there has been a trend toward power plants that are more efficient and cleaner consumers of water. For instance, new natural gas power plants use between 40-60 percent less water per megawatt of power generated than do existing coal-fired plants,[17] and condensers rely on non-copper metals that cause less environmental damage.[18] Energy efficiency and some renewables, like wind and solar photovoltaics, require only tiny amounts of water. But the bad news is well known. Despite the potential water savings associated with other means of power generation, many older generating units are still in operation today, and coal-fired power plants continue to be the dominant power source in the Interior West.

Figure 4 –

Daily freshwater consumption by fossil plants in region in 2000



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Water use by cooling systems

The primary use of water at power plants is for condensing steam, i.e., cooling steam back to water. Water is also used to make up the high-pressure steam for rotating turbines to generate electricity, purge boilers, wash stacks and provide water for employee use. Different cooling system types have distinctly different water needs.

Once-through

As the name implies, once-through cooling uses water only once as it passes through a condenser to absorb heat. Intermittently, chlorine is added to control microbes that corrode the piping and thus can diminish the cooling capacity. This heated, treated water is then discharged downstream from the intake into a receiving water body (usually, but not always, the original water source), with the volume of intake and discharge water being roughly the same. While this is the most common cooling technology currently in use nationwide,[12] it is used for only about 15 percent of generation in the region,[13] and it is rarely used at new facilities. *(See Figure 5)*

Re-circulating (closed-cycle) systems

Closed-cycle, re-circulating systems are the most common cooling system in western states – meeting the cooling needs of nearly 85 percent of the region's generation.[14] Furthermore, EPA has recently promulgated rules requiring new power plants in most cases to use closed-cycle cooling systems and estimates that over the next several decades at least 90 percent of new power plant cooling systems will use closed-cycle technology, even in the absence of new rules.[15] Re-circulating systems, by recycling water, can reduce water withdrawals by at least 95 percent compared to once-through cooling.

Typically, steam comes out of the turbine into a shell and tube condenser. Cold water is run through the tubes of the condenser; the cooling water heats up as the steam condenses back to water. The cooling water reaches the top of a cooling tower where some of it evaporates, forming a plume above the towers. Most dribbles back down through a filler material that has been selected to allow heat transfer. Water is cooled by 20-25°F and returned to the condenser. Cooling ponds and spray facilities are also used to augment the water-cooling and reuse.

While re-circulating systems withdraw much less water than once-through systems, in general they consume more water per kWh of electricity produced.[16] The water also requires more chemical treatment because the fresh water used by the cooling systems contains natural background salts and solids, which can accumulate in the cooling equipment as water evaporates. To reduce deposits and prevent corrosion in order to support a smooth cooling operation, at regular intervals some water is discharged (termed cooling tower blowdown), and fresh water is added that has been treated with chlorine and other chemicals (biocides) to control corrosion, scaling and microbes. The cooling tower blowdown water, which contains the residues of the chemicals used for water treatment, is discharged into receiving waters or designated wastewater collection ponds. *(See Figure 6)*

Some generating units use a combination of once-through and re-circulating systems.

Dry cooling

A very small percentage of plants in the region use dry cooling, where air, not water, cools the steam. The most common type of dry cooling systems in the US – direct-acting – works much like an automobile radiator, with the steam in the tube cooled by air blown over the outside. The water demands from dry cooling are extremely low. There are no evaporative losses, and water consumption is limited to boiler requirements, including routine cleaning and maintenance. *(See Figure 7)*

There are two facilities in the Interior West that rely on dry cooling: El Dorado in Boulder, Nevada, and the 330 MW, coal-fired Wyodak Generating Station in Gillette, Wyoming pictured here. The Wyodak Station, the first large power plant in the US to use dry cooling technology, was built by the Black Hills Power and Light Company in 1977 in northeastern Wyoming. A dry cooling system was installed because local rivers and groundwater could not otherwise support the cooling demands of the plant.

BLACK HILLS CORPORATION, GILLETTE, WYOMING

Figure 5 –
Once-Through Cooling

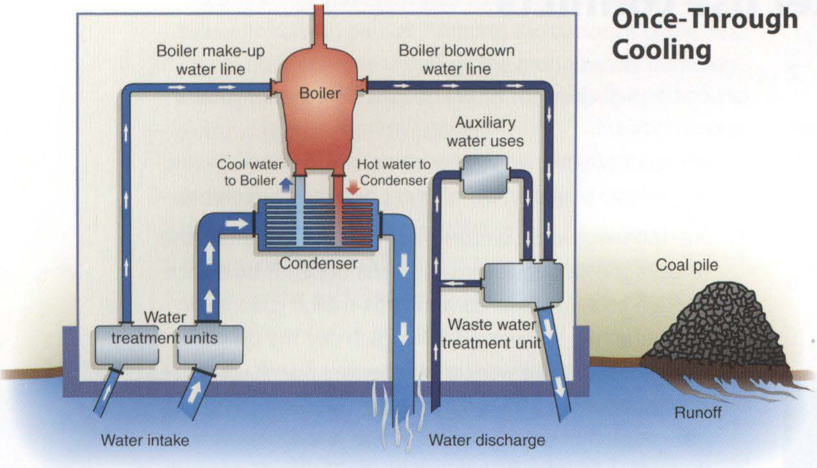


Figure 6 –
Re-circulating Cooling

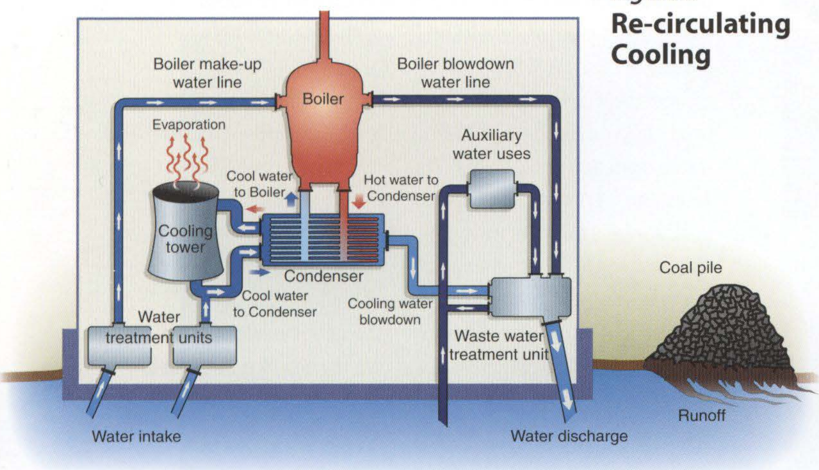
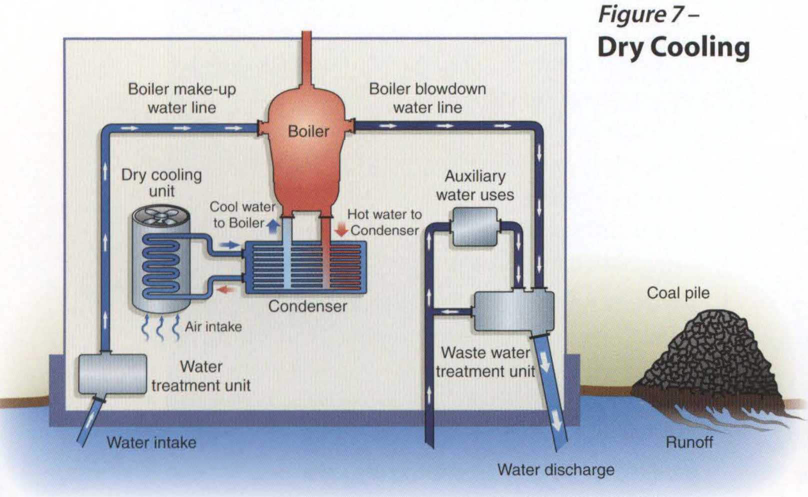


Figure 7 –
Dry Cooling



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Non-cooling uses of water

During the process of electricity generation, impurities build up in the boiler. To maintain quality, the water is periodically purged from the boiler and replaced with clean water. Purged water, termed boiler blowdown (not to be confused with cooling water blowdown), is usually alkaline and contains both the chemical additives used to control scale and corrosion, as well as trace amounts of copper, iron and nickel that leach from boiler parts.

Other sources of water discharged from the plant include metal and boiler cleaning wastes (such as iron, copper, nickel, zinc, chromium and magnesium). Water from non-cooling sources is discharged through either a public wastewater treatment facility or the plant's onsite wastewater treatment facility.

At the plant site as a whole, there are even more sources of water discharge including: coal pile runoff that forms when water comes into contact with coal storage piles (usually acidic and can contain high concentrations of copper, zinc, magnesium, aluminum, chloride, iron, sodium and sulfate); area storm sewers and leachate collection systems; and pyrite transport water generated from coal cleaning (containing suspended solids, sulfate, and metals found in coal).

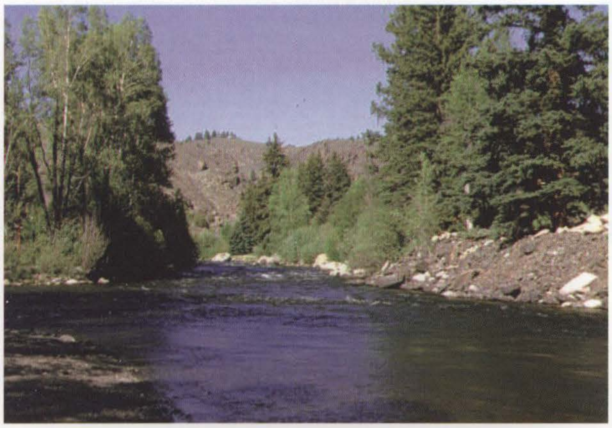
A small amount of water is often also withdrawn and discharged to support operation of air emissions controls.[19] The combustion waste stream, a mixture of fly ash, bottom ash, boiler slag and sludge from emissions control devices, typically is drenched with water and placed in ponds where the solids settle out, and water is discharged into receiving waters. These wastes can contain high concentrations of arsenic, cadmium, chromium, lead, selenium, sulfates and boron.

Figures 5,6 and 7 illustrate how a "typical" fossil steam plant uses water under the three cooling regimes. While there are a number of points throughout the generating and waste handling process where water is needed, with the exception of dry cooling technology, the largest demand is for cooling.

Water competition and water use conflicts

Water diversion and consumption by fossil fuel plants in the West, while small relative to agriculture, can still have significant impacts on streams and groundwater resources on a site-specific basis, especially in basins where water is already stretched to the limit.

Until recently, water use and consumption have not been significant factors in decisions related to the permitting and siting of power plants. There are a few reasons for this. First,



JEFF WIDEN, GUNNISON RIVER, CO

unlike riparian water law in the eastern US, where water in streams and lakes is shared equally among landowners adjacent to the water, western water law dictates that water is a commodity, separate and apart from land ownership. Water rights are tied to specific dates of use that allow older water rights to trump more junior ones during times of shortage. These factors combine to make water rights reliable; if the power plant's water rights are old enough, it is unlikely they will be cut off, even in a prolonged drought. Second, because water plays a relatively minor role in the total cost of power production, power producers are much less sensitive to the price of water than are irrigators and other users.[20]

In recent years, however, water availability has played an increasingly important role in permitting decisions. As water resources become more valuable, and as water has become better understood as the critical component of sustaining multiple habitats, permitting authorities have begun to deny permits or condition them based on potential impacts to water resources.

There is a growing concern over less obvious impacts, too. Scientists have begun to better understand how the withdrawal of water from underground aquifers can lower water tables enough to cause the overlying land to sink.[21] And some fear that an over-commitment of water resources for power generation will close out future options for other economic opportunities.[22]

The examples below give some indication of how water use issues have played a role in recent permitting decisions.

1. The 160-megawatt Corette Power Plant, located along the Yellowstone River in Billings, Montana, depends on a once-through cooling system, diverting 54-million gallons of water from the Yellowstone River each day. The plant's water intake pumps work only if the river flow stays above 1,500 cubic feet per second. In recent years, this threshold was not met for several days at a time, forcing the plant to shut down. To remedy this, in 2001, the Plant's owner and operator, Montana Public Power & Light (PPL), proposed the construction of a temporary 272-foot-long concrete diversion dam across the River's main channel to pool water for its pumps, providing PPL with a dependable supply of cooling water during extremely low flows.[23]

   Concern about this proposed dam's environmental impacts prompted strong and unified opposition. Among those opposed were the US Fish & Wildlife Service, the Montana Department of Fish, Wildlife and Parks, and a coalition of 19 conservation groups that united as the Yellowstone River Conservation Forum. The opposition feared adverse effects on fish migration and dam safety problems.[24] Citing the dam's potential adverse impacts on fisheries, recreationists' safety and the flows of the river itself, the Yellowstone Conservation District Board denied the dam a permit, requiring the plant operators to come up with a different, long-term solution.

2. In August 2002, two proposed plants in Idaho – Cogentrix Energy Inc.'s 800-megawatt natural-gas-fired plant and Newport Northwest's 1,300-megawatt natural gas plant – were denied permits because of the impact on the Spokane-Rathdrum Prairie aquifer.[25] At issue were the extent by which withdrawals from aquifers would affect stream flows and the need to understand the relationship between where water is withdrawn and where the river flow impact occurs. As a result of the denials, Idaho expects to embark on a comprehensive watershed assessment.

3. Water considerations played an important role in the Arizona Corporation Commission's (ACC) decision to halt two out of three proposed gas-fired power plants that came up for review within a three-month period in 2001.[26] One of these, the Big Sandy Power Plant, a 720-megawatt, gas-fired facility proposed for construction near Wikieup,

Arizona would have pumped 5,267 acre-feet of water annually from an aquifer.[27] Among the concerns of the ACC commissioners were the effect the groundwater pumping would have on the aquifer and on the endangered Southwestern willow flycatcher.[28]

Similarly, the Toltec Power Plant, a 1,800-MW gas-fired facility proposed for construction near Eloy, Arizona, was denied a permit in January 2002, in part because the ACC determined that the plan to pump 10,000 acre-feet of groundwater each year would exacerbate already-existing ground subsidence problems.[29]

4. A 600-MW extension of Duke Energy's Arlington Valley power plant in Arizona was recently approved under the stipulation that it participate in Arizona's groundwater recharge program.[30,31] To receive a certificate of environmental compatibility, Duke Energy agreed to recharge 1,000 acre-feet each year during the useful life of the plant.[32]
5. In response to recent increases in proposals for power plant construction, in the first few months of 2003 the New Mexico Legislature considered enacting new regulations to review water efficiency in plants exceeding 50 MW.[33] The bill would require an analysis of water use by all new power plants and consideration of dry cooling.[34]
6. The Washington State Energy Facility Evaluation Council recommended support for the Sumas 2 plant in northwestern Washington, one mile from the border with British Columbia. Following the December 2002 decision, Canada's National Energy Board decided to conduct an environmental assessment, including a look at the possible impact of the plant on the aquifer that moves from Canada to the United States.[35]

The Arkansas River: Stretched beyond its limit

Proposed new fossil plants are especially problematic where water is already stretched beyond its limit. The Arkansas River in southeastern Colorado is one such example, where water has been "over-appropriated." Under an agreement, Colorado and Kansas must share water from the Arkansas. For over 50 years, however, Colorado has been taking more than its share. A recent court decision found that since 1950, water users in Colorado took 428,000 acre-feet in excess of the state's entitlement.[36] Colorado will likely have to pay Kansas $29 million in damages and interest and already has spent $12-15 million to defend the lawsuit.


DAVE VANDER VELDE

The City of Aurora, a suburb of Denver, adds even more tension. Though located in the South Platte basin, Aurora has in recent years acquired rights from farmers along the Arkansas. Through complicated arrangements, Aurora now diverts from the headwaters of the river, leaving several thousand acres of farmland in the lower basin to lie fallow. Water planners at the Colorado Water Conservation Board already anticipate a shortfall of 22,000 acre-feet per year by 2030, just for in-basin uses.[37]

The proposed coal plant by the Tri-State Generation and Transmission Association could complicate the situation further. The 1200 MW facility likely would use over 7 million gallons/day, or 8,300 acre feet/year.[38] That is enough water to meet the demands of over 40,000 residents (whether they reside along the Arkansas or in Aurora) or the consumptive use of 2,500-4,000 acres of crops.

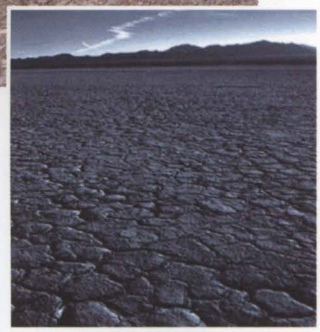
Drought and power production

Drought conditions result in water scarcity and intensified competition for finite water supplies. Drought can significantly reduce electric power generation based on site-specific engineering and hydrologic conditions, can constrain or curtail power production at fossil power plants for reasons related to cooling system design and operation, can cause cooling water source levels to fall below intake structures and can result in water temperatures that prevent acceptable levels in cooling system discharge waters. In areas that rely on hydropower – the case in much of the West – drought conditions can serve up a double whammy. With less water, less hydro is available, placing a larger demand on steam plants, which also must contend with a more limited water supply.[39]

Cooling systems that use lake water are designed assuming that the lake surface will be within a narrow range of normal elevation. However, under drought conditions, lake levels can (and do) fall below this range and cause plant shutdowns. Similarly, drought-induced reductions in river flows can also impact water intake and/or reduce the ability of streams to assimilate heat loading from cooling system discharges. Assessments of several Texas power plants by University of Texas researchers have confirmed that the drought conditions that have occurred in Texas since 1900 would reduce or curtail power generation at certain plants.[40]

Drought conditions also can intensify conflicts between all water users – power plants, domestic well owners, municipal water suppliers, farmers, wildlife and recreational interests. Such conflicts may also result in curtailed power generation – even when the plants hold legal claim to sufficient water to operate without constraint. Competing interests come to the fore during the summer season, as was seen along the Yellowstone River in 2001 when the river was running at 47 percent of normal.[41]


DENVER WATER DEPARTMENT, LAKE DILLON


NOAA

Despite these pressures, drought impacts on unit operation are not typically assessed in the permitting process, and no systematic evaluation is known to have been conducted on drought susceptibility of fossil generation units in the West. Assessing impacts of drought or low-water flow conditions would be similar to flood planning, a common requirement in environmental protection and siting laws.

While drought could clearly threaten Western power system reliability, opportunities exist to modify existing fossil plants or design new fossil plants to avoid or minimize drought-related reliability concerns. In most cases where drought could reduce fossil unit power generation, dry cooling systems could be installed to allow unconstrained generation. While such plant modifications would alleviate drought susceptibility, they do require substantial time and investment.[42]

Common environmental impacts from water withdrawals and discharges

At the intake

Water is brought into the plant through cooling water intake structures. To prevent entry of debris, the water is drawn through screens. Fish, larvae and other organisms are often killed as they are trapped against screens (impingement). Organisms small enough to pass through the screens can be swept up in the water flow where they are subject to mechanical, thermal and/or toxic stress (entrainment). Impingement and entrainment account for substantial losses of fish and can seriously reduce opportunities for both recreational and commercial anglers.[43]

At the point of discharge

Temperature

Discharged cooling water is almost always higher in temperature than intake waters. Large temperature differences between intake and discharge waters (temperature deltas) can contribute to destruction of vegetation, increased oxygen depletion and algae growth, and strain the temperature range tolerance of organisms.[44] Impacts can be multiple and widespread, affecting numerous species, at numerous life cycle stages. In some cases, plants and animals will simply not be able to survive in or adapt to the high temperatures. Warmer temperatures can send the wrong temperature signal to species, thus allowing life stages to get out of out of sync with normal cycles. In other cases, species that can handle (and thrive in) the warmer waters move into the warm-water plume and then become susceptible to the "cold shocks" that occur during periodic plant shutdowns.

Fish are not only affected by the spikes of high temperature. They also are impacted by the chronic and cumulative stress of fluctuations in temperature. Unfortunately, there is only a poor understanding of the cumulative nature and subsequent response of organisms to thermal stress.[45] Effects from thermal discharges are site-specific and dependent on characteristics of the receiving water body, volume and temperature of the discharge water, plant operation schedule and type of cooling system in use.

Temperature deltas between intake and discharge waters commonly exceed 25°F.[46] The largest winter differential – 68 degrees – has been recorded in waters associated with the JE Corette Plant outside of Billings, Montana.[47] High temperatures and low water flows stopped plant production for a few days in the summer of 2001 because water discharged into the Yellowstone River was too hot.[48]

Once-through systems with large, reported temperature deltas include —

- JE Corette *(Montana; Yellowstone River)*
  68 °F (winter)
- JE Corette *(Montana; Yellowstone River)*
  39 °F (summer)
- Dave Johnston *(Wyoming; North Platte River)*
  28 °F (winter)
- Zuni *(Colorado; South Platte River)*
  25 °F (winter)

Water temperature issues are becoming increasingly important in Idaho, western Montana, eastern Oregon and eastern Washington due to the cold water demands of species – including salmon and steelhead – listed as endangered or threatened by the US Fish & Wildlife Service under the Endangered Species Act. In October 2001, EPA Region 10 proposed new Draft Temperature Water Quality Standards to protect these species.[49]

What is a biologically acceptable temperature range?

Operating licenses typically include provisions to protect aquatic resources from thermal impacts. While some licenses list a specific temperature delta that cannot be exceeded, the Federal Clean Water Act includes a provision that allows for waiving of all thermal standards as long as a balanced population of fish, shellfish and wildlife can be demonstrated in the water body where the discharge occurs.[50]

Thus in many states, power plants receive a variance to temperature discharge requirements. The concept of "demonstrated" balance has been widely interpreted. There are concerns about the criteria (or lack thereof) used to determine biological acceptability and the ease with which some states automatically renew the variance without re-evaluation. Unfortunately, acceptability is commonly defined to mean that aquatic organisms are not absent for the entire year. So even if discharges have dramatically altered populations and their life cycles, as long as there is evidence that some fish are present, some of the time, discharges can be deemed acceptable.

Chlorine, anti-fouling, anti-microbial and water conditioning agents

Cooling water is treated with chlorine to limit the growth of mineral and microbial deposits that reduce the heat transfer efficiency, and re-circulating cooling water is treated with chlorine and biocides to improve heat transfer. But the same mechanisms that make chlorine and biocides effective in killing nuisance organisms make them effective in killing non-target organisms as well. This means that both will have an impact on a range of both desirable and undesirable species. Chlorine and its by-products are present in the discharge water plume and can be toxic to aquatic life, even at low concentrations. High water temperatures can magnify the damaging impacts of chlorine.[51]

Chlorine and biocide discharges are subject to federal and state water quality standards. Pursuant to EPA regulation, plants must use best practicable control technology and avoid discharge in toxic amounts.[52] EPA, however, lacks a list of EPA-approved biocides and delegates most regulation to states. At the state level, implementation of standards varies.[53]

There are alternatives to using biocides in cooling systems. Degradation of concrete in cooling towers may be reduced by the use of more durable materials.[54] And plants can use ozone instead of chlorine and traditional biocides to limit build-up of organic and mineral solids.[55] Because ozone is very unstable, it dissipates quickly and reduces the chemical load found in discharged water. The use of ozone as an alternative to traditional biocides in cooling towers decreases cost and environmental impacts. Cost savings result from decreased chemical and water use requirements and from a decrease in wastewater volume.

Non-cooling water discharges

A common chemical from discharge waters is copper, which can leach from water condenser piping and end up in discharge waters, sometimes at toxic levels.[56] In addition, waters discharged from waste treatment have been shown to have high concentrations of arsenic, cadmium, chromium, lead, selenium, sulfates and boron.[57]

Problems with Clean Water Act compliance

Across the West, state and federal agencies responsible for water quality are understaffed and often have difficulty reaching decisions that adequately protect water systems. Clear guidance is needed through federal and state regulation to address power plant water use.

Decisions about water withdrawals and plant siting permits are handled differently by different states and fall within the jurisdiction of local, regional and state planning and regulatory agencies. Power plant water discharges are regulated largely at the state level, whereas rules for water allocation and use are grounded on state and local law.

Water discharges are regulated under the National Pollutant Discharge Elimination System (NPDES) program of the Clean Water Act (CWA). Most states have been delegated the authority to implement and enforce the CWA. In a few states, implementation authority lies with the US EPA. State and local water quality regulatory agencies determine allowable temperature discharges.[61]

The EPA has identified 53 chemicals as pollutants of concern in the wastewater discharged from steam electric plants.[62] A great deal of autonomy is granted to state regulators to choose additional biological and chemical parameters and/or to decide which portion of the waste stream must comply with discharge limits. For instance, NPDES permits rarely set requirements for metals found in combustion wastes water, despite commonly elevated discharges of arsenic, selenium, cadmium, chromium, lead, sulfates and boron.[63] Typically requirements for combustion waste waters only cover total suspended solids, oil and grease. Examples like this illustrate why the NPDES permitting process is not providing full protection from power plant discharges.

Tributylin (TBT), banned in ship-bottom paints but registered for use in cooling towers.

TBT is very toxic in aquatic environments. As a first order impact, its use diminishes invertebrate populations. This impact on invertebrates moves up the food chain in two ways: 1) less food for predator species, like salmon and 2) accumulation of TBT in fish where affected invertebrates are part of the food chain. There is evidence that fish show adverse effects at very low concentrations and effects include masculinization of feminine fish.[58] While TBT has a short lifetime in water, it persists and continues to have an impact for a much longer time in sediments.[59] The recognition of its harmful effects has prompted bans in ship paint for some vessels. While most of the attention is focused on banning its use in paints and fishing gear, TBTs continue to be registered for use in cooling towers.[60]

Serious concerns have been raised about problems that arise when so much authority lies in the hands of states without clear federal requirements.[64]

- **Lack of predictability.** This makes planning difficult for industry and leaves regulatory agencies uncertain as to what requirements are appropriate.
- **Lack of guidance.** Without clear national requirements, states often lack authority to pursue efforts to best protect ecological resources.

Other issues with state authority include:

- **Permit backlogs.** EPA has identified backlogs of NPDES permits as a nationwide problem and has set a goal to reduce backlogged permits to 10 percent, from a current national, industry-wide average of 17.3 percent.[65] As of July 2002, 19 percent of the major NPDES permits in the power sector of the Interior West states had expired.[66]
- **Compliance and enforcement problems.** In an analysis conducted on violations, compliance and enforcement of air, water and solid waste laws in the power plant sector, US EPA found that over 10 percent of the CWA violations were considered to be of "significant non-compliance."[67]

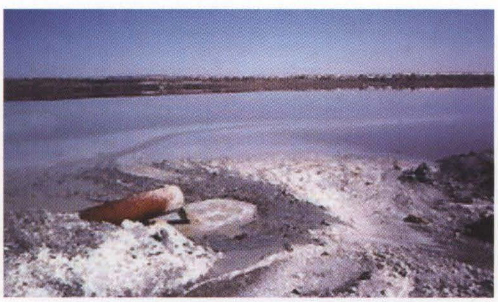
Notably, clearing the backlog of permits should not be an end in itself. Backlogs must be resolved inside a regulatory system that results in real, on-the-ground protection of the nation's waters.

Find out more about local permitting decisions by visiting **www.rivernetwork.org**

Find out more about proposed changes to the Clean Water Act at **www.cwn.org**

When "zero" doesn't always mean no discharge

Power plants that maintain and use water within their boundaries are often called "zero-discharge" facilities, based on the assumption that no post-generation water leaves the property. But "zero discharge" can be a misnomer. Public Service Company of New Mexico (PNM) claims the San Juan Generating Station in Fruitland is a "zero-discharge" facility.



USGS, EVAPORATION POND, JIM BRIDGER PLANT, WY

But that claim is being challenged by local residents who contend that waste from the mining operation and power plant have moved beyond the company's property lines and deposited large amounts of dissolved solids, including high concentrations of sulfates, into a nearby arroyo system, thereby contaminating local groundwater and sediments.[68,69] The contaminated water is blamed for livestock deaths. One area rancher claims to have lost more than 1,000 sheep following exposure to the contaminated water downstream of the plant.[70] A lawsuit currently seeks reparations based on these claims.

Evaporation and settling pond waters can leak

Similar dangers crop up in other states, too. According to the Arizona Department of Environmental Quality, the Cholla Steam Electric Power Generating Station, in east central Arizona, is contaminating ground and surface water with boron, sulfate, chloride and sediments as a result of disposal of fly and bottom ash in unlined ponds with no leachate collection system to capture contaminants.[71]

Ponds that do not leak can also cause serious damage to migrating birds as they stop over at these highly contaminated waters. While this has been best documented in California, problems have occurred throughout the West in places where evaporation ponds are used.[72] The effects on birds include destroyed insulation and buoyancy – which can lead to hypothermia and drowning – and mortality from sodium toxicity or avian botulism as a result of ingesting the water high in contaminants and salts.[73]

Elevated selenium in ponds, either from combustion wastes or concentrated from naturally-occurring high levels as is found in western states, has been shown to cause adverse effects on bird health and reproduction.[74]

Sodium concentrations in evaporation ponds at the Jim Bridger Plant in Wyoming exceeded the toxicity threshold for aquatic birds, according to a US Fish & Wildlife Service study.[75] To alleviate the conflict, the Bridger Plant installed a bird-deterrent – a non-lethal "bird-hazing" project[76] – designed to discourage any wildlife (mainly waterfowl) from entering the evaporation ponds.[77]

Even relatively clean water that is discharged from plants in dry western areas can pick up salts and sulfates found in dry streambeds, thus resulting in high levels of sulfates and sediments in rivers and streams.

Technologies exist to conserve water and reduce impacts

Dry cooling technologies currently available reduce water demand and, as a result, minimize many of the water-related impacts associated with power production. The low intake requirements of dry cooling systems allow for more flexibility in plant siting since the facilities can meet their relatively minor water requirements using a variety of sources, including treated sewage effluent discharges. This, in turn, frees facilities from having to locate next to ecologically-sensitive waters.

Worldwide, there are more than 600 power plants using a dry cooling technology, in hot and cold climates alike. One of the largest systems is located at a 1,200 MW gas-fired combined cycle plant in Saudi Arabia, where ambient air temperatures can reach 122°F. In the US, dry cooling systems are used in over 50 operating plants – about 6,000 MW of installed capacity – and market penetration is growing. The Arizona Corporation Commission came close to requiring two proposed plants to use dry cooling technology in 2002, but stopped short of actually imposing this condition.[78,79]

While estimates for both capital cost and operating and maintenance expenses vary, dry cooled plants are more expensive to build and operate than are wet cooled plants. EPA calculates the capital expense of wet cooling at a combined cycle plant as 3 percent of total capital cost compared to 6.5 percent for a dry cooling system. At a hypothetical 700 MW combined cycle plant, operating and maintenance costs are $1.8 million/year for wet cooling and $7.4 million/year for dry cooling. Total annualized costs for the 700 MW facilities are estimated at $3.1 million (.06¢/kWh) for the wet cooling tower system and $13.1 million (.25¢/kWh) for the dry cooling system.[80]

In between wet and dry cooling are hybrid designs and modifications to existing systems. Dry cooling systems can be fitted with water nozzles to be used in the hottest weather, when air-drying is less efficient.[81] Other hybrid systems rely on wet cooling when there are adequate supplies of water and dry cooling during a dry season or drought year.[82]

In addition, there are systems where the water is recycled and essentially distilled off, leaving a solid cake of salts. The water, which is fairly pure, is reused. The resulting solid discharges can be disposed of in regulated landfills. This can virtually eliminate the discharge issue associated with cooling towers.[83]

Technologies also exist to handle waste from power plants in a manner that protects ground and surface waters through lined and covered impoundments, leachate collection and even use of fully closed tanks where water is treated before discharge.

Renewable energy and energy efficiency

There are two other essential parts of a comprehensive strategy to minimize power system water use and pollution in the West: improving the efficiency of using electricity and expanding production of energy from renewable power resources that consume little or no water.

Increased electricity production from many renewable energy technologies, particularly wind power and solar photovoltaic power, would displace use of power generation resources that would otherwise cause a wide range of environmental impacts and further deplete scarce water resources. Figure 8 provides state-by-state estimates of renewables potential and shows huge opportunities for growth. Expanding energy efficiency investment

Figure 8 –

Electricity production potential from renewable resources, million MWh/yr[84]

State	Wind	Solar	Biomass	Geothermal
Arizona	5	101	1	5
Colorado	601	83	4	<1
Idaho	49	60	9	5
Montana	1,020	101	6	N/A
Nevada	55	93	1	20
New Mexico	56	104	<1	3
Utah	23	69	1	9
Wyoming	883	72	<1	N/A
Total	**2692**	**682**	**22**	**41**

Figure 9 –

Cooling water withdrawal and consumption in gal/kWh

Plant & Cooling System	Withdrawal (cooling & process)	Consumption (cooling)
FOSSIL [85,86,87]		
Steam		
Once-through	20 - 50	~.3
Re-circulating	.3 - .8	.24 - .64
Dry cooling	~.04	0
Combined Cycle		
Natural gas, once-through	7.5 - 20	~.1
Natural gas, re-circulating	~.23	~.18
Natural gas, dry cooling	~.04	0
Coal, re-circulating	~.38*	~.2
RENEWABLES		
Wind [88]	**~.001**	**0**
Solar – photovoltaic [89]	**~.004**	**0**
Solar – parabolic trough [90]	~.83	~.76
Geothermal [91,92]	**	0 - 1.0
Biomass [93,94]		
Steam, once-through	23 - 55	~.35
Steam, re-circulating	.35 - .9	.35 - .9
Steam, dry cooling	~.05	0

* Includes gasification process water
** If plants require cooling water, it is typically obtained from geothermal heating fluid.

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NREL, FOOTE CREEK RIM WIND FARM, WY

helps minimize the need for incremental power production, and thus avoids environmental impacts and water allocation issues. Improved efficiency and more "no water use" renewable power also helps reduce potential drought-driven power system reliability problems.

Figure 9 compares water withdrawal and consumption across both renewable and conventional fossil power technologies, clearly revealing the water use and consumption benefits of wind and solar photovoltaic power. If the next likely increment of new power generation –16,800 MW or 112,590,000 MWh – taps wind and photovoltaics, there could be significant water savings. Developing only a small portion of these resources could fully cover the next expected increment in power needs and save upwards of 116 million gallons of water per day.[95] Renewable development is already on the increase in several states through the introduction of renewable portfolio standards.

The potential for water savings from energy efficiency is also very high. Accelerated adoption of cost-effective energy efficiency measures in Arizona, Colorado, Nevada New Mexico, Utah and Wyoming could save the region 25 billion gallons a year – 10 percent of current consumption – by 2010.[96,97]

Moving ahead

This is an excellent time to address power plant water issues, due to regional drought concerns and the many new power plants being proposed in the region. In addition, EPA's current regulatory focus on cooling water intake structures means there is an immediate opportunity for much-needed regulatory action. Water-saving technologies that minimize harm to aquatic organisms – a major focus of EPA's water intake structure rulemaking – would also dramatically reduce power plant water use, consumption and discharges.

It is time to re-assess and maximize the efficiency of water use. Reducing the impact of power plants on water use and water quality will require policy changes at the national, state and local levels. Citizens should become much more involved in advocating for these policies, especially when plants undergo review for siting/permitting.

Specific actions that minimize power plant impacts on Western water include:

Reduce reliance on fossil fuels

- Maximize investment in energy efficiency and renewable energy resources that use little or no water, thereby minimizing the future need for fossil fuel power production and associated water consumption and pollution.
- Promote use of renewable power sources by contacting your local utility and pressing for a meaningful renewable portfolio standard and other policies that increase the use of renewable energy.

For existing plants

- Call on the EPA to require, at a minimum, closed-cycle re-circulating systems.
- Require assessment of the cost/benefit of retrofitting with dry cooling systems.

For new plants

- Advocate for dry cooling systems to be installed at all combustion steam plants.

For all plants

- Assess potential Western power system reliability problems that could result from local and region-wide drought conditions.[98]
- Implement corrective action based on this assessment to prepare for drought, including modification of cooling water systems.
- Withdraw water from underground sources at rates that will avoid subsidence.
- Withdraw water from surface sources in ways that minimize the impacts to fish passage, entrainment and impingement of aquatic life, and other water uses.
- Improve combustion waste management by requiring plants to utilize "state of the art" practices, including impermeable liners and covers, groundwater monitoring, and leachate collection, treatment and clean up.
- Prevent cooling/waste treatment pond contamination from spreading to off-site areas.

Water quality

- Revise existing power plant NPDES permits to include all toxic substances likely to be found in discharges.
- Require use of the safest processes possible to reduce corrosion, fouling and microbial growth in cooling systems and include any toxic substances used in revised NPDES water discharge permits.

Final note —

This primer is a work in progress. We are continually working to understand the water impacts from power plant use and identify the best opportunities to minimize water quality and consumption problems and conflicts. As this is done, updated web versions and additional information will be made available at our websites: **http://www.lawfund.org/** and **http://www.catf.us/**

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