Water Use by Ethanol Plants

Potential Challenges

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About this publication

Water Use by Ethanol Plants: Potential Challenges

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Introduction

Ethanol production using corn grain has exploded in the Upper Midwest. This new demand for corn, and the new opportunities for value-added processing and cattle production in rural communities, has created the best economic development opportunity in the Corn Belt states in a generation or more. Ethanol demand has increased rapidly recently because of favorable economics of ethanol vs. gasoline, and the need for a performance enhancer to replace MTBE (methyl tertiary-butyl ether) in gasoline. Ethanol's growth has been so dramatic that there are now concerns about the amount of corn available to meet various demands, including food, animal feed and export.

Overall, with increased research and investment in the industry and the potential for energy-efficient cellulosic material to displace corn as the primary feedstock, the environmental footprint of ethanol is expected to markedly diminish.[1] However, one of the most important emerging concerns is the consumptive use of water. Consumptive use of water is broadly defined as any use of water that reduces the supply from which it is withdrawn or diverted.

As would be expected, most ethanol plants are being sited in the Corn Belt. Many of these regions are also experiencing significant water supply concerns, particularly in the western portion of the region. Minimal data is available on groundwater depletion, and the scope of future water availability is not clear. It will be to the benefit of the ethanol industry, and rural development initiatives in general, to get more clarity on the relationship between ethanol production, water consumption, and impacts on water supplies. Otherwise, shortage of water could be the Achilles heel of corn-based and perhaps cellulose-based ethanol.

Water Use in the Midwest

Conflicts over water use are growing in the Midwest. Large livestock confinements, meat and grain processing plants, and expanding urban regions are all increasing water use. For several years the U.S. Drought Monitor[2] has shown significant areas of water stress during the growing season in parts of the Midwest and Great Plains although it appears rainfall is returning to normal levels. However, drought is a recurring issue in the Midwest and Great Plains.

Rural industries, especially livestock production, consume considerable water. Individual swine, for example, use about five gallons of water per day. A typical 10-confinement unit with about 1,100 hogs per unit, would require about 50,000 gallons of water per day (gpd), more during hot dry weather. Beef and dairy cattle will require 20 or more gpd per head during summer.[3] Increasingly beef finishing feedlots are being sited near ethanol plants in order to use the distillers grains as feed. Distillers grains are a byproduct of ethanol production.

Crop irrigation, while not widespread in the rain fed Corn Belt east of the Missouri River, is necessary in Great Plains states. However, crop irrigation is critical to the seed industry, which must have dependable water to produce high quality seed. Many expanding cities have already bought water rights from irrigation districts, essentially putting irrigated agriculture out of business.[4]

The effects of ethanol production on groundwater withdrawals will vary locally and be affected by a number of factors including volume used, properties of the aquifer, other uses, and rate of aquifer recharge. Near surface water table aquifers (commonly termed **unconfined**) are found along streams and rivers in much of the Midwest. These aquifers are usually sands and gravels, and recharge readily from precipitation and adjacent water bodies when water is plentiful, but they are also very susceptible to drought and overuse.[5] On the other end of the spectrum are the **confined** aquifers that underlay most of the earth's surface at varying depths. When they are pumped, the water table is not lowered, rather the water pressure is lowered and the water in nearby wells declines. They usually recharge more slowly and while they are a buffer to drought, excessive pumping will cause long term lowering of well levels.

Generally, water availability in the Midwest is a local, rather than a regional issue and will vary over time. The distribution of groundwater availability and sustainability is not uniform, nor is the distribution of demand.[6] While western states have developed complicated legal arrangements for issuing water rights and developing water diversions, these practices have not been necessary, nor are they likely to be politi-

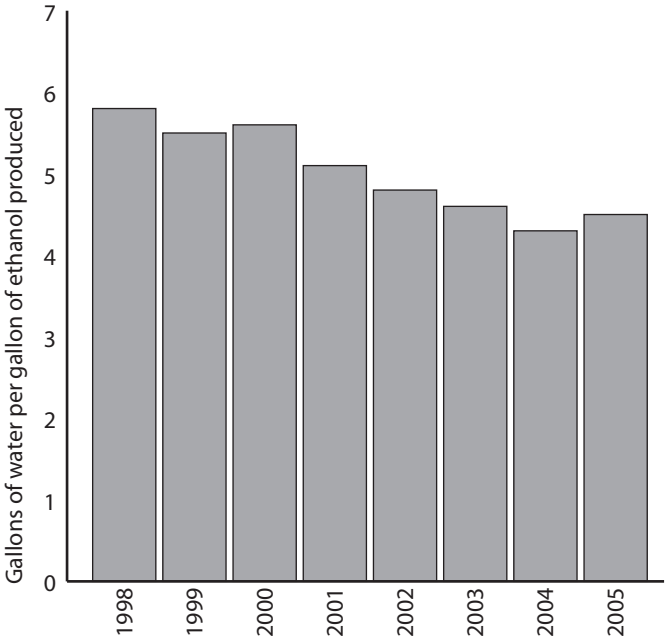
cally feasible, in the Midwest. This places a greater impetus on local government to protect local water supplies from undue exploitation. But regional water confrontations are certain to increase. South Dakota and North Dakota recently challenged the Corps of Engineers' handling of Missouri River flows, and urban water consumption is depleting aquifers in the Chicago-Milwaukee region.[7]

Consumptive Water Use

Consumptive water use by ethanol plants largely comes from evaporation during cooling and wastewater discharge. Ethanol plants are designed to recycle water within the plant. The quality of the cooling water is key because of the need for high quality water in the boiler system. As a rule of thumb, water utilization is 10 gallons per minute for each 1 million gallons of yearly ethanol production. Thus a typical 50 million gallons per year ethanol plant would need 500 gallons per minute of water. Modern ethanol plants have sophisticated water treatment techniques to enable recycling of water to boilers. These treatment techniques should also enable the plants to use lower quality water such as sewage treatment plant effluents and possibly even water recycled from animal feedlots.

There are no publicly available records on water use by ethanol plants for the U.S. In a review of ethanol states, only the Minnesota Department of Natural Resources apparently has records on water use by specific plants in reference to the amount of ethanol produced. Minnesota ethanol plants report a wide range of water use, with most plants in a range from 3.5 to 6.0 gallons of water consumed per gallon of ethanol produced. Average water use has declined from 5.8:1 in 1998 to 4.2:1 in 2005, indicating that the plants are achieving greater efficiency over time.[8] The Renewable Fuels Association (http://www.ethanolrfa.org) estimates 3 gal water per gal ethanol.

Figure 1. Average water use efficiency for Minnesota ethanol plants



It appears that with the current technology, about 4.0 gal/gal of ethanol is a good estimate, and that over time ethanol plants are becoming more efficient in their water recycling technologies.

Figure 2. Ethanol's estimated national water consumption

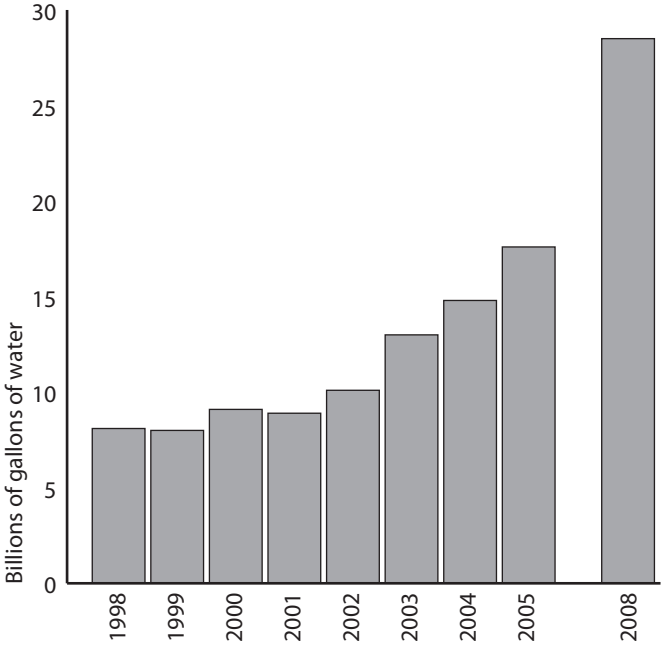


Figure 2 takes Minnesota's water consumption averages and applies them to national ethanol production estimates, which includes ethanol plants expected to come online through 2008. The result is a 254 percent increase in volume of water used in ethanol production from 1998 through 2008. If changes aren't made, it is likely ethanol water use will see even more of an increase in the next decade. Much of the Corn Belt has plentiful water supplies, and ethanol's water demands can be met through appropriate planning. Other regions, such as the greater Chicago area and western Iowa and Nebraska, may run into competing water uses. One can expect that water availability will challenge the ethanol industry in many regions, particularly west of the Missouri River.

The state of Iowa prepared a water plan in 1996.[9] The total water use for industrial purposes was estimated to be about 108 billion gallons per year (bgy), and the report projected water use by 2015 of 120 bgy. Currently Iowa has 2,094 million gallons per year of ethanol capacity (in operation and under construction). Using the multiplier of 4 gallons water/gallon of ethanol gives 8,376 million gallons per year, or about 7 percent of the projected water use. There is the likelihood of a doubling of Iowa's ethanol capacity by 2012, thus the potential industrial use could be up to 14 percent of the projected use. This does not necessarily indicate that state-wide water available for ethanol is in short supply, but it does show that ethanol plants will add significantly to Iowa's industrial water use.

While other states do not have similar data available, regulatory officials have expressed concern about the rapid growth in ethanol plants and resulting water consumption. Lack of water has already curtailed some ethanol plant permits. One of the first was a proposed plant in Pipestone, Minnesota, by Cargill, Inc. The Lincoln-Pipestone Rural Water System could not meet the 350 million gallons per year of water needed by the proposed 100 million gallon per year ethanol plant.[10] In Grand Island, Nebraska, a proposed Cargill ethanol plant was approved after the water needed was offset by reducing water use in an agricultural area about 15 miles away. In Iowa, Department of Natural Resources officials have cautioned that continued growth of "wet industries," which includes ethanol production, in the state could bring water availability issues.

Recommendations

The emerging bioeconomy provides a tremendous economic development opportunity for the rural Midwest. But Midwest agriculture is built on the region's incredible soil and water resources. Economic development is only sustainable if it strengthens, rather than depletes, these resources. Options for reducing ethanol's water consumption include the following.

- **Maintain and strengthen regulatory oversight by state and local government on the siting of ethanol plants, with special emphasis on the water supply and availability.** The ethanol industry can become much more water efficient, but is unlikely to do so unless it is required. The permitting process should allow all potential users of the affected aquifer or surface water supply to evaluate the impact the facility will have on water availability now and in the future. As communities plan for their urban and industrial future, it is important that the permitting process be transparent and allow for local input.
- **Where feasible, site plants adjacent to municipal wastewater facilities.** Ethanol is an industrial process that does not require potable water. Most modern plants have facilities to treat water to the level that it can be used within the plants. Municipal wastewater, which would otherwise be discharged to surface waters, can readily be used by an ethanol facility. This approach could also lower the ethanol plant's energy costs by reducing water pumping. Wastewater treatment plants have an incentive to encourage secondary uses of their wastewater because of the increasingly stringent regulations placed on their discharges to surface waters.[11] Drawbacks to this concept include the resistance to siting industrial facilities close to cities, and the reduction of discharge to streams that need wastewater to maintain minimum flows.
- **Look for water recycling opportunities with livestock facilities.** The distillers grains from ethanol plants have considerable value as an animal feed, particularly for cattle. Livestock facilities are increasingly sited next to ethanol plants so that the distillers grains can be fed directly to cattle, which is much more energy efficient than drying and transporting the grains. Similar to municipal wastewater treat-

ment plants, adjacent cattle facilities provide an opportunity for greater recycling of water between the ethanol plant and the livestock facility.

- **Place a greater economic value on water.** The ethanol industry made tremendous progress in improving the energy efficiency of ethanol production over the past two decades, largely because corn farmers and ethanol producers could save a lot of money through more efficient production practices. Because water is not valued like energy, that same incentive does not exist for water efficiency. Policymakers can use regulation, taxes and economic incentives to create a business climate that promotes greater water efficiency in the ethanol industry.
- **Maintain publicly available records on ethanol's water consumption.** The extent of the problem of ethanol's water consumption is largely unknown because data is not publicly available. Effective policies that promote a more water-efficient ethanol industry cannot be crafted without more knowledge about the performance of current ethanol plants. Regardless of whether the plant uses municipal or private water supplies, water consumption should be made publicly available.

Find more on the bioeconomy at agobservatory.org

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Summary Data

Average water use efficiency for Minnesota ethanol plants

Ethanol producers	1998	1999	2000	2001	2002	2003	2004	2005
Albert Lea (Exol/Agra Resources)	6.3	6.3	6.0	6.1	5.6	5.5	5.2	4.9
Benson (Chippewa Valley Ethanol)	3.3	3.5	4.8	3.5	3.5	3.1	3.2	3.6
Bingham Lake (Ethanol2000)	4.0	4.2	4.7	4.6	4.3	4.7	4.2	4.4
Buffalo Lake (MN Energy)	10.6	6.2	7.1	6.9	7.0	5.8	4.6	4.5
Claremont (Al-Corn)	4.6	4.3	4.1	4.2	3.9	5.4	4.5	4.3
Little Falls (Central MN Ethanol)	—	5.9	4.8	4.2	4.1	3.8	3.5	4.2
Luverne (AgriEnergy LLC)	4.9	5.8	5.2	4.8	4.7	4.6	4.5	4.5
Marshall (ADM)	7.7	7.6						
Morris (DENCO LLC)	9.3	10.0	12.3	8.2	6.0	6.1	6.0	6.1
Preston (Pro-Corn)	5.6	5.2	4.7	4.6	4.4	4.1	3.8	4.0
St. Paul (MN Brewing)	—	—	18.7	7.9	21.9	32.6	12.2	—
Winnebago (Corn Plus)	4.1	3.5	3.5	3.5	4.5	4.1	3.9	
Winthrop (Heartland)	4.8	5.1	4.3	5.0	4.1	3.7	4.5	4.2
Bushmill's Ethanol (Atwater)								
Granite Falls Energy LLC (Granite Falls)								
Northstar (Lake Crystal)								

Source: Minnesota DNR Waters, 2006


IA
TP