

Ethanol plant conserves water through reuse

Minnesota Energy's ethanol plant uses three to six gallons of water in the production of one gallon of fuel. By installing additional plumbing, the plant conserved water and decreased the amount of pollutants in the water discharge streams.

Company Description

Minnesota Energy is a fuel ethanol plant in Buffalo Lake, Minnesota. In addition to producing ethanol, the facility also provides grain handling services and home heating fuel to several communities.

Process Description

Ethanol (EtOH) requires a large amount of water to convert corn into transportation fuel. A typical ethanol plant in Minnesota can use three to six gallons of water per gallon of fuel produced. Some water is needed for preparing the corn for fermentation; however, 80% is non-contact water used in cooling and steam production processes. Softeners and reverse osmosis (RO) systems are used to clarify and improve water quality before it is used for steam generation or filtered coolant. The water treatment process creates wastewater in boiler and cooling tower blowdowns, as well as in the effluent rejected from the RO system.

Incentives for Change

Minnesota Energy requested a MnTAP intern to analyze and recommend ways to reduce the plant's water and fuel use and improve the condition of the water being discharged from the plant. The substantial water costs motivated the ethanol facility to evaluate water recovery and reuse. Minnesota Energy believed that it was possible to recycle certain waste streams with minimal process effects; however, the MnTAP intern was brought in to verify that assumption.

Loss Mechanisms

Minnesota Energy pumped water from a well and sent it through a series of iron filters before storing it in a tank. From the tank, the water was distributed for the corn mashing process, to the cooling tower, and for boiler pretreatment. Water used in the corn mashing process either evaporated, was recovered for reuse, or remained in the fuel or the dried distillers' grains. Non-contact cooling water passed through heat exchangers to remove heat before redistribution. Some of the return water was lost in the tower due to evaporation and blowdown. The boiler

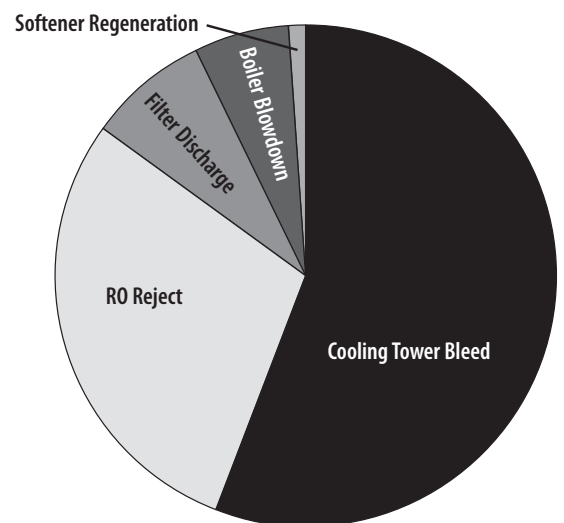


Minnesota Energy implemented the MnTAP intern's recommendations for water reuse in their ethanol plant, saving them seven million gallons of water annually.

pretreatment water was pretreated with a RO membrane. The RO permeate was sent to water softeners, where the residual water was discharged, passed through a deaerator, and finally delivered to boilers and used for process heating.

The MnTAP intern examined the discharge streams to determine if water from each stream could be reused in select process steps and if the effluent quality could be improved to reduce solids and biological oxygen demand (BOD) loading in the

Figure 1. Water Discharge



facility's lagoon. The intern evaluated the water quality needs for the production processes and found that a substantial proportion of wastewater could be treated and recycled within the plant.

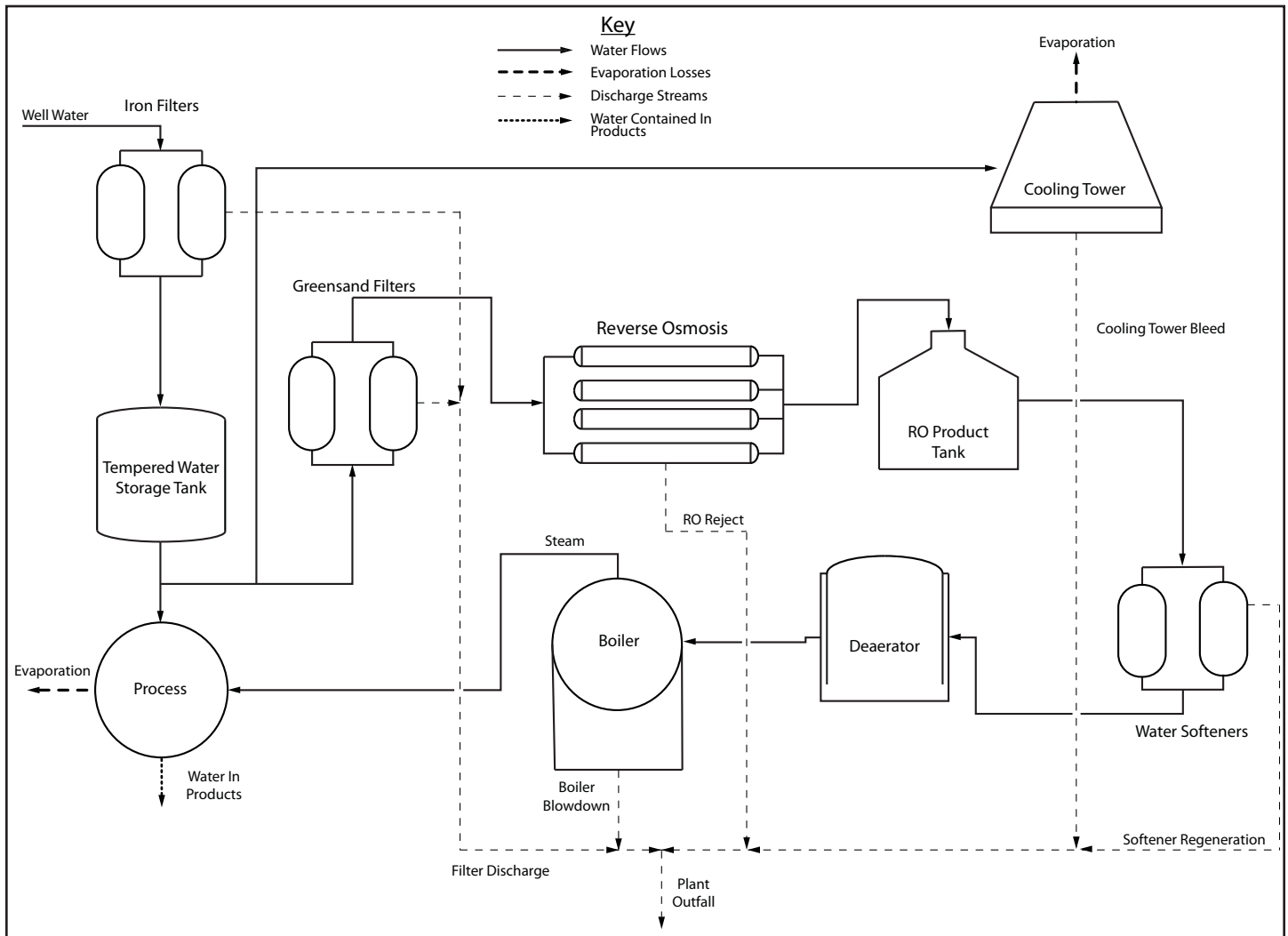
Water Reuse

Water in each discharge stream had low concentrations of solids and other pollutants including iron, chloride, and chlorine compounds. The flow of effluent streams was also low compared to cooling tower effluent streams that were evaluated. The RO reject water was selected for reuse, because its components were similar to process water and would not affect the process conditions of corn mashing and fermentation. To prove that the RO reject was compatible as process water, the Brix value, an indication of sugars present in the fermentation unit, and the EtOH percentage following fermentation needed to be stable. Minnesota Energy installed plumbing costing under \$100 to divert the RO reject water to the process stream, saving 4.75 million gallons of water annually and \$165 in chemical treatment costs. The company reduced pollutants by 100,000 pounds of solids, three pounds of chlorine, and 9,000 pounds of chloride.

The MnTAP intern also selected the boiler blowdown water stream for reuse. This stream was diverted to the process. This modification reused and saved one million gallons of water. Effluent to the lagoon was also reduced by 10,000 pounds of solids and 1,000 pounds of chloride annually. The intern recommended that the heat generated from boiler blowdown be used in the process of corn mashing, which can save at least \$4,000 in energy costs annually. The intern also explored a more expensive option of installing a heat exchanger on the boiler blowdown to save up to \$42,000 annually. Minnesota Energy is considering these recommendations.

Two other discharge streams, softener reject water and filter discharge water, were significantly smaller or potentially difficult to blend with the process water supply. The reuse of the softener reject water amounts to a 50,000 gallon per year savings, but has an implementation cost of over \$1,000. In addition, the softener system is scheduled to be replaced by a new RO water unit. The filter discharge water would result in an annual savings of two million gallons, which is twice the savings of the boiler blowdown water recovery. However, the stream contains high

Figure 2. Water Flow Process



concentrations of iron and chlorine residuals, which could foul the process or scale equipment. Minnesota Energy decided that investing in the pump and plumbing to divert the regeneration water and in the chemicals to treat it was not a beneficial option.

New Reverse-Osmosis Treatment System

The MnTAP intern recommended the installation of a second RO water treatment system to polish water sent to the boilers that later feeds through the process. The reject water could be used for process cooling and additional water supplied to the cooling tower. Installing a second RO system would save Minnesota Energy over 10 million gallons of water annually. In addition to saving water, the RO system would reduce plant effluent by over 200,000 pounds of suspended and dissolved solids, 30,000 pounds of chloride, and 90 pounds of chlorine. The discharge from the plant with a new RO system would reduce the need to expand its facultative lagoon, which treats all the plant effluent.

Effluent Quality

Currently, all Minnesota Energy plant effluent is sent to a lagoon with aerobic digestion on the open surface and anaerobic activity at the bottom. The lagoon treats the wastewater by reducing chemical and biological oxygen demand and solids, while degrading organic compounds. The MnTAP intern analyzed the lagoon's effectiveness in order to improve the effluent quality. The intern recommended dredging the pond and adding a pond aeration unit. Dredging the pond would remove accumulated solids and reduce the load that the bacteria work to decompose. The addition of an aeration unit would increase organics and solids aerobic digestion, which occurs faster in an oxygen-enriched environment. Although neither offered a savings amount, the recommendations would reduce the potential of solids and other untreated material from passing over the lagoon weir. Recycling facility water and adding a second RO system would significantly reduce the loading into the pond.

Results and Benefits

The MnTAP intern's implemented recommendations saved Minnesota Energy seven million gallons of water annually and reflect the potential for over 12 million gallons of water saved with a new RO water system. Minnesota Energy reduced their overall water consumption by roughly 10% of annual use, while reducing 70% of water discharged per year. The total water and chemical savings were \$42,180 annually, with an implementation cost of \$18,000. Factoring out the purchase of a new RO system, the payback period was about six months for the water reuse project. Minnesota Energy has also lessened the total solids outflow by 120,000 pounds annually.



For More Information

MnTAP has a variety of technical assistance services available to help Minnesota businesses implement industry-tailored solutions that maximize resource efficiency, prevent pollution, increase energy efficiency, and reduce costs. Our information resources are available online at <mntap.umn.edu>. Please call MnTAP at 612.624.1300 or 800.247.0015 for personal assistance or more information about MnTAP's Intern Program.

This project was conducted in 2008 by MnTAP intern Kevin Erickson, a senior in chemical engineering at the University of Minnesota.