Water, Water, Everywhere, and We Use Here and There!

J.S. McLaren

Just look at that satellite view of Earth and notice all the blue color. Yes, the Earth is covered by two-thirds water representing an almost unimaginably huge amount of water. So large is the volume that it buffers the atmosphere, and the oceans' currents determine our weather. No wonder the astronauts call it the Blue Planet. Standing on the shore, we notice that water is continually in motion. What we don't immediately see is that billions and billions of gallons of water are moving out of the sea, and eventually returning back to the sea, molecule by molecule. This movement through the atmosphere is called the hydrological cycle.

Total global water:
3.4×10^{20} gallons, or 320 million cubic miles
Atmospheric water:
3.2×10^{15} gallons, or 3000 cubic miles
Biological water:
3.0×10^{14} gallons, or 300 cubic miles

While many species live on land, water remains a biological necessity in a terrestrial system (the global biological system typically contains ~0.0001% of the total). Perhaps this is why humans find the subject of water to be emotionally irritating. The terrifying vision of running out of water is certainly a headline grabber. The idea that water is "used" to make ethanol biofuel seems to stir strange and often irrational emotions – for example, how dare we destroy water just to improve our transport fuel situation! However, is this "use" of water just science fiction, partly true, or something that we need to address immediately or otherwise might we have to stop driving in order to survive?

There are three basic components to consider in answering that question: We have to explore water in relation to the feedstock for ethanol, the process for ethanol, and the utilization of the ethanol including residual outcome.

Due to favorable economics, sufficient production volume, and the declining real costs of corn-based starch, corn is the major feedstock for global ethanol production. As all plants do, corn takes up water from the soil and that water facilitates biological reactions. The vast majority of water passes through the corn plant and is emitted back into the atmosphere through the many pores on its leaves. This normal occurrence in all plants is called transpiration.

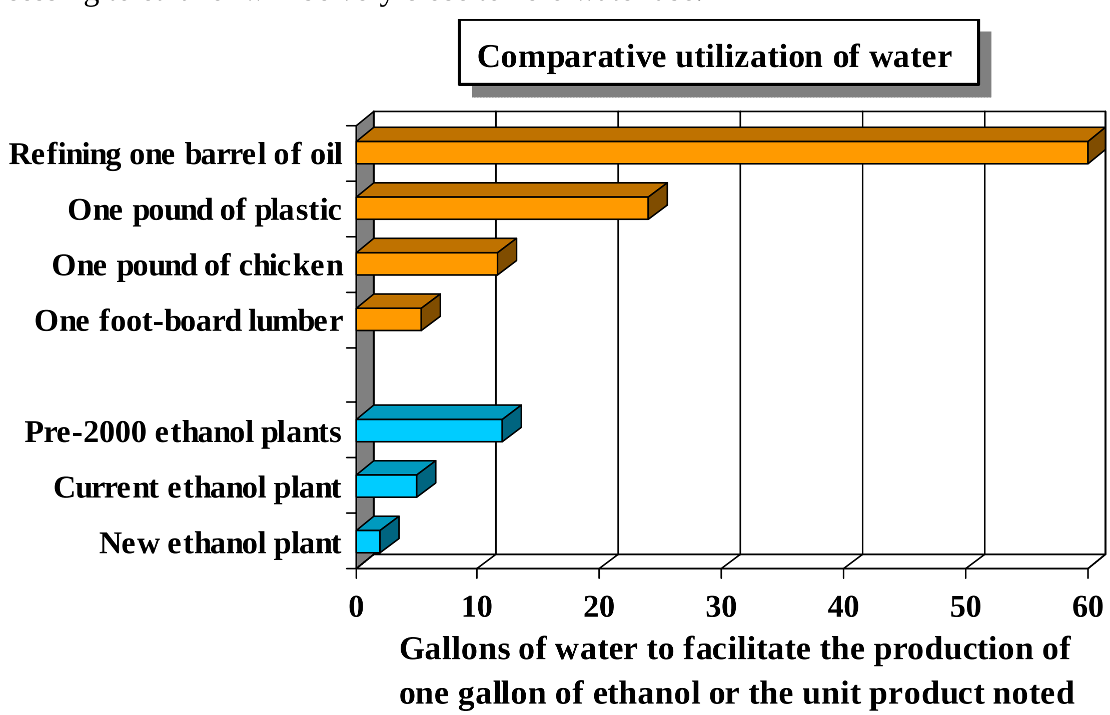
Transpiration is used to move some mineral nutrients and to cool the plant; it's somewhat analogous to sweating in humans. Over the course of a growing season, each corn plant will move about 14 gallons of water through itself and back into the atmosphere. For comparison, a typical person in America drinks more than that amount every month. The majority of the water taken up by the corn plant is involved in transpiration and it serves a purpose, yet it is not "used" as such but is returned into the hydrological cycle.

A certain amount of water is removed from the field in the corn grain at harvest. Typically, there is 14 percent to 18 percent moisture content in the grain which means a bushel of corn contains about 8 pounds of water, or about one gallon of water per bushel. This water is also not "used" since it is carried to the subsequent event where the corn is consumed. Since over

60 percent of domestic corn is used as feed then that water becomes part of the water intake for the livestock population. In the case of the nearly 17 percent of corn that is processed for ethanol, the water in the grain will be carried into the ethanol production process. For the nearly 18 percent of corn that is exported, it might be debated that that water is being used since it leaves the United States. However, the hydrological cycle has no geopolitical boundaries and that water will be returned into the global hydrological system elsewhere.

The only water that is truly used by corn plants is the relatively small amount involved in photosynthesis. This amazing biological reaction actually splits the water molecule into hydrogen and oxygen. The hydrogen is used in other biological reactions and the oxygen is released into the atmosphere. In reality we would not want to stop this particular use of water, since it is the basis for all oxygen-breathing life on Earth. Moreover, the higher the growth and yield of a plant system the more oxygen is released. Corn is the highest yielding plant that can be grown on a large-scale across America and, therefore, makes a considerable "generally unrecognized" contribution to our well-being by using a little water.

In relation to industrial processing, there is a growing shift away from the use of chemical solvents and metal catalysts, towards bio-processing and enzymes (biocatalysts). Bio-processing takes place in an aqueous environment and, consequently, total water use may increase as more solvents are replaced. Contrary to the general industry trend, in ethanol processing the unit use of water has declined by a considerable amount in recent years. While some academic commentators have propagated a misconception of more water use, the actual commercial organizations involved have been working continuously over several years to alter the ethanol processing design in ways that reduce the amount of water intake. While complete recycling of water has not quite been achieved, the future ethanol designs for corn processing to ethanol will be very close to zero water use.



Technically, none of the water in these processes is “used up” since it flows through the system and will eventually return to the hydrological cycle. We term this facilitation of production and it can be thought of as temporary utilization of water. For example, just as corn grain carries some water into the ethanol professing plant, each gallon of ethanol carries water back out of the process. For those who wish to compare amounts “used” in facilitation of various diverse processes, the chart provides estimates per unit. Incidentally, in addition to the inherent energy, ethanol provides the required oxygenate for proper gasoline combustion and the water in every gallon is emitted via the tailpipe and returns into the atmosphere.

Unlike crude oil which is a finite resource and is not cycled, water resources are almost infinite and it is cycled, albeit at different rates in different systems. Resolving any real issues requires formulation of the correct question in a technical non-agenda-based manner. Rather than nonsense about water “use” in a process, we should perhaps be more accurately addressing the question as “how long does the process and/or product tie-up a certain volume of fresh water?”

Not all water is in a form readily usable for drinking or by many processes, but this is not due to a shortage of water. Technologies (e.g. reverse osmosis) are increasingly available for conversion from the mass water sources to provide more than enough fresh water for all existing needs. The current limitation seems to be the cost required to achieve that conversion. Therefore, it becomes a question of what value society puts on having water available to facilitate processing and the provision of useful products. For example, recycling technology itself is now being accepted as “normal” cost of doing business. Judging by the increasing price of bottled water it seems that several dollars per gallon is acceptable when we want it to be.

Data in this article was adapted from:

U.S. Geological Survey
DOE- National Renewable Energy Laboratory
Discussion with commercial ethanol plant personnel

Dr. J. McLaren is the Founder and President of StrathKirn® Inc., a technical analysis and business consulting company focused on new technology applications and emerging markets, across the agriculture, biotechnology, and biofuel industries.