Supporting the Heart of the Water-Energy-Food Nexus

by Maury D. Gaston

A nexus is a relationship or connection between people or things. Several years ago, leaders in the water and power industries began to speak of the water-energy nexus. The water-energy nexus goes back to the very beginning of mechanical power, when the turning of a waterwheel and shaft was made possible by the gravity flow of water. [1] Mechanical power was transferred from that turning shaft to various machines throughout a factory.

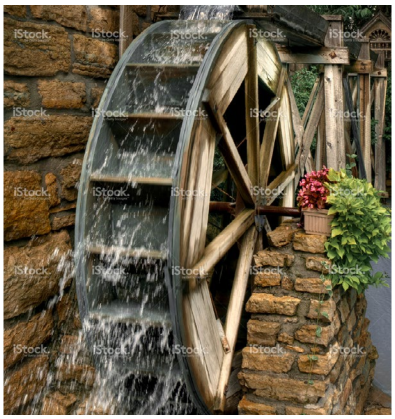

Figure 1. A New England water wheel furnishing mechanical power to a factory.

With the advent of electricity and public water supply systems, the water-energy nexus became the intersection of the amount of water required to generate electricity through the use of water for steam and water for cooling; and the amount of electricity required to collect, transport, filter and disinfect, pump, and deliver water to consumers in industry, business, agriculture, and homes. Even nuclear power, the most advanced form of electrical generation, continues the use of large amounts of water for steam and cooling. [2]

The Department of Energy recently published a comprehensive report on the water-energy nexus. [3] News stories involving the nexus include reports about how the ongoing severe drought in the west has affected the capacity of hydroelectric generating plants. There is simply not enough water behind some dams to generate hydroelectric power. Shasta Dam holds back the largest man-made reservoir in California, and Lake Shasta is down to 50 percent capacity. This has resulted in a reduction of electrical generation at Shasta Dam by one third, an amount equal to the power used by 175,000 homes. Because of the drought, across all of California, the production of hydropower is down 20 percent. [4]

A consequence of this is that other sources must be found for the generation of energy and those alternative sources often have a carbon footprint. Even clean-burning natural gas has a larger greenhouse gas footprint than essentially carbon-free hydropower. Peter Gleick, President of the Pacific Institute, estimates the use of other sources to replace electrical capacity lost from hydro has led to an 8 percent increase in CO_2 emissions from California power plants during a three-year period. [5]

How much water is required to generate electricity? [6] Using fossil fuels and depending on the specific process involved, it takes about 25 gallons of water to produce 1 kilowatt-hour of electricity. This means a typical home requires about 25,000 gallons of water each month to produce its electrical demand. That's more than twice the typical amount of water used by that same family of four for conventional household use. Further, the electricity used to operate our factories and businesses dwarfs residential use. The United States Geological Survey estimates that 45 percent of all water use in the United States is for thermoelectric power generation. [7]

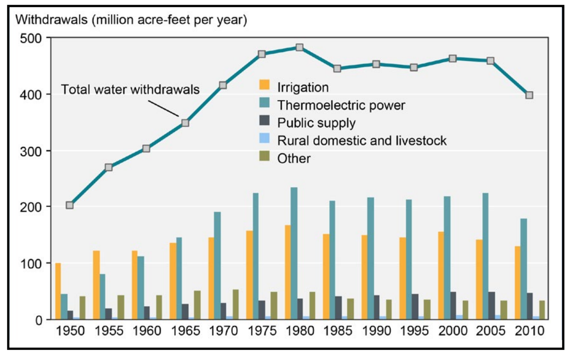

Figure 2. United States' water use by sector since 1950.

It's important to remember "use" does not equal "consumption." We have all the water we have ever had, and we never really consume any; we just change its form. In the context of thermoelectric generation, consumption is evaporation. All of the water used in electrical generation returns to the hydrological cycle and most of it returns in liquid form, but massive amounts are used in the process.

The flip side of the water-energy nexus coin is the energy required to collect, transport, filter and disinfect, pump, and deliver water to consumers in industry, business, agriculture, and homes. At 8.34 pounds per gallon, water is heavy. Since water is withdrawn from surface sources that flow downhill or from deep within the ground, water nearly always must be lifted up, and that requires a great deal of power. Further, large amounts of energy are used to clean waste water before it is returned to a stream.

In an informative State of the [Water] Industry report, Black & Veatch said energy can account for as much as 30 percent of a utility's costs. [8] Overall, about 3 percent of the United States' energy production is used to supply water for its various needs. [9] One easy-to-understand equivalency presented by the United States Environmental Protection Agency estimates that running a residential hot water faucet for five minutes consumes the same energy as burning a 60-watt light bulb for 14 hours. [10]

The water-energy nexus is not simply the water required to produce electricity and the electricity required to pump water, but water and the production of fossil fuels are also inextricably linked. Lawrence Berkeley National Laboratory estimates the United States uses between one and two billion gallons of water daily to refine nearly 800 million gallons of gasoline. [11]

So, it's clear - water requires energy and energy requires water. Lots of each.

More recently, a third leg was introduced to this topic – food. The water-energy-food nexus applies to the water required to produce and deliver both energy and food, the energy required to produce and deliver both water and food, and the food required to produce both water and energy. As the popular old song goes, "You can't have one without the other!"

In a much-ballyhooed example, it was recently reported in The Wall Street Journal that 502 gallons of water are required to produce one pound of almonds, or 1.3 gallons per almond. In a typical year, California agriculture uses four times the volume of water as California's urban areas. [12]

Let's take a look at how much water is used to produce certain foods and fibers. [13]

- Approximately 4,000 gallons of water are required to grow a bushel of corn and 11,000 gallons to grow one bushel of wheat.

- That's about 1,000 gallons of water to make a two-pound loaf of bread.

- 1,400 gallons of water are used to produce a meal of a quarter-pound hamburger, an order of fries and a soft drink.

- A traditional Thanksgiving dinner for eight will require 48,000 gallons of water, or 6,000 gallons per person.

- The cotton in a pair of denim jeans will use 1,800 gallons of water, and 400 gallons are used to grow the cotton in a shirt.

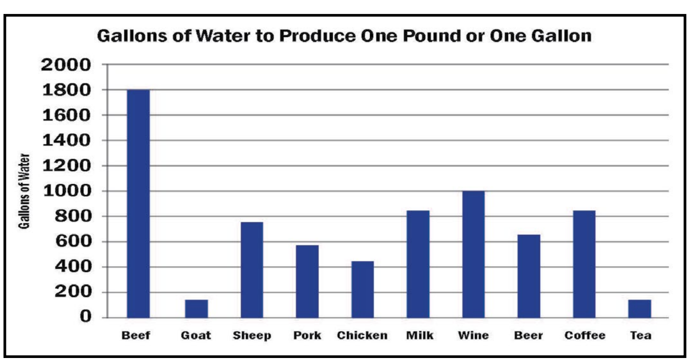

Figure 3. Gallons of water required to produce one pound of meat or one gallon of a different liquid.

Not all of the required water can be supplied in the right place at the right time by rainfall. The United States Geological Survey estimates that irrigated agriculture accounts for 38 percent of the nation's freshwater withdrawals. Even more is required for processing and getting finished agricultural production onto our dinner tables.

Irrigated farmland accounts for 55 million acres in the United States. Nebraska tops the list with 15 percent of its land being irrigated, sourced primarily from the Ogallala aquifer; and California is second with 14 percent of its land being irrigated, mostly from Rocky Mountain snowmelt, turning the arid San Joaquin Valley into the nation's vegetable basket. [14]

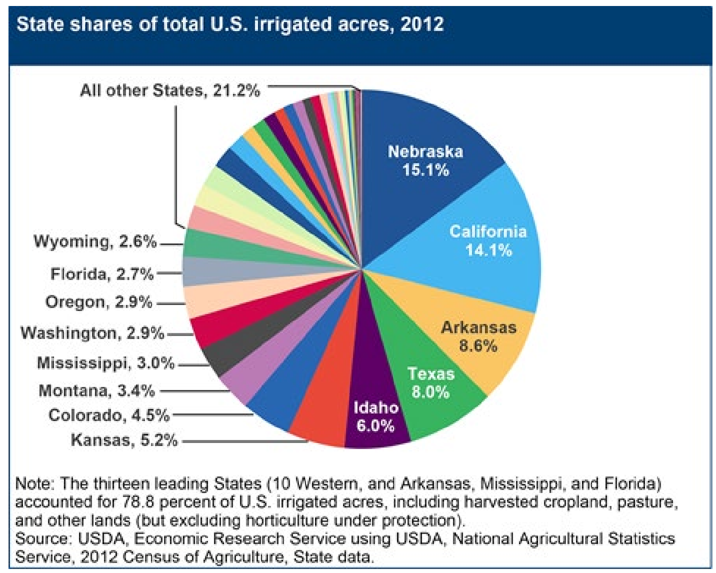

Figure 4. Percentage of irrigated land for various states.

We've seen that water shortages have affected energy production and increased carbon emissions in California. The same drought has affected food costs and the broader economy. [15] California's agricultural sector lost 17,000 jobs in 2014 and more than 20,000 are predicted for 2015. Fallow land related to a lack of water is approaching 1,000,000 acres. This is a powerful negative example of the essential nature of the water-energy-food nexus.

Having looked at water, energy, and food and seen how much each depends on the other, let's now turn our attention to how one manufacturing company serves each of these dimensions of the nexus.

The AMERICAN Cast Iron Pipe Company was founded in Birmingham, Alabama, in 1905 to manufacture cast iron pipe. At the turn of the previous century, rapid industrialization was occurring as many people were moving from rural areas to cities in search of manufacturing jobs. Water-borne disease was still very much a threat to human life, with cholera and typhoid fever outbreaks and their resultant deaths not being uncommon. [16]

AMERICAN's founder, John Eagan, wanted to invest his wealth in a noble cause to better the lot of mankind, and he knew clean water and sanitation would do that. Led by Charlotte Blair, a visionary Birmingham businesswoman, Mr. Eagan invested in the new company and ultimately became sole proprietor.

Figure 5. AMERICAN founders John J. Eagan and Charlotte Blair.

Since that time, AMERICAN has pioneered numerous innovations in the pipe industry from new joints to cement mortar lining to ductile iron metallurgy to zinc coatings. As a result of AMERICAN's industrial leadership in World War II when 100 percent of her production supported the Allies, what later became AMERICAN Centrifugal was founded. These special steel castings served numerous industries after the war. Continuing expansion and diversification, AMERICAN acquired Fox Steel of Jacksonville, Florida, in 1962 and entered the natural gas and energy markets.

Figure 6. An AMERICAN Ductile Iron Pipe project being installed which will supply clean drinking water for the community.

The Darling Valve Company was acquired in 1969, and AMERCIAN began the path to valve and fire hydrant leadership. In 1989 the Waterous Company of South St. Paul, Minnesota, was acquired, further advancing AMERICAN into the flow control and fire protection world. In 1991, American-Darling, whose roots date to 1888, and Waterous, which was founded in 1844, were merged into a single operating division known today as AMERICAN Flow Control. This division is responsible for the manufacture of the American-Darling and Waterous brands of fire hydrants, as well as AMERCIAN Flow Control gate valves, tapping valves, check valves, and related products. Collectively, the joining of these iconic brands has positioned AMERCIAN as a significant leader in the fire protection and flow control industries.

Figure 7. Images of AMERICAN Flow Control's fire hydrant brands, American-Darling and Waterous, as well as the Series 2500 gate valve, the industry's first ductile iron resilient wedge gate valve.

AMERICAN Flow Control has also developed a line of resilient wedge gate valves from 16-inch to 60-inch diameter with Flex-Ring restrained joint ends. This unique offering of the same boltless joint restraint between both pipe and valves is another example of innovative leadership by AMERICAN. In addition to valve and hydrant products, WATEROUS produces high-performance pumps for fire trucks.

In 2000, AMERICAN built a green-field spiral weld pipe facility in Columbia, South Carolina, making steel pipe to 12-feet in diameter and thicknesses to one inch. As a result, AMERICAN has produced massive pipe for waterworks and even power projects through penstocks. In 2003, AMERICAN purchased what became AMERICAN Castings in Pryor, Oklahoma, making large castings primarily for the heavy equipment industry. In 2014, AMERICAN SpiralWeld built another mill in Flint, Michigan, to produce a 77-mile pipeline that will supply fresh water for the agricultural industry of the area.

Figure 8. AMERICAN spiral welded steel pipe being installed in a parallel trench setting.

This diversification of products has resulted in AMERICAN playing a significant role in all three legs of the water-energy-food nexus. Water is the most obvious of these with millions of feet of AMERCIAN cast iron, ductile iron, and spiral welded steel pipe providing drinking water and fire protection in all 50 states and 38 countries around the world.

In the energy arena, the obvious connection is AMERICAN Steel Pipe's electric-resistant welded steel pipe used for oil and natural gas transmission. AMERICAN Steel Pipe recently expanded its processing capacity and can now produce up to 700,000 tons of world-class steel pipe annually for the high-pressure petroleum market, serving America's energy needs and contributing to American energy independence.

Figure 9. AMERICAN Steel Pipe ERW line pipe being installed to deliver natural gas.

A not-so-obvious contribution to the energy arena comes from the ductile iron pipe product line and the larger-than-nominal inside diameter of ductile iron as compared to plastic PVC pipe and concrete cylinder pipe. The larger inside diameter means it takes less energy to pump the same volume of water through ductile iron than through alternative materials. Similarly, the use of full port-opening resilient wedge gate valves by AMERICAN reduces head loss and associated energy consumption to one-tenth that of butterfly valves. [17] This means by using ductile iron pipe and resilient wedge gate valves made by AMERICAN, less energy is used, fewer fossil fuels are consumed, fewer greenhouse gases are emitted, and utilities and localities have stronger balance sheets and ecosystems.

In June of 2014, Journal American Water Works Association published a study of the Huntsville, Alabama, water system's 1,297 mile pipe network, constructed of 96 percent iron pipe, and its energy consumption. A theoretical flip of that system to smaller-inside-diameter plastic PVC and concrete cylinder pipe showed that energy costs would increase $700,000 and kilowatt hours by 7,110,105 per year. [18] Those kilowatt-hours would have required about 177 million gallons of water in the generating cycle, each year. We see from this that not only does AMERICAN supply the pipe that transports water, but AMERICAN's type of pipe uses less energy to move the water, a double-win in the nexus arena.

Further on the energy side of the nexus, and as noted, in addition to welded steel pipe to transport oil and gas, AMERCIAN furnishes penstock piping for hydropower and furnishes fire protection for refineries.

Figure 10. An upper peninsula Michigan penstock by AMERCIAN SpiralWeld.

Figure 11. AMERICAN Castings produces many components for the agricultural machinery markets.

To complete AMERCIAN's contributions to the water-energy-food nexus, AMERICAN Castings in Pryor, Oklahoma, produces components that are required for the assembly of numerous machines that serve the agricultural industry. Tractors, harvesters, crop sprayers and other essential equipment in the agricultural industry all have frame and structural components, drive axles, front axles, housings, brackets, links, track drive components, engine flywheel housings and many other parts made by AMERICAN. One would be hard pressed to find a large agricultural machine without components made by AMERCIAN Castings.

Water, energy, and food are each interdependent. Each are essential to our lives and our economies, yet none are sufficient.

The products and professionals of the AMERICAN Cast Iron Pipe Company play vital roles in supporting the heart of the water-energy-food nexus.

The founder of AMERICAN who sought a noble cause to serve mankind surely found one.

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About the Author

Maury D. Gaston is a 34-year veteran of the water industry and member of the American Water Works Association. He is a member of the AWWA A21 Committee and chairs sub-committee 1 dealing with design and manufacturing standards of ductile iron pipe. Mr. Gaston is Manager of Marketing Services for AMERICAN Ductile Iron Pipe and AMERICAN SpiralWeld Pipe. He also serves as Chairman of the Auburn University Alumni Engineering Council and is a Director and past Chairman of the state of Alabama Engineering Hall of Fame. Mr. Gaston may be contacted at 205-325-7803 and mgaston@american-usa.com.