Hawaii Renewable Energy Development Venture
Technology Assessment

Water/Energy Integration

1. Overview, Background, and Context

This discussion is less about technology. Instead it is a discussion on the issues that face the development of an energy crop/forestry industry for the state of Hawaii. Factors such as land use and labor supply must be taken into account. However, one of the most important issues is related to the use of and availability of water for the creation of a successful industry. Water is also necessary for cooling and emissions scrubbing for thermoelectric generation. On a national level, in calendar year 2000, thermoelectric power generation accounted for 39 percent of all freshwater withdrawals in the U.S., roughly equivalent to water withdrawals for irrigated agriculture.

The Energy Information Administration (EIA) projects that the U.S. population will grow by about 70 million in the next 25 years and electricity demand to grow by approximately 50 percent. Technologies are available that can reduce water use in the electric sector, including alternative cooling for thermoelectric power plants, wind power, and photovoltaics, But cost and economics, among other factors, have limited deployment of these technologies. Water use in the extraction and processing of transportation fuels is less. However, as the U.S. and Hawaii seek to replace imported petroleum with fuels from domestic sources, such as bio-fuels, the demand for water to produce fuels from energy crops and forestry could grow significantly.

A recent study examined energy requirements for water supply and treatment across the country. The biggest difference among regions is the amount of energy used to supply water for agriculture. In general, per capita non-agricultural use of energy for water is similar region to region. Supply and conveyance can be the most energy-intensive portion of the water delivery chain. If the water source is groundwater, pumping requirements for supply of freshwater from aquifers vary with depth:

- 540 kWh per million gallons from a depth of 120 feet
- 2000 kWh per million gallons from 400 feet

Another aspect of the water/energy nexus is that growth in energy demand occurs when freshwater resources and overall freshwater availability become strained from limitations on supply and increasing domestic, agricultural, and environmental demands. Depending on the water quality needs for particular applications, freshwater supplies can be augmented with degraded or brackish water. Water quantities available for use are dependent on the water qualities needed for each use. Increased use of brackish or degraded water may be required in some areas if water users can accept the quality limitations or can afford the

cost of energy and infrastructure for water treatment.

Hawaii must carefully consider energy and water development and management so that each resource is used according to its full value. Since new technologies can reduce water use, there will be a great incentive for their development by the public and private sectors.

Bio-fuels currently provide about 3 percent of U.S. transportation fuel, with more than 130 ethanol and bio-diesel plants in operation producing over 4 billion gallons of bio-fuel each year. Hawaii currently mandates that 10% of transportation fuel be augmented by ethanol. The current supply of ethanol is brought in from the mainland or from international sources. Bio-fuel feedstock produced from crop residues in excess of those needed to maintain a healthy ecosystem, from feedstock grown without irrigation, or from feedstock grown with nontraditional water will have less freshwater use intensity associated with production. This could provide significant volumes of bio-energy and bio-fuels in the future with low water use intensity. In all cases, water use is associated with processing, but further technology development is likely to lower these values.

Production of alternative fuels, such as hydrogen from methane, also requires water at up to triple the requirements for water consumption in petroleum refining. Reforming hydrogen from methane is quite water intensive. Even production of hydrogen by electrolysis using a water-independent source of energy like wind requires water as feedstock to the electrolyzers. Electrolysis requires 21 gal per MMBtu. A typical evaporative-cooled thermoelectric power plant will use 100 to 200 gal per MMBtu to power the electrolyzer. If renewable energy sources such as wind or photovoltaics were used to power the electrolyzer, little additional water would be needed.

Few surface-water storage projects have been built in recent years and groundwater supplies are in decline. There are promising means of increasing storage in order to increase reliable yields of water that involve the use of aquifers as part of the water management system. This includes "conjunctive use" (wherein groundwater and surface water are managed jointly, using surface water when it is abundant and groundwater during dry seasons and dry years). In addition, artificial recharge and aquifer storage and recovery are approaches that can increase reliable supplies by purposefully augmenting recharge with excess surface water (or treated effluent) in times when it is readily available, and then withdrawing that water in times of shortage. There are significant energy implications. These waters may be converted to potable water by using desalination. Desalination requires more energy than typical public water supplies. Energy requirements for desalination are similar to the requirements for pumping water long distances.

Freshwater supplies can be supplemented by use of degraded water,

such as discharge from wastewater treatment plants. Throughout the energy sector, there are opportunities to co-produce energy and water. Locating power plants adjacent to water treatment facilities or more brackish or produced water resources could partially displace freshwater needs. In addition, waste heat from power plants can be used in some desalination cycles, and biogas from wastewater treatment plants can be used to generate power.

Most national analyses of bio-fuel feedstock for current production include corn and soybeans. In Hawaii, sugar cane and potential tropical palm species will be the sources for ethanol and bio-diesel respectively. These crops may require significant quantities of water. Reduction of water use requires the ability to use plant material that does not require additional water, including crop and forestry waste and crops that do not require much irrigation, such as switch grass. Research is under way to develop the processes to produce ethanol from the lingo-cellulose in these materials.

For an example of production, as of 2004, at least 45 bio-diesel plants were in operation, producing approximately 25 million gallons of bio-diesel with 54 more plants proposed or under construction. The conversion process from soy to bio-diesel requires 1 bushel per gallon of fuel. Water withdrawal for the conversion process is about one gallon of water for every gallon of bio-diesel produced. Water use for soy production averages 45,000 gal per MMBtu, with a range of 14,000 to 75,000 gal per MMBtu. Water use during processing is 4.2 gal per MMBtu produced.

2.0 Status of Commercial Readiness/Appropriateness to Hawaii

Hawaii's water delivery infrastructure – in terms of its usefulness for agriculture – has deteriorated. Water delivery systems, such as ditches, have not been maintained. Additionally, little work has been done in utilizing brackish waters for irrigation. As an island state with limited resources, Hawaii must utilize technologies that have been developed in other parts of the world to more effectively re-use water for agricultural purposes.

Low-tech solutions are required if Hawaii is to make use of its agricultural lands for energy crops. Creative, inexpensive solutions need to be developed to upgrade water delivery systems and to make use of brackish, gray water.

3.0 Considerations for Specific Technologies/Resources

Any project that is funded to improve water supply or to make more efficient use of water must be tied to related projects that will develop biomass-for-energy supplies and technologies. This is because these projects are funded by the Department of Energy (USDOE). The USDOE is seeking solutions for more economic development of renewable energy

systems, including bio-fuels. Projects that simply focus on improving delivery systems for water, making more efficient use of water (such as drip irrigation systems), or technologies that will utilize gray (brackish) water will not be considered for funding. These projects must be coupled with related activities that will improve the ability of Hawaii to produce feedstock that will – in turn – lead to the development of an indigenous bio-fuels industry.