WATER QUALITY IMPLICATIONS OF BIO-FUELS DEVELOPMENT IN GEORGIA

Sara Barczak[1], Keshav Das[2], and Rita Kilpatrick[3]

AUTHORS: [1]Safe Energy Director, Southern Alliance for Clean Energy (SACE), 3025 Bull Street, Suite 101, Savannah, GA 31405, [2]Assistant Professor, Faculty of Engineering, University of Georgia, Athens GA 30602, [3]Georgia Policy Director, SACE.
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Abstract. Georgia's energy for electricity comes mostly from fossil fuels and nuclear power plants, and the energy for transportation comes almost solely from petroleum. Much of the state's new electric power supply slated for development is natural gas. Negative impacts of conventional fuel based systems include pollution of water resources (e.g. contaminants such as mercury ending up in water bodies through atmospheric deposition, direct contamination through tanker oil spills, leaking underground storage tanks, etc), excessively high volumes of water intake in electric power plant operations, and large water consumption (i.e. water lost primarily through evaporation in cooling systems). There is a strong need to advance less water intensive energy technologies such as clean, renewable forms of energy, including various bio-fuels, wind, and solar technologies. These energy sources can offer substantial water quality benefits in contrast to Georgia's current energy mix and at the same time offer local economic benefits. In Georgia, bio-fuels are currently seen to provide the biggest, near-term opportunity among renewable supplies, with over 17 million tons/yr of biomass available and as much as 12% of the State's total electricity demand could be generated from biomass. The benefits to the state include increased self-sufficiency, improved water resource quality, and long-term environmental and rural development benefits.

INTRODUCTION

The objective of this report is to describe how Georgia's current energy sources affect water quality, with a focus on some impacts from electricity generation, along with highlighting a sampling of bio-fuels under development and the potential impacts those energy sources would have on water quality.

ENERGY USE IN GEORGIA

The majority of the energy consumed in Georgia comes from petroleum for transportation and coal and nuclear for electricity. Figure 1 lists the state's total energy

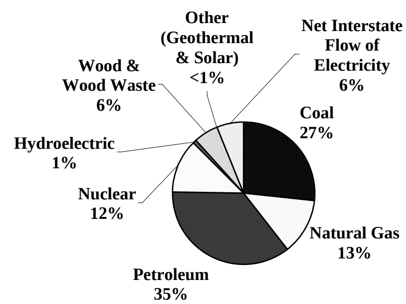

Figure 1. Georgia's total energy consumption by source, 2001 (EIA).

consumption by source in 2001 (in trillion BTUs) according to the Energy Information Agency (usage sectors include: residential, commercial, industrial, transportation, and electric power). Despite resource availability, very little energy has been generated in Georgia and the region from non-hydroelectric renewable energy sources (such as solar, wind, and bio-fuels).

Water quality impacts by the electric power sector

Georgia's current electricity generation negatively impacts state water quality. Figure 2 shows that coal-fired power plants rank as the largest industrial source of airborne mercury emissions in Georgia and in 2001 Georgia ranked 12th in the nation for mercury emissions from electric utilities. Mercury is generally deposited through rainfall. Its organic toxic form, methyl mercury, contaminates lakes and rivers and can make recreation and eating fish unhealthy. As a hazardous neurotoxin, mercury poses a health hazard, especially for pregnant women and young children, while also negatively impacting aquatic life. Georgia has 122 mercury advisories warning people of the dangers of eating fish, including one issued in the entire coastal and estuarine region for the King Mackerel known for its ability to accumulate high levels of mercury (Corrigan 2003 & GADNR, 2004). Recreational fishing is an important part of our economy; Georgia's recreational fishing industry is estimated to bring in more than $500 million annually

(Corrigan, 2003). According to the Georgia Environmental Protection Division, in 2003 about 40 percent of all fish tissue tested statewide recommended limiting consumption to one meal per week or month, depending on the type of fish, mostly due to mercury contamination.

A variety of hazardous chemicals, heavy metals, and radioactive contaminants are released into surface waters during routine operations at nuclear power plants including: biocides; acids; phosphates; chromium; and tritium (NRC, 1996). Water discharged from nuclear and coal power plants can be warmer than receiving waters resulting in "thermal plumes" that can stress aquatic life in part by aggravating the problem of low dissolved oxygen levels. Nuclear power plants can also damage aquatic life through entrapment or impingement of the animal — essentially getting trapped against an intake screen or pulled through the condenser cooling system. Additionally, in the case of a severe accident, nuclear plants have the capability of long-term contamination.

Bio-fuels

Biomass is an abundant, under-utilized energy source in Georgia. Humans have used bio-fuels (energy from organic matter that is essentially "stored" sunshine) since the beginning of time when wood was burned to cook food and generate heat. Bio-fuel sources include [1] agricultural and forestry residues, [2] urban and industrial wood wastes (which can be converted to electricity via direct fire, co-fire, gasification, or pyrolysis), and [3] animal waste (converted to electricity through anaerobic digesters that produce methane gas that can be captured and used in turbines, primarily for high moisture content wastes such as hog waste).

The use of bio-fuels for both electricity generation and transportation fuel (biodiesel) has the potential to reduce global warming pollutants, such as carbon dioxide and methane, if used in place of fossil fuels. For instance, through photosynthesis "energy crops" remove from the atmosphere a quantity of carbon dioxide roughly equivalent to that released when the biomass is processed to obtain energy. Advanced technologies that can gasify biomass to produce electricity are up to twice as efficient as burning the biomass directly, thereby generating reduced greenhouse gas emissions (EPA, 2000). In addition, biomass typically has significantly lower sulfur than coal, which translates to lower sulfur emissions. For example, typical hardwoods and softwoods contain 0.036 and 0.011 lbs-S/MMBtu, respectively (DOE, 2005). In comparison, medium sulfur coal contains over 0.61 lbs-S/MMBtu (DOE, 1995). Displacing coal with hardwoods translates to S-emissions that are less than 6% of that released by an equivalent amount of coal. Emissions of sulfur, nitrogen, and mercury return to water bodies through atmospheric deposition and contribute to fish kills and contaminants entering the food chain. Biomass based energy can contribute significantly to reducing this risk.

Homegrown bio-fuels

Georgia has the greatest biomass generation potential in the South when compared to other forms of renewable energy or when compared to biomass potential in other states in the South (REPP, 2002). A 2003 feasibility study on the generation of electricity in Georgia from biomass fuel sources using various technologies (direct fire, co-fire, gasification, and pyrolysis) estimated that there is 17 million dry tons/yr of biomass available in Georgia; enough energy potential from Georgia's agricultural feedstocks to power nearly 12% of the State's total electrical demand, or over 31% of the State's residential consumers (Curtis, et al., 2003).

Homegrown energy projects can help spur local economic development and provide additional social and environmental benefits. It should be noted that the extent to which specific benefits are gained from the use of bio-fuels as energy sources, such as possible water quality improvements or economic advantages, will vary based on the technologies used. Such benefits include:

- *Local job growth*. Energy projects that use biomass resources are predicted to create more local jobs than conventional energy projects, especially in slow-growth rural areas because local suppliers within a 50-mile radius of the site generally produce bio-fuels. In contrast, the average distance between production and consumption of fossil and nuclear fuels is much greater (REPP, 2002).
- *Economic enhancement*. Using farm or processing residues for energy generation can provide an economic bonus for farmers since there is a reliable supply that is readily available on-site requiring little or no remanufacturing, and it reduces the materials having to be discarded. In addition, transportation fuel can be made affordably and efficiently with the use of many farm crops, such as soybeans, further increasing economic opportunities in the agricultural sector.
- *Environmental / social improvement.* Extracting and capturing methane gas from animal waste for energy use can control manure odor and help farmers meet controls for manure management (that aim to reduce surface and groundwater contamination).

Poultry litter: water quality impacts and energy implications. Georgia is the largest source of poultry litter in the country (UGA OES, 2004). Though poultry litter could be used as an energy source, it is typically used as a fertilizer on cattle pastures, hay fields, and croplands. Poultry litter field applications can be a source of water pollution. Elevated soil phosphorous levels and elevated nutrient and bacteria levels can occur in nearby streams from continuous, heavy repeated application of litter (Bush, 2003). Since many of Georgia's poultry houses are in the northeastern part of the state, they can have excess litter supply, while the southwest portion of the state, in particular, is in need of nutrients. Consequently, poor water quality resulting from runoff of litter and other types of fertilizers into surrounding surface waters can be particularly problematic in the northeast.

Agricultural land use (e.g. crop production) is most common in Georgia's southwest counties. The heavy use of man-made fertilizers can negatively impact water quality in surface and groundwater resources through runoff and infiltration, especially after heavy rains. Since the Upper Floridan aquifer is shallow in the southwest, the ground water is susceptible to contamination from nitrates and other chemicals. Ground water monitoring of nitrate concentrations conducted near Albany, Georgia has shown nitrate levels in some well locations greater than 10 milligrams per L (mg/L), which is the maximum contaminant level set for nitrate by the U.S. Environmental Protection Agency (USGS, 2003).

Where there is excess poultry litter in Georgia and it is not economic for farmers to use it for specific fertilizer purposes or is problematic for them to use due to water quality concerns, then the excess litter could be used for energy recovery. Poultry litter had several desirable characteristics including the second lowest supply and delivery price for biomass feedstocks (behind pecan hulls). Along with pine bark and peanut shells, poultry litter had cheaper supply and delivery costs than natural gas (Curtis, et al., 2003).

The local project described below could possibly serve a role in further processing poultry litter and other agricultural feedstocks that could be more effective both to enhance soils, reduce fertilizer use, and as a deterrent to water pollution.

The EPRIDA project. An alternative to electric power from coal or nuclear plants is through hydrogen fuel cells. Although still relatively expensive and not widely tested and used, some fuel cells are commercially available for distributed power generation. Hydrogen required to operate fuel cells is typically made from methane (in natural gas) through a process called steam reforming. Scientists at the National Renewable Energy Laboratory (NREL) have developed technology similar to methane steam reforming, but using hydrocarbon vapors released from biomass pyrolysis (Evans, 2002). Pyrolysis is a process of heating biomass (e.g. peanut hulls) in the absence of oxygen producing hydrocarbon vapors and a solid residue charcoal. Recent work has shown that charcoal can remove air pollutants emitted from coal-fired power plants such as sulfur dioxide and nitrogen oxides (Day, 2005). The final product is a charcoal based fertilizer containing sulfur and nitrogen, which also serves as a soil amendment that enhances microbial activity in soil (e.g. nitrogen fixing bacteria) (Ogawa, 1994). The use of this charcoal in soil can reduce fertilizer needs (thereby reducing surface and groundwater contamination from fertilizer runoff), enhance crop productivity, and sequester the carbon in charcoal for thousands of years (Steiner, 2004).

Eprida-Scientific Carbons Inc., a Georgia company in collaboration with the University of Georgia and a team of other research universities, is conducting research to complete technology development and leading to technology transfer. This U.S. Department of Energy funded project is the nation's largest renewable hydrogen production plant and is located at the University of Georgia's Bioconversion Research and Education Center in Athens, Georgia. The uniqueness of the approach is the potential for co-products such as charcoal, carbon-based fertilizer, glues and chemicals from the hydrocarbon vapors, etc. The availability of these value added co-products reduces the overall cost of producing hydrogen, making the process attractive.

In addition to having no toxic emissions, fuel cells require less water compared to traditional power generating systems. In Georgia, water consumptions for coal and nuclear power plants are 0.39 and 2.95 kg(water)/kWh. The Pyrolysis-Reforming system consumes 6.05 kg(water)/kg(hydrogen) and when used in a typical low temperature fuel cell, translates to water consumption of 0.38 kg(water)/kWh (assuming a 50% water use efficiency) (Larminie and Hicks, 2000; Evans et al., 2002).

Electricity is obtained directly from hydrogen in the fuel cell system therefore requiring no additional water. In contrast traditional systems generate steam to run turbines for electricity generation. Therefore coal and nuclear plants have much higher water intake needs of 103 and 4.39 kg (water)/kWh, respectively. These needs can create critical impacts on water bodies during times of low rainfall.

RECOMMENDATIONS

Bio –fuels are a valuable energy source both for displacing coal in combustion plants or through generation of hydrogen and clean bio-fuels. Though the primary environmental benefits of using biomass in place of fossil or nuclear fuels tend to focus on reducing air and global warming pollution, the impacts on water quality from using bio-fuels should be further studied and factored into policy decisions. Local renewable hydrogen production that can utilize many types of biomass generated from Georgia's agricultural industry, such as the EPRIDA project, should be studied further with specific focus on its water quality impacts.

SUMMARY

Georgia's current energy use relies heavily on fossil and nuclear fuels that have negative impacts on water quality. There is a strong need to advance less water intensive energy technologies throughout Georgia. Such clean, renewable forms of energy, including various bio-fuels, wind, and solar technologies should be evaluated for their water quality benefits.

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