CLIMATE CHANGE IMPLICATIONS FOR GEORGIA'S WATER RESOURCES AND ENERGY FUTURE

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Abstract. Georgia faces growth management risks associated with global climate change that are important for water and energy specialists and planners to address. According to the National Academy of Sciences, among others, the predicted impacts of climate change include sea level rise, salt marsh deterioration, possibly more severe and long-lasting droughts, and likely decreases in summer river flows.

Georgia's existing energy infrastructure, especially electricity production, already draws heavily from the state's water supply sources. Current impacts from existing electricity supplies include degradation of water quality and reduction of available water supplies. Climate change, population growth, and economic development will have variable impacts on rivers and reservoirs. These impacts need to be integrated into decision-making about the location and choice of new energy technologies in the state.

Already policy makers are cognizant of the general ways that Georgia's energy industry is a highly water dependent enterprise. At the same time, our region faces large, rapid population growth and has among the highest per capita electricity use in the nation. New attention is being given to the merits of energy efficiency as a statewide resource. As the state continues to grapple with how best to manage energy and water resources, how to plan for future growth, and how to become more resource efficient, the addition of planning for climate change impacts will help to ensure that the state's water and energy resources are developed and managed wisely.

INTRODUCTION

This report discusses some of the global warming scenario impacts on Georgia's water resources and the measures that can be taken in the energy sector to help mitigate these impacts. Particular focus is given to the electricity sector, including energy efficiency given the inherent water benefits these technologies provide. Initiatives to advance water conservation through energy efficiency and conservation measures would provide valuable water resource benefits to Georgians while also providing necessary steps to help reduce the electricity sector's contributions to greenhouse gas emissions and subsequent global warming, or climate change effects. Additionally, this report considers some of the new power plant proposals in Georgia and what the associated implications are for Georgia's water resources, with a focus on the Savannah River Basin.

ENERGY AND WATER USE IN GEORGIA

The majority of the energy consumed in Georgia comes from petroleum for transportation and coal and thermonuclear sources for electricity 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 from non-hydroelectric renewable energy sources (such as solar, wind, biopower, and bio-fuels).

Global warming pollution linked to current energy use

In considering mitigation strategies, the state needs to take into account the reality that since 1960 Georgia's carbon dioxide (CO_2) emissions have increased 315% according to data from Oak Ridge National Lab (ORNL). According to ORNL, in 2001 the state of Georgia emitted 158.2 million metric tons of CO_2.

In Georgia, utilities represent the largest single sector contribution of carbon dioxide followed by transportation, according to the U.S. Environmental Protection Agency. Carbon dioxide (CO_2) is a primary global warming pollutant. Georgia's coal-fired power plants contribute over 83 million tons of CO_2 annually with power plants in the Southeast contributing over 502 million tons of CO_2 annually. If the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee were considered a country, it would rank 5th in the world, ahead of India and Germany, for contributions to global warming pollution.

Table 1. Water withdrawal and consumption rates for fossil and nuclear fuel plants

Fuel Source	Technology	Withdrawal (gal/kWh)	Consumption (gal/kWh)
Nuclear	Once-Through	46.2	0.1
	Recirc-Wet Tower	1.5	1.5
Fossil (Coal)	Once-Through	37.7	0.1
	Recirc-Wet Tower	1.2	1.1

Water impacts from the electricity sector

Georgia's existing energy infrastructure, especially electricity production, already negatively impacts water supply sources in terms of degrading water quality and reducing water availability. The predicted effects from climate change pose additional and more severe implications for Georgia, especially Georgia's water resources. Some effects include sea level rise, salt marsh deterioration, more severe and long-lasting droughts, and likely decreases in summer river flows.

Water used primarily for cooling is an important resource for all thermoelectric plants. In Georgia, thermoelectric plants used slightly more than half, 3310 million gallons per day (Mgd), of the total surface water used statewide in 2000 (Fanning 2003). A large portion of this water is returned to the source, albeit at a higher temperature, and generally a much smaller fraction is lost or "consumed." However, a potentially significant environmental risk that has received little attention is the relatively large consumptive use of water for evaporative cooling during thermonuclear plant operation. Georgia currently has two nuclear power plants each with two nuclear reactors; Plant Hatch is near Baxley on the Altamaha River and Plant Vogtle is near Waynesboro on the Savannah River. Both use mechanical draft cooling towers for cooling the reactors, resulting in less water withdrawn than plants using "once-through cooling" but with a much greater volume of water consumed or lost.

According to a 2004 study for the U.S. Department of Energy as shown in Table 1, nuclear plants generally have higher water withdrawal rates in gal/kWh than compared to pulverized coal plants, regardless of whether cooling technologies are used or not. Once-through cooling technologies for coal and nuclear plants have equivalent consumption rates. However, when mechanical draft or recirculating cooling technologies are used, nuclear power has larger water consumption rates.

New energy supply sources proposed for Georgia, such as expanding nuclear power generation at nuclear Plant Vogtle by building up to two new reactors, could reduce water availability in the Savannah River as climate change impacts, such as reduced summer river flow, develop. This information is particularly relevant at this time because federal subsidies are being made available in an effort to lower capital construction costs for approximately the next six thermonuclear power plants nationally. Thus, there is significant financial incentive for nuclear utilities to move forward with new plants as quickly as possible. The possible expansion of Vogtle is currently under initial review by the U.S. Nuclear Regulatory Commission as it studies Southern Nuclear Operating Company's early site permit application submitted in August 2006.

An additional factor for consideration is the large, rapid population growth Georgia and the surrounding region is predicted to experience in the next decade, coupled with the fact that this region has the highest per capita electricity use in the nation. Though future advanced nuclear reactor designs may require little or no consumptive use of water, such as the Pebble Bed Modular Reactors (PBMR), these are still experimental, though close to production in South Africa, and are not part of the proposed nuclear expansion for Georgia or elsewhere in the United States.

Level of Consumptive Use. The two 2430 MW reactors, which have been operating at Plant Vogtle since 1987 and 1989, withdraw a monthly average of 68,670,000 gallons per day (Energy Information Administration 2000). Estimated consumption data from the Georgia Environmental Protection Division in 2001 showed consumption of approximately 43,000,000 gallons per day, or only about one third of what was withdrawn by Plant Vogtle from the Savannah River was being returned.

The proposed two new Westinghouse AP-1000 reactors for Plant Vogtle will reportedly use approximately 53,602,560 gallons per day (gpd) from the Savannah River under normal use with a maximum withdrawal of about 83,208,960 gpd (Southern Nuclear Operating Company 2006). Between 50-75% will be consumptive use, that is, lost as steam. The remainder will be returned to the Savannah River at a warmer temperature resulting in thermal impacts to the river. To put this into perspective, with average per capita daily water use in Georgia at 75 gallons from surface and ground water, more water will be lost as steam from the possible four reactors at Plant Vogtle than is used by all residents (2005 census) of Atlanta (470,688), Augusta (190,782) and Savannah (128,453) combined (Fanning 2003).

COMPETING DEMANDS FOR WATER IN THE SAVANNAH RIVER BASIN

Population growth rates in the lower Savannah River Basin are significant. The Savannah metro area is projected to increase 13% between 2000 and 2010. Currently, Savannah exploits the Floridan Aquifer for the majority of residential water supply. However, new water demand will largely come from surface waters due in part to problems of saltwater intrusion into the Floridan Aquifer in the region of Hilton Head and Savannah (Kentel et al. 2005). These levels of future water use underestimate real increases in water demand because future water supplies for industrial and commercial growth are not included. A Department of Energy 2004 report predicted that the largest population increases will happen in the water-challenged states in the west and southeast and that to meet increasing electricity demand, power plants "will have to compete with a growing population for limited supply of freshwater—coupled with increasing competition for freshwater from other use sectors such as agriculture, mining, industrial and in-stream use."

Constraints During Drought

Climate change models generally indicate either no to moderate increase in precipitation during winter months. They also indicate that seasonal shifts in rainfall coupled with higher temperatures may result in significantly drier months from late spring through early fall. Thus, modeling predictions for summer and early fall months may constitute what we would currently classify as drought conditions. Recent work that utilizes models (GFDL CM2.1) developed by Princeton's Geophysical Fluid Dynamics Laboratory pose the future possibility of long-term mega-droughts that could embrace the southwestern U.S. and the subtropics including Georgia (see figure 6 in Seager 2006). While the severity, duration, and frequency of future droughts are uncertain, the possibilities should not be ignored when planning for long-term water allocation.

Consumptive water use exacerbates the severity of droughts and further reduces the assimilative capacity of the Savannah River. Lakes Hartwell, Thurman, and Russell, upriver from Augusta were created, in part, to mitigate drought years by releasing stored water to maintain minimal flow levels. The Savannah River Drought Contingency Plan Update (USACE 2006) calls for maintaining a minimum flow rate of 3600 cubic feet per second (cfs) during level 3 drought years. Therefore the average total daily use of water by the four reactors (two existing and two proposed) at Plant Vogtle will be approximately 4% of the Savannah River during a level 3 drought with a maximum daily use withdrawal of about 10%. Consumptive losses represent as much as 3 to 7.5% of the Savannah River below Lake Thurmond during a level 3 drought.

Increasing consumptive use of water in the Savannah River Basin during low flow periods could contribute to other environmental risks. Here, we call attention to salt water moving upriver as river flows decrease. One risk is that salt water may enter the Savannah Wildlife Refuge and impact the productivity and wildlife value of this important refuge. An additional risk is how the salt water wedge moving upriver will impact the productivity of the Savannah River estuary.

Additionally, the predicted effects of global warming on this region, such as summer heat waves or droughts, and how the existing or proposed reactors at Vogtle may be negatively impacted or unable to generate electricity under those conditions should be studied. This deficiency was demonstrated by the 2006 summer heat wave, when nuclear power plants in France, Germany, and across Europe, and in the U.S. at the Cook nuclear plant in Michigan, had to shut down because the water temperatures were too high to allow for safe operation.

Consideration should be given to current and future energy production in terms of limited water availability (e.g. in times of drought). Most power production in Georgia relies on continuously and readily available water supplies. If that trend continues, and coincides with drought conditions, Georgia could be vulnerable.

Impacts of Energy Efficiency on Water Use. The "end-use" sector that relates to the consumer or demand side of the energy equation offers significant and immediate water saving potential for Georgia. Demand-side energy efficiency is not just a way to save energy; it is also a way to save water. Energy efficiency measures can reduce the need for new power plant generation and expanded capacity and thereby decrease the amount of water withdrawn and consumed for electricity generation from Georgia's highly valued water resources.

Georgia has room for improvement when it comes to using energy more efficiently. In 2003, EIA data ranked Georgia 10th in the nation for total energy consumption (this included all sectors: residential, commercial, industrial, and transportation). Georgia ranked 8th in the nation for per capita energy consumption for electricity.

Significant water savings can also be achieved in Georgia through more attentive selection of fuel supplies and choice of technology for power generation. Over the next several decades, safer alternatives to highly centralized, low efficiency, water consumptive power plants, such as the proposed expansion at nuclear Plant Vogtle, will be imperative. The list of rapidly emerging efficient, safe, and cost-effective technologies to meet the growing demand for electricity is large and growing.

RECOMMENDATIONS AND SUMMARY

A water supply and demand model should be developed for the entire Savannah River Basin that takes into account variable drought intervals, lengths, and severity along with increasing water demand from population growth and economic development. In addition to water supply and demand, future increased demand for more assimilative capacity in the Savannah River should be included. Changes in assimilative capacity will, of course, affect acceptable levels for minimal flows. In turn, energy technology choices and growth management decisions should be tailored accordingly to accommodate projected constraints in the Savannah River Basin.

Georgia faces growth management risks associated with global climate change that are important for water and energy specialists and planners to address. Georgia's existing energy infrastructure, especially electricity production, already significantly impacts the state's water supply sources. Climate change, population growth, and economic development will have variable impacts on rivers and reservoirs. These impacts need to be integrated into decision-making about the location and choice of new energy technologies in the state. As Georgia continues to grapple with how best to manage energy and water resources, how to plan for future growth, and how to become more resource efficient, the addition of planning for climate change impacts will help to ensure that the state's water and energy resources are developed and managed wisely.

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