Comments on the Technical Memorandum For the Georgia Statewide Energy Sector Water Demand Forecast

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1. Introduction and Summary

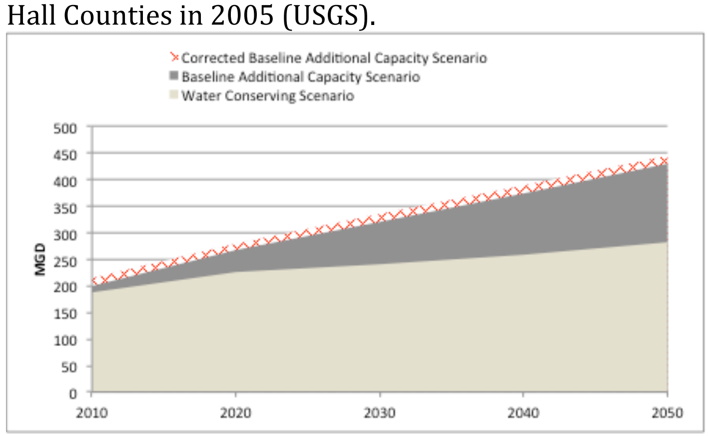
It is only recently that policymakers, researchers and citizens have begun to explore the linkages between energy and water consumption. Though we depend on a reliable electric supply to provide us a clean, reliable water supply and vice versa, there is a tendency to plan for one without thought to the availability of the other.

The focus of these comments and the Environmental Protection Division's ("EPD") energy sector water forecast is on the amount of water that is needed to meet Georgia's electricity demands. We applaud the state of Georgia and the EPD for establishing a planning process that recognizes the relationship between electricity production and water consumption. The choices that Georgia regulators, policymakers and utilities make today about the state's electricity supply will have observable and significant impacts on future water use and consumption. Georgia's recent past has revealed the problems drought and lack of water can cause and, consequently, the need for integrated water and energy planning.

However, our review reveals that the EPD's water consumption forecast for the energy sector significantly overestimates the amount of water that the state needs to set aside for electricity production because, in large part, it overstates how much new electric generating capacity the state will need. Most importantly, EPD's forecast does not address the future *availability* of water in Georgia[1] and the potential tradeoffs between providing for water in the electricity sector as opposed to water for agricultural or human consumption or other important uses.

Georgia's Electric Sector Could Use 150 MGD Less by 2050 than EPD Estimates

Correcting for some, though not all, the inaccuracies we've identified in EPD's forecast results in 150 million fewer gallons consumed each day by the electric sector by 2050. That's nearly equal to the water consumption in Carroll, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry and Hall Counties in 2005 (USGS).



1 The question of water availability is beyond the scope of this report, but will be part of the Regional Water Planning Councils' planning process.

2. EPD Scenarios

A. Two electricity growth rates used in EPD scenarios

EPD presents two forecasts of future electricity needs in the Technical Memorandum[2] - a reference case and a high case. The reference case is the Baseline Power Needs forecast, which anticipates annual growth of 1.64%. The high case is the Alternative Statewide Power Needs forecast, which projects a 2.14% rate of annual growth. All EPD scenarios assume that peak load will increase 1,000 MW per year.

EPD created two scenarios of energy supply to meet demand under the Baseline Power Needs forecast. The first scenario, the 2017 Capacity Scenario, adds 7,896 MW of net electricity capacity through 2017, but does not include new electric capacity after that date. Even so, Georgia can still meet its power needs through 2040. The second scenario, the Additional Capacity Scenario, adds 37,896 MW (megawatts) of new generation through 2050.

B. Background on power plant and cooling system types assumed in EPD scenarios

Nearly all the electrical generation in EPD's scenarios is assumed to come from thermoelectric power plants (nuclear, coal, oil or gas-fired). The rate of water consumption by a thermal power plant is primarily a function of its efficiency and secondarily a function of the cooling system employed.

For example, Figure 1 shows a Sankey diagram for a typical coal-fired power plant. The diagram is read from left to right and follows the energy content of the fuel (in this case coal at a rate of Btu/hr) into the plant to its conversion into electricity.

[2] Davis, William and Mitch Horrie. "Technical Memorandum Re: Statewide Energy Sector Water Demand Forecast.", October 29, 2010. Available for download at http://www.georgiawaterplanning.org/pages/forecasting/energy_water_use.php

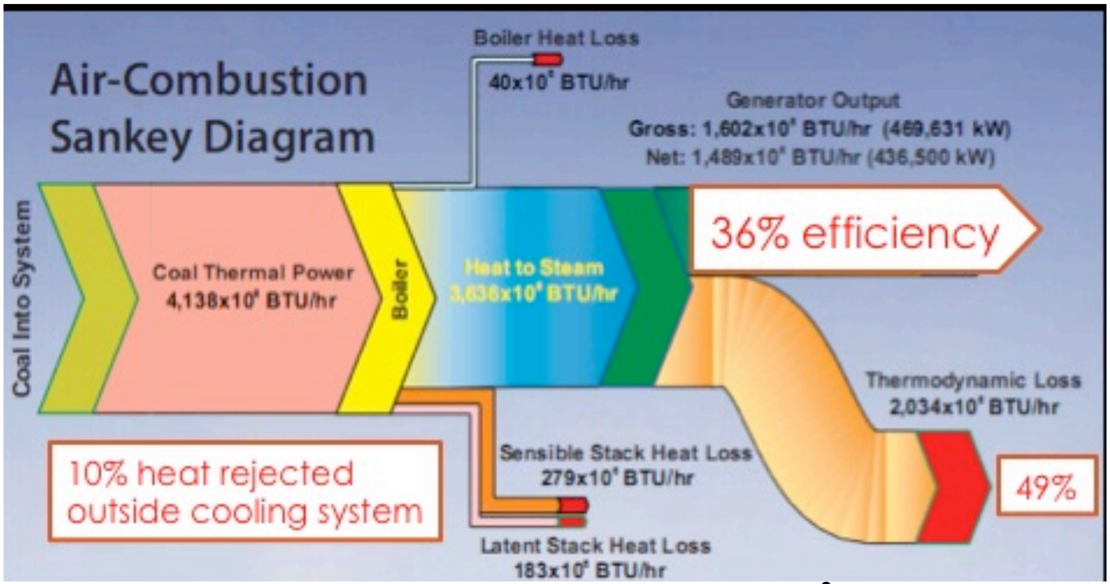


Figure 1. Sankey Diagram for a Typical Coal-Fired Power Plant[3]

Roughly 10% of the thermal input is rejected as heat and carried away without the need for a cooling system. A third (36%) is converted into electricity (generator output). And 49% is waste heat (thermodynamic loss that must be carried away most often by water). By increasing the generator output (the efficiency) one can simultaneously reduce the amount of waste heat. Coal and nuclear power plants are roughly 36% efficient. The most efficient thermal power plant commercially available is a combined cycle natural gas plant with an efficiency close to 50%.

A thermal power plant's water consumption is also influenced by the choice of cooling system. Air-cooled systems are available, though uncommon. The most common type of power plant cooling systems use water. These are once-through and closed loop (or recirculating) cooling systems.

A diagram of a once-through cooling system is shown in Figure 2.

3 Ochs, Thomas, Danylo Oryschchyn, Steven Gerdemann, Cathy Summers. "Strategies for Improving Efficiencies in Oxy-Combustion Retrofits." A post at the Seventh Annual Conference on CCS, May 2008. http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/Strategies%20for%20Improving%20Efficiencies%20in%20Oxy-Combustion%20Retr.pdf and Timothy Diehl, USGS.

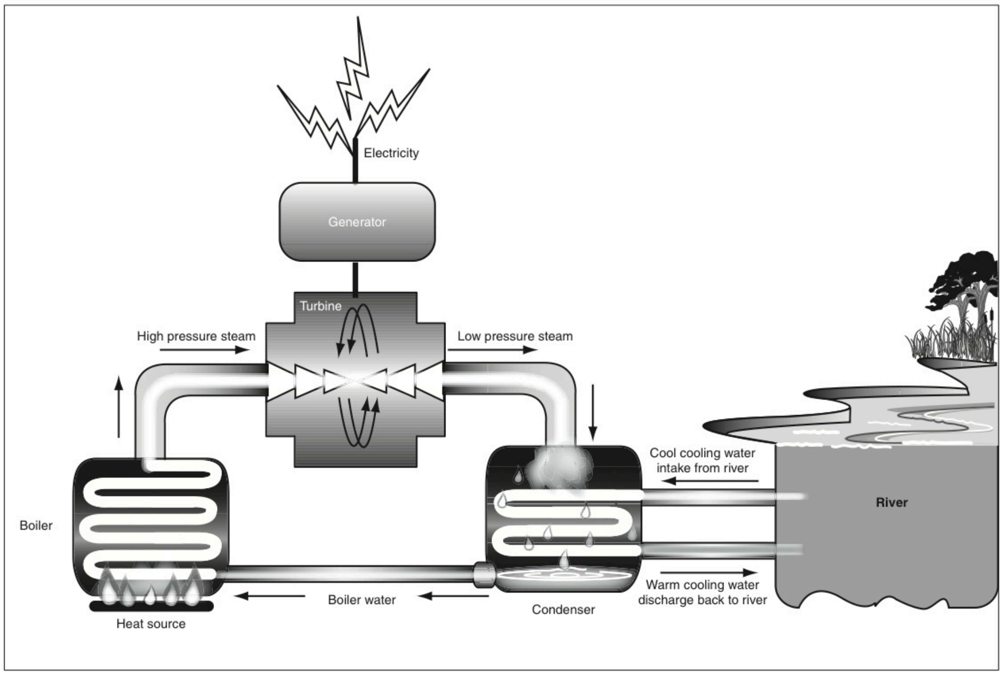


Figure 2. Steam Turbine with a Once-Through Cooling System[4]

Water is pulled in from the source – typically a river, lake or ocean – passed through the condenser of the power plant and immediately sent back to the source at an elevated temperature.

Figure 3 is a Landsat image of the Brunner Island coal-fired power plant that has a once-through cooling system. The red plume in the Susquehanna River is the discharged cooling water. The color of the plume in this Landsat image indicates that it does not mix immediately with the surrounding, cooler water and is therefore more likely to evaporate downstream of the plant.

4 Government Accountability Office, *Energy – Water Nexus: Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use*, October 2009.

Figure 3. Landsat Image of Three Mile Island Nuclear and Brunner Island Coal Plants[5]

5 Franklin & Marshall College, http://www.fandm.edu/uploads/media_items/images-departments-earth-brunnera_6-5-3-jpg.480.379.s.jpg

Figure 4 shows a closed loop system.

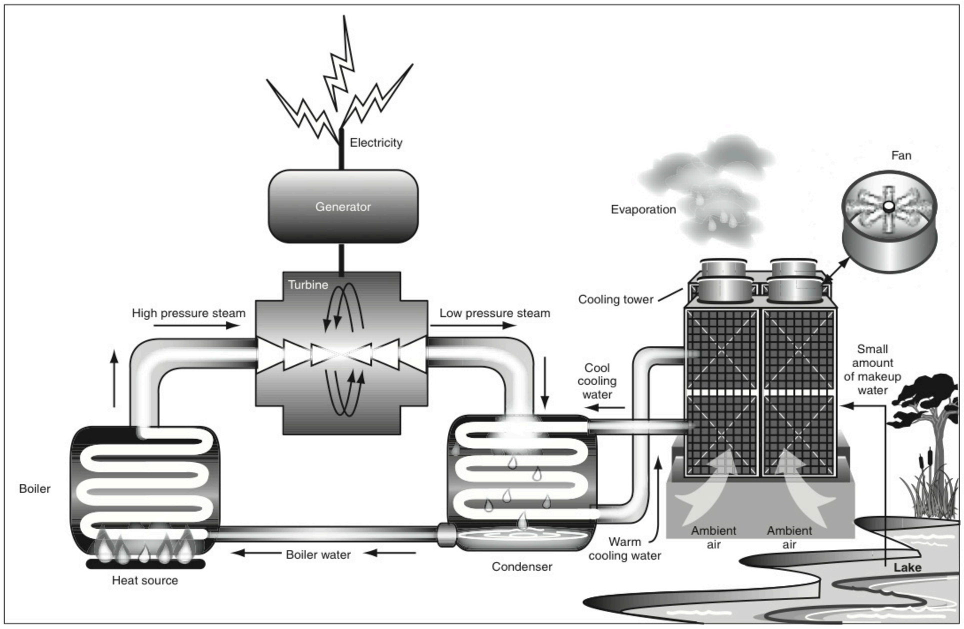


Figure 4. Steam Turbine with a Closed Loop Cooling System[6]

In a closed loop cooling system, water is pulled from the source, used to cool the plant and then sent to a cooling tower where it is condensed and reused again. In the process of condensing the water, roughly two percent[7] is lost through evaporation during each pass through the cooling tower. However, because the same water is used multiple times, roughly 70 to 90 percent of the water is ultimately consumed by the plant (depending on temperature and other factors) primarily due to evaporation from the cooling towers.

3. Inaccuracies that Impact the Forecast

We identified a number of problems with EPD's Technical Memorandum. We recommend that EPD address each of these inaccuracies in its baseline forecast, as well as adopting an alternative, water conserving scenario, as described in Section 5.

A. Forecast electricity consumption is based on an excessive growth rate

The EPD water consumption forecast is a worst-case scenario rather than a best estimate based on available data because it assumes that electricity consumption grows at an unreasonably high rate.

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6 Id.

7 U.S. National Energy Technology Laboratory (NETL). "Water Usage in Coal to Electrical Applications." http://www.netl.doe.gov/technologies/coalpower/gasification/gasifipedia/7-advantages/7-1-2_waterusage.html

It is understandable that EPD had difficulty developing a reliable energy forecast because the state of Georgia allows electric utilities to maintain energy forecasts "trade secret," in contrast to the vast majority of states which routinely publish such data.

In place of this information, EPD used population as the explanatory variable for energy consumption. Based on eighteen years of historical data, EPD found a positive correlation between population and electricity consumption and carried that relationship forward through 2050. The result is an assumption that electricity consumption will increase 1.64% annually (Baseline Power Needs).

The same relationship was used to develop the Alternative Statewide Power Needs forecast, but rather than taking the mean value for the dependent variable, i.e., electric generation needs, EPD took the upper limit of the 95 percent confidence interval. To put it another way, because population did not entirely explain generation, there is some variability around the mean value or the most likely result (which yielded the 1.64% rate). To estimate a higher rate of growth, EPD took the highest, yet still statistically significant value it could. That yielded a 2.14% rate of growth in the Alternative Statewide Power Needs forecast.

Though analytically correct, we doubt the validity of these forecasts for the simple reason that population is not the only variable explaining electricity consumption.

EPD's use of population growth as a proxy for electricity consumption growth neglects the steady erosion of that relationship over recent history. As illustrated in Figure 5, electricity growth has slowed from an average of 9.8 percent in the 1950s to 0.5 percent in the 2000s even as the U.S. population has dramatically increased.

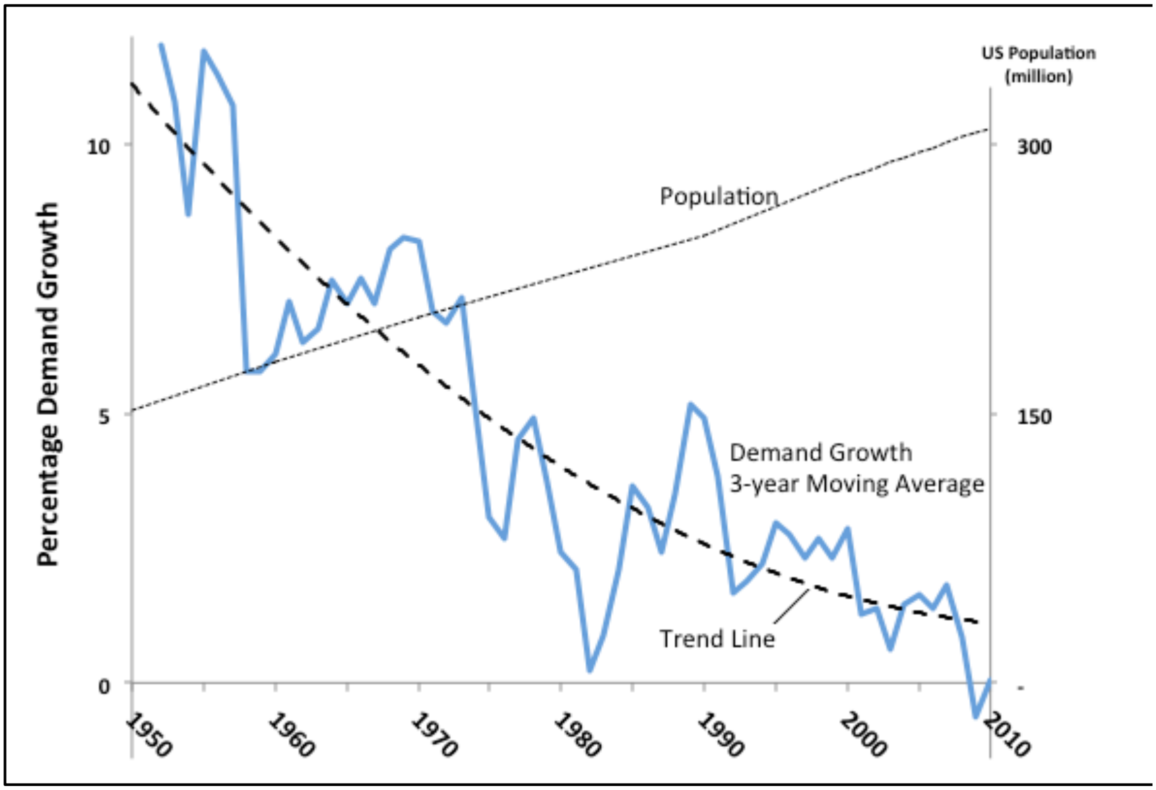

Figure 5. U.S. Electricity Demand Growth and Population, 1952-2010 (3-year moving avg.)[8]

Because of this and because of the recent downturn in the economy, we view these rates of increase as highly uncertain. A better estimate than EPD's 1.64% figure might be the 0.9% annual growth rate forecast in EIA's Annual Energy Outlook 2011 for the southeastern region of the SERC Reliability Corporation (SERC), which includes Alabama and Georgia.

B. Inaccurate baseline exaggerates current and future demand

The base 2010 electricity consumption used in the Technical Memorandum is too high. The EPD assumed that electricity generation in 2010 was 146,495 GWh (gigawatt hours) when Georgia utilities actually reported generation of 135,850 GWh.[9] The exaggerated baseline is magnified in future years by the excessive growth rate.

C. Capacity development scenario is poorly informed

EPD assumes that peak load will grow by 1,000 MW per year from 2020 to 2050, and that capacity additions to meet this demand will be dominated by nuclear and coal-fired

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8 Energy Information Administration (EIA). *Annual Energy Outlook 2011*. At http://www.eia.doe.gov/forecasts/aeo/MT_electric.cfm and U.S. Census Bureau.

9 See EIA Form 923.

plants. These assumptions are neither reflective of recent history, consistent with likely future trends, nor justified when considering ongoing technological change.

The assumption of 1,000 MW per year growth in peak demand (most energy used at any moment of the year) is greater than historic trends. Approximately 800 MW per year of capacity has been built in Georgia since 1990. Furthermore, even adopting this historic figure would likely be an overestimate, considering the declining rate of load growth (discussed above). It is unrealistic to project a near doubling of electrical generating capacity without clear justification.

Another problem with the capacity development scenario is that half of the 30,000 MW of new capacity needed to meet this demand is assumed to be from nuclear and coal-fired power plants. This assumption is neither reflective of the existing system nor the capacity additions that have been made in recent years. Since 1990, capacity additions have been primarily natural gas plants. This type of capacity is easier to site and generally lower cost than coal or nuclear plants. Gas plants also happen to use much less water.

Furthermore, EPD's forecast overlooks other energy options that require significantly less water than nuclear or fossil-fired technologies. These include energy efficiency, solar and wind. Including these energy resources in its forecast would significantly reduce forecast water consumption.

D. No plant retirements after 2017

EPD has assumed that there will not be any power plant retirements after 2017. EPD's forecast implicitly assumes that a significant number of existing units will still be operating in 2050 in spite of being quite old. Plant Harlee Branch, for example, will be at least 80 years old by 2050. It is unrealistic to expect that power plants will continue to operate to that age.

It is likely that much of that older capacity uses once-through systems and if replaced MW for MW by new coal generation, water consumption could increase by roughly 60% (see Table 1).[10] A conservative assumption, i.e., one that would tend to minimize retirements, would be to retire plants once they reach 60 or 70 years of service.

E. Exclusion of the proposed Plant Ben Hill Coal Plant

Plant Ben Hill, a proposed 850 MW coal-fired power plant planned for south-central Ben Hill County, is not included in Table 10 of the Technical Memo which lists planned energy facilities. EPD excluded planned facilities that do not have a water permit, but

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[10] There are other energy alternatives such as energy efficiency, wind, solar and natural gas combined cycle, all of which consume less water.

Plant Ben Hill is no more or less likely to be built than Plant Washington, which was included in the forecast. Presumably Plant Ben Hill would have an in-service date prior to 2017, so the projected water consumption from this plant should be included in the Suwanee-Satilla region forecast demand. Assuming the plant is dispatched at the capacity factor assumed by EPD for comparable plants, it would consume an additional 8 million gallons per day (MGD).

F. Zero water consumption inappropriately assumed for once-through cooling systems

For purposes of its forecast, EPD has assumed that once-through cooling systems consume no water. While this may be technically accurate within the confines of a plant, as described previously, significant evaporation occurs when the warmed water is discharged back to its source. EPD implicitly acknowledged this fact by republishing consumption figures for once-through cooling systems from two sources in its Technical Memorandum – though it did not ultimately use those numbers. Table 1 compares EPD and one of those sources, the Electric Power Research Institute (EPRI).

Table 1. Comparison of EPRI and EPD Water Consumption Estimates[11]

Plant Type	**Once-Through (gallons/MWh)**	
	EPRI	*EPD*
Coal	300	0
Combined Cycle	100	N/A
Nuclear	400	N/A

It is important to note that new electric generation is very unlikely to have once-through cooling systems because of environmental concerns over the ecological impacts of withdrawing such large amounts of water. However, the forecast is affected by this inaccuracy because approximately 3,500 MW of existing capacity in Georgia has a once-through cooling system. Those plants include Plant Hammond, Plant Harlee Branch, Plant McManus, Plant Mitchell, and one unit at Plant McIntosh.

G. Additional water consumption for Flue Gas Desulfurization Units (Scrubbers) is not included

It is our understanding that most of the coal-fired power plants in Georgia either already have or are planning to install Flue Gas Desulfurization equipment ("FGD") to reduce sulfur dioxide emissions. It is unclear whether the EPD's forecast includes the increased water consumed by coal plants as a result of the addition of FGD equipment since EPD's numbers are the average of data from 2003 to 2007, prior to FGD installations at most plants. To the extent that the future water consumption by the state's coal-fired power

11 Id and EPD Technical Memorandum.

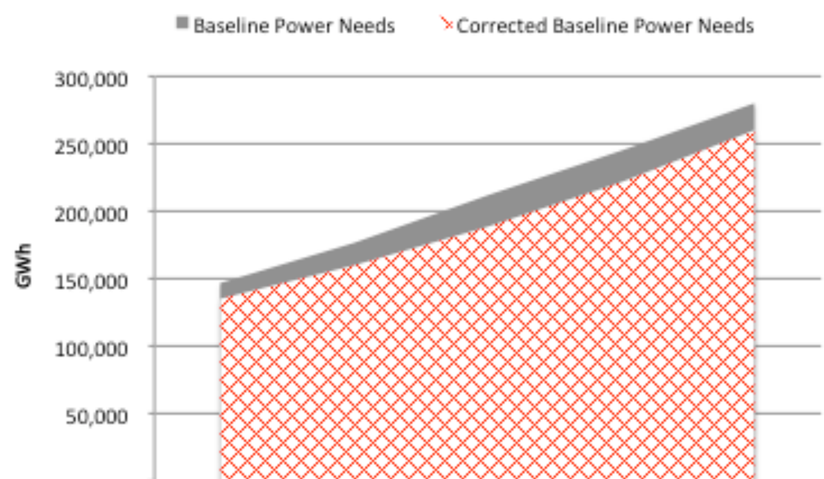
plants ignores the impact of FGDs, their future water consumption will be underestimated by roughly 10%.

H. Additional water consumption for carbon capture is not included

The 12,000 MW of new fossil-fired capacity that EPD assumes will be added during the forecast period (in the Baseline Power Needs Additional Capacity Scenario) could be required to install a pollution control technology called carbon capture. Although this technology will reduce the units' emissions of greenhouse gases, carbon capture will likely increase consumption rates by roughly 100%.[12] The technology is most likely to be required for new coal plants completed during the 2020 – 2050 timeframe to meet greenhouse gas regulations.

4. Corrected Baseline Power Needs Additional Capacity Scenario

We've developed a "Corrected Baseline Power Needs Additional Capacity Scenario" that adopts the 2010 electricity consumption reported by Georgia utilities to the EIA: 135,851 GWh rather than 146,495 GWh as EPD assumes.



	2010	2020	2030	2040	2050
Baseline Power Needs	146,495	176,080	210,957	245,533	280,726
Corrected Baseline Power Needs	135,851	159,849	188,086	221,311	260,405

Figure 6. Comparison of Baseline Power Needs and Corrected Baseline Power Needs Scenario Energy Forecasts

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12 U.S. National Energy Technology Laboratory (NETL). "Water Usage in Coal to Electrical Applications." http://www.netl.doe.gov/technologies/coalpower/gasification/gasifipedia/7-advantages/7-1-2_waterusage.html

By 2050, the difference between these two forecasts magnifies to about 20,000 GWh. The effect of this change on water consumption will be driven by the energy resource mix that serves future needs and secondarily, by the type of cooling system used by thermal power plants included in that mix.

Another "simple" correction to EPD's analysis is to assign a consumption value to once-through cooling systems. For example, the EPRI data cited in EPD's report estimates that fossil fuel-fired power plants with once-through cooling systems consume 300 gallons per MWh generated. Under that assumption, EPD underestimates water consumption by thirteen to fifteen million gallons per day as demonstrated in Figure 7.

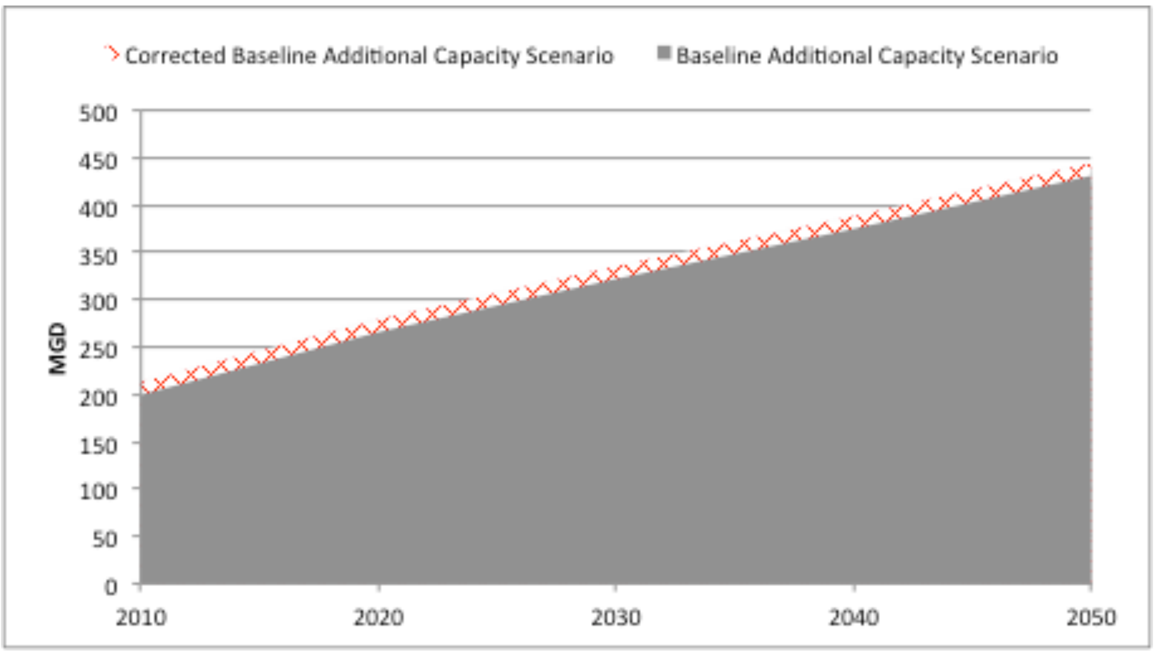

Figure 7. Comparison of EPD Baseline Additional Capacity Scenario Water Consumption with and without Consumption for Once-Through Cooling (MGD)

Note that the Corrected Baseline Additional Capacity Scenario illustrated in Figure 7 incorporates a different change here than what was shown in Figure 6. Figure 6 shows the change in GWh needed when starting from the proper 2010 baseline. Figure 7 simply shows the relative impact of adding in the consumption from once-through cooling systems. These two items were the only changes that were practical to implement given the limited data made public by EPD. We recommend EPD make additional changes, including accounting for FGD related water consumption, retiring older units, development of near-term capacity, and adopting a more realistic peak load forecast, which would produce an improved forecast.

5. A Water Conserving Scenario

As we noted in Section 2, EPD's water consumption scenarios all assume that nearly all electrical generation is produced by thermal power plants. However, wind and solar photovoltaic systems are not thermal power plants and therefore do not require water for cooling. The nominal water requirements of these technologies are for activities such as cleaning solar panels or turbine blades.[13]

In addition, energy efficiency and demand response resources use no water. Energy efficient technologies provide the same performance and convenience as conventional technologies but use less energy. Energy efficient technologies include compact fluorescent light bulbs, energy efficient refrigerators, building insulation, etc. Demand response is the reduction of load, typically at peak periods of usage. For example, a manufacturing facility might shift use of energy-intensive equipment to times of the day when demand decreases and therefore prices are more affordable. The combination of energy efficiency and demand response is commonly referred to as demand-side management (DSM).

Our proposed Water Conserving Scenario ("WCS") is an adjustment to the Corrected Baseline Power Needs Scenario. We did not adjust the assumptions related to power plant development plans through 2017, nor did we adjust the long term capacity forecast.

EPD adopts utility assumptions regarding the development of 7,896 MW of net capacity through 2017 (see Table 10 of the Technical Memo). We do not endorse that assumption as realistic for several reasons, not the least of which is that it results in far more generating capacity than is needed. Considering the permitting, licensing and financial obstacles to completing the large, water-intensive proposed plants (Vogtle reactor Units 3 and 4, Plant Washington and Longleaf coal plants), it remains uncertain whether these plants will ever be built. If these plants become operational, they would increase state water consumption by 44 million gallons per day relative to supplying the same amount of electricity from natural gas combined cycle plants.[14]

Our proposed WCS adjustments include the replacement of forecast power plant construction after 2017 with the use of energy efficiency and demand response resources, some natural gas rather than coal and nuclear, additional water consumption at plants with once-through cooling systems and the Corrected Baseline Power Needs energy forecast. Detailed data tables for the Water Conserving Scenario are given in Appendix A.

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13 United States Department of Energy (DOE), *Energy Demands on Water Resources, Report to Congress on the Interdependency on Energy and Water*, p. 41, December 2006.

14 Based on EPD assumptions.

The additional energy efficiency is applied starting in 2011, assuming Georgia begins to achieve incremental energy efficiency savings each year of 1.0% of sales.[15] Demand response reduces peak demand by 8.6% in any given year. Just the addition of DSM means that Georgia can meet its forecasted energy needs through 2050 and its peak demand needs until sometime after 2030.

The factor driving need for new capacity after 2030 was the increase in peak load[16] of 1,000 MW per year rather than the need for more megawatt hours. To meet "peaking" needs at low cost, we assumed 6,000 MW of new gas turbines (GTs) between 2030 and 2040 were built and an additional 6,000 MW between 2040 and 2050. This scenario suggests that Georgia's electricity needs could be met with much less water in 2050 than suggested in EPD's forecast.

As illustrated in Figure 8, energy efficiency savings (and to a lesser extent the Corrected Baseline Power Needs forecast described in Section 4) result in far less electrical generation in the Water Conserving Scenario than the Baseline Additional Capacity Scenario – a difference of nearly 100,000 GWh by 2050.

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15 Chandler, Sharon and Marilyn A. Brown. "Meta-Review of Efficiency Potential Studies and Their Implications for the South." Working Paper #51 of the Georgia Tech Ivan College School of Public Policy.

16 Peak load is the highest moment of power demand during any one year and is measured in MW.

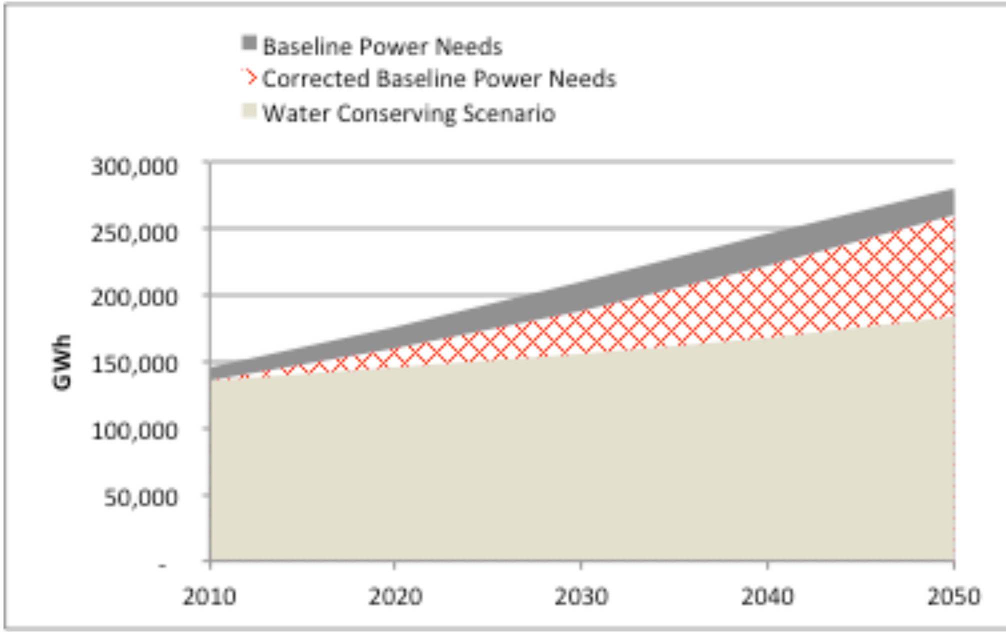

Figure 8. Generation (GWh) for Baseline Power Needs, Corrected Baseline and Water Conserving

As illustrated in Figure 9, the Water Conserving Scenario also requires much less generating capacity by 2050 because over 21,000 MW of DSM have been implemented.

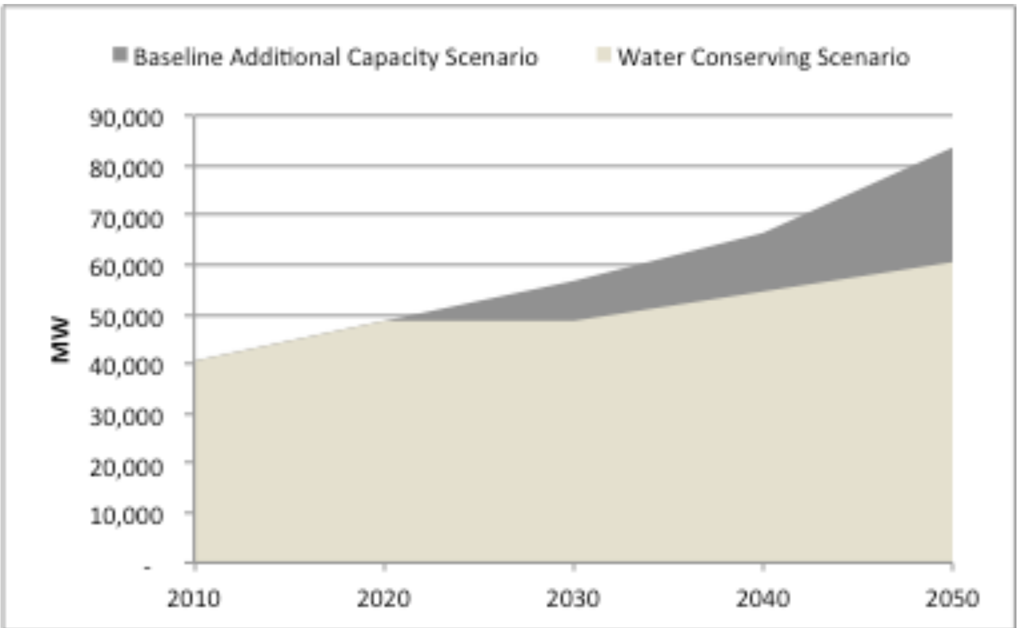

Figure 9. Total Generating Capacity (MW) for Water Conserving and Baseline Additional Capacity Scenarios

As illustrated in Figure 10, Georgia's energy needs can be met with far less water resource demand than suggested by the EPD Baseline forecast. Even under the Water Conserving Scenario, the electricity sector would consume additional water in the future. However, instead of more than doubling consumption by 2050, consumption increases nearly 50 percent by 2050. Both scenarios meet Georgia's generation demands but the water demands are radically different.

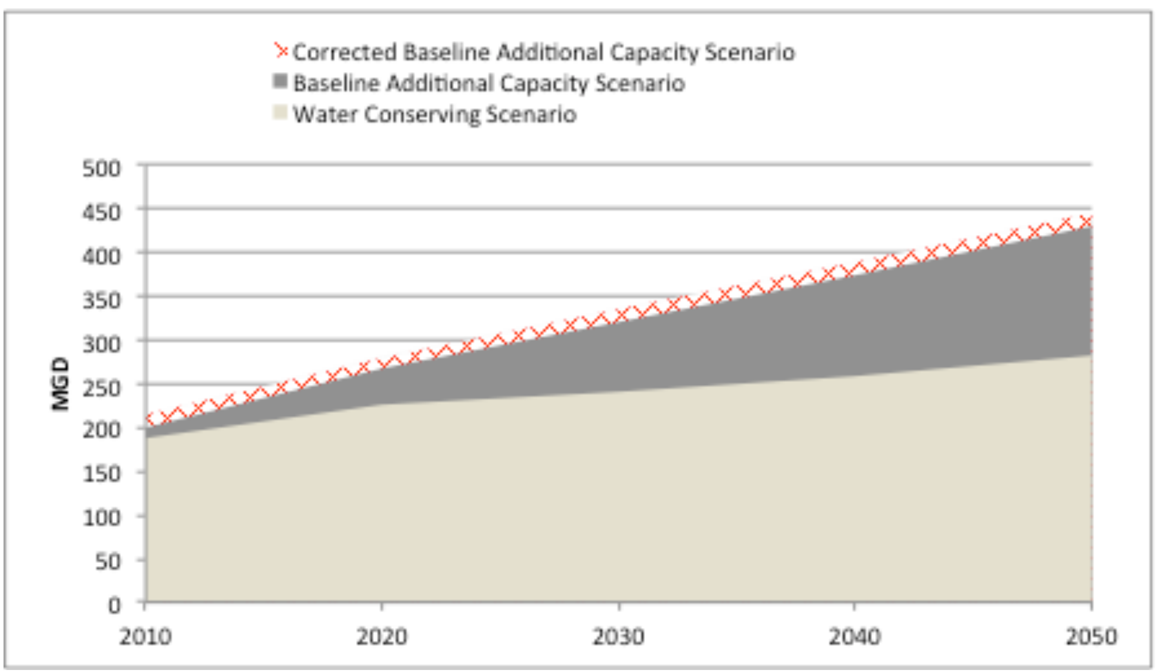

Figure 10. Water Consumption Demands, MGD

6. Summary of Recommendations

Georgia is taking an important step toward smart energy-water planning by examining how energy production and consumption might influence water consumption. The assumptions made in the EPD Technical Memo, however, mean that the Baseline case is actually a worst-case scenario: too much energy production requiring excessively high water demand. We recommend the following revisions to correct this problem:

1. Revise the EPD baseline scenario to correct for the inaccuracies identified in Section 3.[17]
2. Develop a Water Conserving Scenario that includes energy efficiency (1.0% energy savings per year) and demand response resources and a preference for natural gas among conventional resource options. EPD could add wind and solar resources to this scenario although doing so would introduce a greater level of complexity.

These changes would more accurately reflect future electrical generation. The implication of which, is a more realistic scenario of water consumption in the electric sector. Finally, as we noted in the introduction to this report, forecasting future water consumption that may be required for future electricity generation is only meaningful when accompanied by an assessment of water availability.

[17] We view the Alternative scenario as wildly unrealistic regarding future energy use and power plant construction. EPD may wish to omit this scenario from a revised analysis.

Appendix A

Table A.1 Capacity Factors of Power Generation Combinations in the Water Conserving and Baseline Additional Capacity Scenarios

Water Conserving Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	26.8%	16.0%	16.0%	22.0%	23.5%
FF/Bio, GT	3.0%	2.0%	2.0%	2.0%	2.0%
FF/Bio ST, OT	45.0%	26.0%	35.0%	35.0%	27.0%
FF/Bio, ST, CT	70.0%	60.0%	65.0%	66.0%	77.0%
Nuc, ST, CT	84.0%	73.0%	75.0%	85.0%	85.0%
Hydro	10.0%	10.0%	10.0%	10.0%	10.0%
Baseline Additional Capacity Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	26.8%	19.4%	17.0%	17.0%	17.0%
FF/Bio, GT	3.8%	2.0%	2.0%	2.5%	2.0%
FF/Bio ST, OT	57.0%	53.0%	53.0%	53.0%	53.0%
FF/Bio, ST, CT	74.0%	68.0%	67.0%	65.7%	65.3%
Nuc, ST, CT	90.0%	89.0%	89.0%	89.0%	89.0%
Hydro	10.0%	10.0%	10.0%	10.0%	10.0%

NG, CC, CT = natural gas combined cycle with cooling towers
FF/Bio, GT – fossil fuel/biomass, gas turbine[18]
FF/Bio ST, OT = fossil fuel/biomass, steam turbine, once-through cooling[19]
FF/Bio ST, CT = fossil fuel/biomass, steam turbine, cooling towers[20]
Nuc, ST, CT = nuclear, steam turbine, cooling towers

18 It should be assumed that gas turbines are fired with natural gas or diesel fuel. From a technological standpoint, it is highly unlikely that biomass would be used in a gas turbine.

19 It should be assumed that steam turbines are fired with coal. From a technological and economic standpoint, it is highly unlikely that biomass would exclusively be used in a steam plant.

20 It should be assumed that steam turbines are fired with coal. From a technological and economic standpoint, it is highly unlikely that biomass would exclusively be used in a steam plant.

Table A.2 Generation (GWh) by Power Generation Combination in the Water Conserving and Baseline Additional Capacity Scenarios[21]

Water Conserving Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	18,403	12,662	12,657	17,396	18,589
FF/Bio, GT	2,801	1,932	1,932	2,984	4,035
FF/Bio ST, OT	14,083	8,003	10,772	10,773	8,311
FF/Bio, ST, CT	67,772	79,935	86,644	87,928	102,594
Nuc, ST, CT	29,742	39,941	41,035	46,506	46,500
Hydro	3,195	3,195	3,195	3,195	3,195
EE	-	14,873	32,373	52,964	77,193
DR	-	-	-	-	-
Total	135,996	160,540	188,608	221,745	260,418
Total Required	135,851	159,849	188,086	221,311	260,405
Baseline Additional Capacity Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	18,403	15,353	17,916	22,384	26,851
FF/Bio, GT	3,548	1,932	2,283	3,291	3,729
FF/Bio ST, OT	17,839	16,313	16,313	16,313	16,313
FF/Bio, ST, CT	71,645	90,593	112,650	133,607	155,747
Nuc, ST, CT	31,866	48,695	56,491	64,288	72,084
Hydro	3,195	3,195	3,195	3,195	3,195
Other Renewable	-	-	2,110	2,455	2,807
Total	146,495	176,080	210,957	245,533	280,726
Total Required	146,495	176,080	210,957	245,533	280,726

NG, CC, CT = natural gas combined cycle with cooling towers
FF/Bio, GT – fossil fuel/biomass, gas turbine
FF/Bio ST, OT = fossil fuel/biomass, steam turbine, once-through cooling
FF/Bio ST, CT = fossil fuel/biomass, steam turbine, cooling towers
Nuc, ST, CT = nuclear, steam turbine, cooling towers
EE = energy efficiency
DR = demand response

[21] "Total" GWh in the Water Conserving Scenario do not exactly match the "Total Required" because developing capacity factors to the number of significant digits necessary to exactly match the Total Required would not have yielded, we believed, a significantly more accurate forecast.

Table A.3 Water Consumption (MGD) by Power Generation Combination in the Water Conserving, Baseline Additional Capacity Scenarios and Corrected Baseline Additional Capacity Scenarios

Water Conserving Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	10	7	7	9	10
FF/Bio, GT	-	-	-	-	-
FF/Bio ST, OT	15	13	13	13	13
FF/Bio, ST, CT	105	124	135	137	159
Nuc, ST, CT	72	96	99	112	112
Hydro	-	-	-	-	-
Total	202	241	254	272	295
Baseline Additional Capacity Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	10	8	10	12	15
FF/Bio, GT	-	-	-	-	-
FF/Bio ST, OT	-	-	-	-	-
FF/Bio, ST, CT	111	141	175	208	242
Nuc, ST, CT	77	117	136	155	174
Hydro	-	-	-	-	-
Other Renewable	-	-	-	-	-
Total	198	266	321	375	430
Corrected Baseline Additional Capacity Scenario					
	2010	2020	2030	2040	2050
NG, CC, CT	10	8	10	12	15
FF/Bio, GT	0	0	0	0	0
FF/Bio ST, OT	15	13	13	13	13
FF/Bio, ST, CT	111	141	175	208	242
Nuc, ST, CT	77	117	136	155	174
Hydro	0	0	0	0	0
Other Renewable	0	0	0	0	0
Total	213	280	334	388	444

NG, CC, CT = natural gas combined cycle with cooling towers
FF/Bio, GT – fossil fuel/biomass, gas turbine
FF/Bio ST, OT = fossil fuel/biomass, steam turbine, once-through cooling
FF/Bio ST, CT = fossil fuel/biomass, steam turbine, cooling towers
Nuc, ST, CT = nuclear, steam turbine, cooling towers