Analyzing the Absence of Renewable Portfolio Standards in Georgia

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EIA: Energy Information Administration

GHG: Greenhouse Gases

RPS: Renewable Portfolio Standard

ABSTRACT

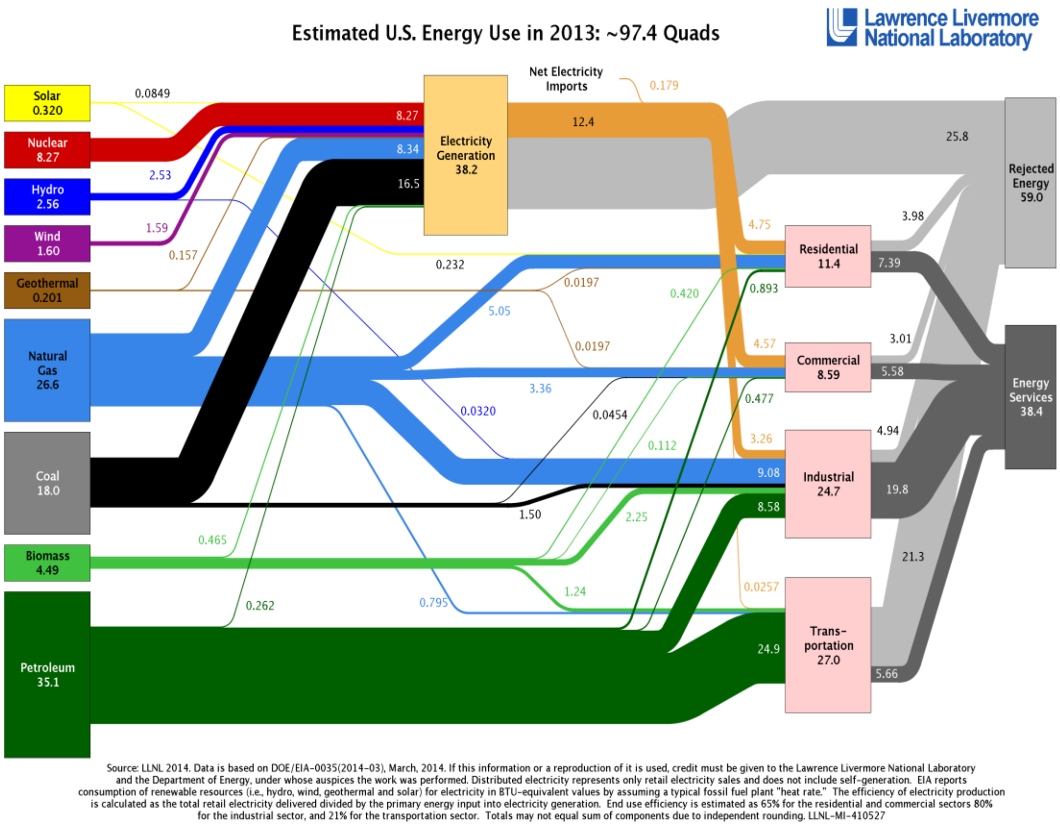
The United States electrical utility industry is being called upon to reduce carbon dioxide emissions from fossil fueled electricity-generating plants, which are responsible for 40% of the nation's carbon dioxide output (EPA, 2014). One response to this has been the state-level adoption of Renewable Portfolio Standards (RPS)—policy tools that require electrical utilities to generate a pre-determined fraction of their electricity from renewable sources. Although 37 states having adopted RPS, a block of seven Southeastern states have not, even though these states appear to have substantial renewable energy technical resources. The question arising is: Why have these states not adopted RPS? This thesis focuses on the state of Georgia and explores four potential hypotheses to answer this question: 1) The collective experiences of the 37 adopter states show that RPS are not causally linked to increased use of renewables; 2) Contrary to beliefs, the renewable resources in Georgia are inadequate; 3) The inherent structure of the electric utility system in Georgia is not hospitable to large scale use of renewable energy; 4) Conservative politics in Georgia oppose the adoption of RPS. I found that the primary reason Georgia has not adopted RPS is within the circumstances of hypothesis #3 and Georgia's commitment to expanding nuclear energy for electricity generation. Additionally, I found that circumstantial evidence suggests that Hypothesis #4 is a likely secondary explanation.

INTRODUCTION

In 2013, the United States' total primary energy consumption was approximately 97 Quads (quadrillion British Thermal Units), about 40% of which was used for the purpose of generating electricity. From this sector, 43% came from the combustion of coal and 20% from the combustion of natural gas (*Figure 1*). Electricity production from coal and natural gas combustion account for about 30% and 10% respectively, of U.S. total carbon dioxide emissions. (EIA Energy Annual Report, 2013). The heat-engines that drive electrical generators are able to convert 32% of their combustion energy into the mechanical work of electrical generation (*Figure 1, designated "rejected energy."*). In other words, about 68% of that combustion energy is lost as heat—an unavoidable thermodynamic transaction cost of converting heat to mechanical work in a cyclic heat engine. Considering carbon dioxide emissions and climate change, about two thirds of the electric sector's carbon dioxide emissions are therefore associated with waste heat. Consequently, the electrical generation is a primary target for reducing dependence on the combustion of fossil fuels (almost exclusively coal and natural gas).

One means of reducing carbon dioxide emissions is to replace the electricity generated from coal and natural gas with "renewable" energy sources: some combination of sunlight, wind, biomass, falling water (hydroelectricity), and geothermal heat. Electricity generation from renewable energy sources has not been economically competitive with that from well-established coal and natural gas fired power plants, and as a result, electrical utilities have had little incentive to adopt such practices. Consequently, advocates of expanded renewable energy production see government intervention, whether through financial incentives or regulations, as an important means of cutting carbon dioxide discharge from the electrical sector.

Figure 1- EIA Sankey Diagram of Energy Use by Sector



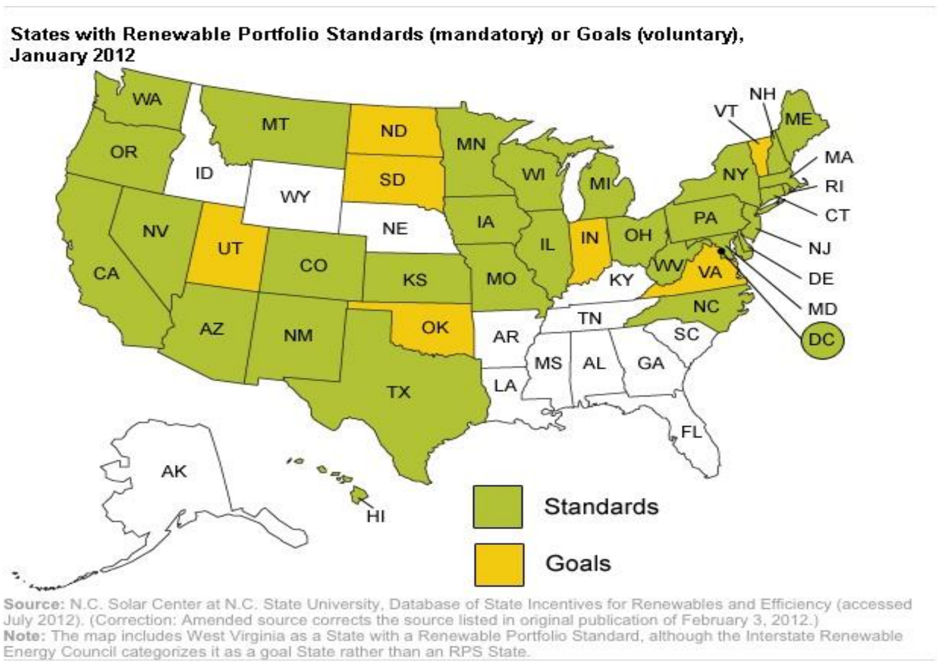
In the late 1990s, the California Public Utilities Commission convened a working group to consider the role of renewable energy in the restructuring of the state's electric utility industry. This group introduced the concept of legally required Renewable Portfolio Standards (RPS) as a state-level mechanism that required electrical companies operating within the state to switch a specified percentage of electricity energy produced from fossil fuels to renewable energy sources (Wiser et al., 2007). The proponents of RPS assumed that electrical utilities will find the means necessary to reduce the additional expenses of deriving a greater proportion of electricity from renewables. As a result, RPS would ultimately catalyze the competitiveness of renewable energies through a market-based, bottoms-up approach (Rabe, 2007). The California legislature enacted RPS regulations in 2002, and subsequently other state governments created RPS regulations predominantly through legislation, but also through regulatory channels and voter-approved initiatives (Wiser et al., 2007). RPS emerged at the state-level, rather than at the Federal level, because the legislatively delegated authority of the Federal Energy Regulatory Commission (FERC) does not provide the scope to create and enforce a nationwide RPS mandate. Such authorization requires Congress to pass a new law, an event that renewable energy advocates generally see as unachievable.

Since the formulation of RPS in 2002 by the California legislature, 37 state governments have established RPS. Therefore it is reasonable to assume that the experiences of these 37 adopter states have established a body of information on the environmental and social conditions and the political processes that catalyze adoption of RPS. Currently state-level RPS are the most widespread state-level legislative approach to encourage renewable energy sources for electricity generation. States develop their own goals for carbon dioxide reduction, timeframe for implementation, and enforcement mechanisms (Shrimali et al., 2012). Each state also determines what mixture of renewable resources (wind, solar, etc) it will use.

THESIS RESEARCH QUESTION

A curious feature of RPS initiatives is their absence in the Southeastern region of the U.S. (*Figure 2*). It is noteworthy because this area is commonly regarded as "sunny"—their latitude range (below 25 degrees) is slightly south of the solar-energy hot spots in the Southwestern U.S.—and presumably has a similar degree of solar power potential. Additionally, the Southeast has forestry and agriculture industries that could produce biofuels, and at least superficially there are no reasons to assume that the wind resources are not at a minimum as good as those of several of the 37 states with RPS. The question then is: Why have the Southeastern states not adopted RPS if such rich renewables potential exists? The following thesis examines this question through four hypotheses that individually or in conjunction could answer it.

Figure 2- States with Renewable Portfolio Standards (2012)



THE FRAMEWORK OF RPS

Before attempting to answer this question, it is necessary to understand that RPS are “local” constructions, and individual state governments, perhaps motivated by local citizens’ advocacy groups, can choose whether or not to institute mandates. There are no federal governance mechanisms for standardizing RPS among states, and consequently comparisons of the efficacy of RPS frameworks among states are subject to consideration of local resource conditions and political structure. Some states that have adopted RPS may base their goals upon delivered electrical energy (expressed as megawatt hours-MWH), while others could base their goals on electrical generating power capacity (expressed as megawatts-MW). The distinction between delivered electrical energy (MWH) and power (MW) must be made because power (MW) is a metric for the capacity to generate electrical energy (MWH). Delivered energy (MWH) is the metric for how that capacity was actually used. Hypothetically, a utility could claim that 15% of its capacity is from renewable energy, but if the utility doesn't use that capacity it obviously accomplishes nothing. Among the 37 states that have adopted RPS, the goals for the fraction of total electrical energy generated (MWH) from renewables fall between 4% and 30%, depending upon resource availability, electricity demand, and population distribution. Additionally, some states' goals reflect local secondary objectives. For example, some states may see opportunities for "new jobs" associated with renewable energy technologies (e.g. solar panels and wind turbines); others could perceive opportunities to exploit federal fiscal stimulus packages. Others may see disincentives because of the costs to taxpayers if their utilities were subsidized to implement RPS goals, alongside the increased cost of electricity to end-users.

RPS are predominantly aimed at "large" central regulated electric utilities that generate the majority of electrical energy within a state. States also may have municipally owned generators and cooperatives that could constitute "special cases" in the RPS context because they could fall outside of the state's regulatory structure, depending on the state. In terms of the large central utilities, however, there are conventionally three options for meeting RPS requirements. The first is by operating independent and exclusively renewables-derived electrical generating facilities. The second is by purchasing Renewable Energy Certificates (RECs) from qualified "green" energy producers, who then allocate the right to the benefits achieved from their clean energy back to the buyer. The third is the purchase of "bundled renewable electricity", meaning a group can buy energy directly from a solar, wind, biofuel/biomass, or geothermal facility (EIA, 2014).

The emergence of RPS in California was initially the outcome of a political experiment to reduce the environmental impacts of electricity generation while simultaneously creating a healthy market for renewable technologies. Since the early 2000's 37 states have now adopted RPS. Whether their adoption was the outcome of activist groups or the initiatives of governance, it seems reasonable to conclude that these states have determined that the RPS mechanism is a feasible method for increasing the integration of renewable energy sources into the electricity system. The question then arises, in view of the experiences of 37 states and their interest groups, why does a block of the Southeastern U.S. not have RPS in place?

Narrowing the Research Scope

This thesis examines four hypotheses for explaining the absence of RPS.

1. Contrary to beliefs and assumptions, the experiences of the 37 adopter states show that RPS do not result, in practice, in an increased use of renewable energy sources for electrical generation. In other words, data among the 37 states may demonstrate increased use of renewables, but the increase was the result of "some other" mechanisms or conditions, which cannot irrefutably be credited to RPS.

Thus, the Southeastern states may see no reason to adopt RPS if they do not prove useful in the experience of the adopting states.

2. The Southeastern states, although they superficially appear to have abundant solar and wind potential, do not have sufficient renewable energy resources to provide the electrical generation necessary to support RPS.
3. The organizational and technical infrastructure of the Southeastern states' electrical generation and distribution system makes RPS an impractical method for achieving increased renewables-derived electricity.
4. The political and social attitudes of the Southeastern states reject the need for renewable energy. Or, if they accept the need for renewable energy, they reject a government mandate, such as RPS, as a means of promoting their expansion into the electricity sector.

These four hypotheses are examined within the scope of Georgia as a case study, and my findings ultimately conclude that the lack of RPS in Georgia is likely a combination of the circumstances found within Hypotheses #3 and #4.

THE SOUTHEAST'S SIGNIFICANCE IN U.S. ENERGY

Before examining these hypotheses, a foundational question must be addressed: Are the Southeastern states relevant for study in terms of their percentage of national energy consumption and carbon dioxide emissions? This region first garnered particular interest because of their RPS absence, seemingly ample renewables resource potential, and nationwide impact in terms of size and emissions. Although Georgia will be examined as a case study, it is worth putting Georgia into the context of a holistic view of the Southeast. This thesis, however, is not a comparative study of similarities and differences among the Southeastern states.

According to the U.S. Census Bureau, the Southeastern states include the following: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, and Tennessee. Only five of the twelve above employ RPS mandates. Those that do not, and will thus be evaluated for significance, are: Mississippi, Alabama, Florida, South Carolina, Tennessee, Kentucky, and specific to this study, Georgia.

These seven states collectively account for 17% of the total U.S. population. Their CO_2 emissions from electricity production are summarized in the table below. Electricity production in the 7 non-RPS Southeastern states collectively account for about 448/1984 = 25% of U.S. total electrical energy related CO_2.

State	Million metric Tons Carbon Dioxide for Electric Power (U.S. total Electricity CO_2 ~1984) U.S. TOTAL CO_2 ~ 5300	Electric Power's Share of State Carbon Dioxide Emissions
Alabama	74	57.5%
Florida	110	48.7%
Georgia	68	44.1%
Kentucky	94	63.4%
Mississippi	23	38.2%
South Carolina	38	48.7%
Tennessee	41	39.4%

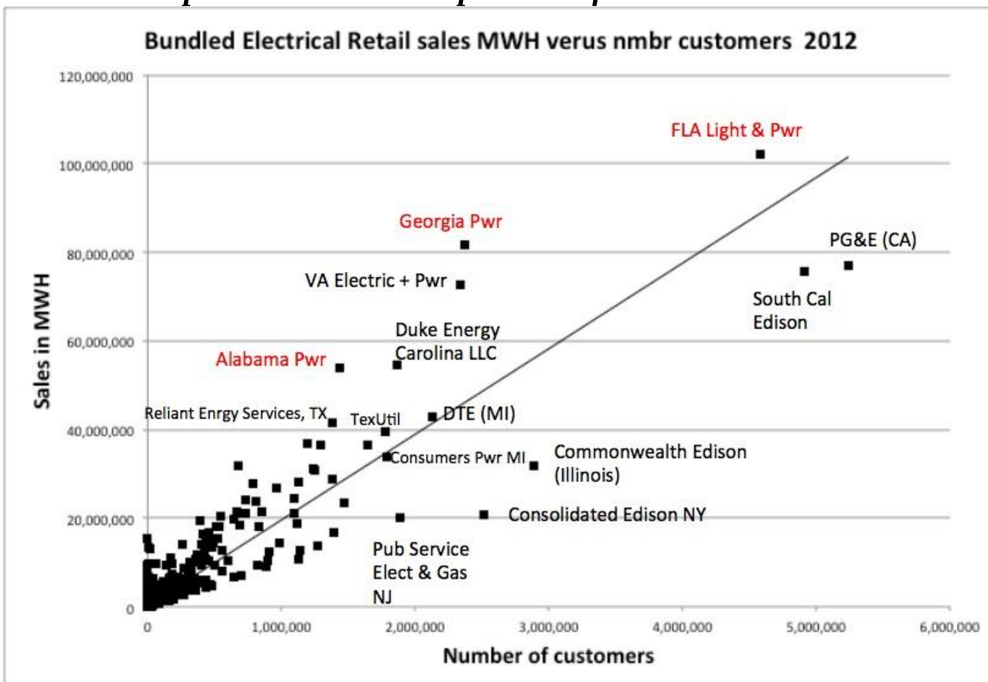
Coal, the "dirtiest" of the fossil fuels, is the most heavily used energy source within the electricity sector and is responsible for 43% of the U.S. total generation

(*Figure 1*). Nationally, CO_2 emissions from coal-fired electricity generation are about 1600 million metric tons, and the seven non-RPS states alone produce approximately 18% of these national coal emissions. In 2014, Florida, Alabama, and Georgia electrical energy production was 19,000 MWH, 11,000 MWH, and 9000 MWH respectively, ranking them nationally among states #2, #6, and #9, respectively in net electrical energy generation. Collectively all seven of the Southeastern states lacking RPS produced about 20% of the nation's net electricity in 2014 (EIA, 2014).

Another perspective on electrical energy consumption within the Southeast is their per-capita electrical energy consumption, which is higher than national averages. The EIA annually tabulates electrical energy retail sales and the number of customers served by individual utilities. From these data, I plotted electrical energy sales as a function of the number of customers for all the nation's utilities (*Graph 1*). The slope of the linear regression least squares best fit of electrical energy/customer estimates the national average per-capita consumption, which is then found to be 20MWH/customer. The highlighted utilities, Georgia Power, Alabama Power, and Florida Light and Power, are chief generators for their respective states. The per-capita electrical energy sales of these utilities are again considerably above the national average. This trend is likely the result of the Southeast's hot, humid climate, because seasonal air-conditioning requires large amounts of electricity. By contrast, states with severe winters rely more heavily on heating by natural gas than by electricity.

After gathering these data together, it can be seen that the non-RPS states are collectively significant contributors to the total U.S. carbon dioxide emissions associated with electrical energy production. Therefore, an examination of why these states have not adopted RPS is indeed a substantial piece in the nation's energy accounting.

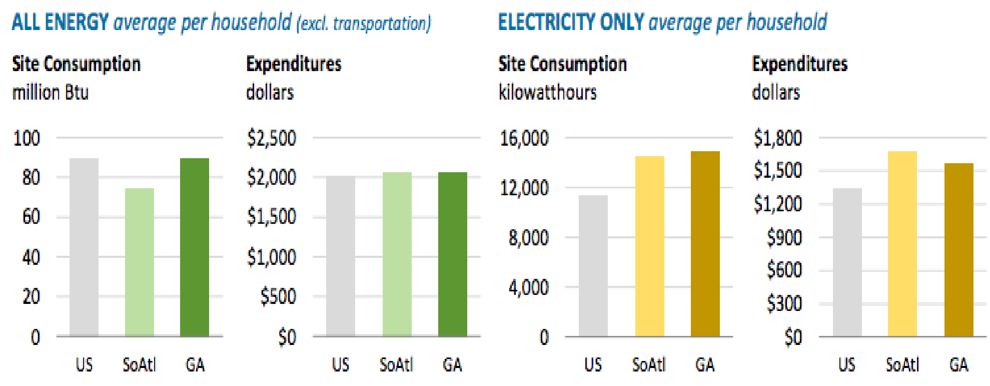
Graph 1- Electrical Companies # of Customers vs. Sales



Georgia as a Case Study

As the resources necessary for examining the absence of RPS in the entirety of the Southeast are beyond the scope of this study, a single state will be researched as a particular case study. These findings can then be used, at least foundationally, for future research into the absence of RPS throughout the region. Georgia will be the focus of this research for several reasons. Firstly, Georgia's per capita electrical retail sales are markedly higher than regional and national averages, suggesting they would benefit more than others from RPS adoption (*Graph 2*). Georgia's population (about 10 million) ranks it 8th among the states. Although Florida ranks 3rd in population (20 million), its geographical population distribution spans nearly 400 miles north to south, whereas the population of Georgia is concentrated in the greater Atlanta area. The condensed Atlanta metropolitan area accounts for about 60% of Georgia's population and the majority of electricity will therefore be transmitted to Atlanta from nearby generating facilities, meaning the larger corporations that would fall under RPS legislation.

Graph 2- Georgia's Energy and Electrical Standing



As discussed in a later section, I discovered in the course of this study that Georgia is unique within the Southeastern states in its recent investments into nuclear power for its electricity generation. The use of nuclear energy is likely to achieve greater carbon dioxide reductions than could be achieved by practical implementation of solar, wind, and biofuels. In retrospect, the choice of Georgia as the focus for this study could have been motivated by the nuclear story by itself.

The geographic, social, economic, and demographic characteristics among non-RPS states are sufficiently diverse that the results of this focus on Georgia will likely not be wholly applicable to all non-RPS states. The scope of my research is not wide enough to fully delve into the intricacies of each state's electrical production system, and I chose to focus on Georgia. While not a comparative study among Southeastern states, the following research will exploring the factors that may be plausible explanations for Georgia's lack of RPS. The findings taken from this state can later be used as an example and template for future examinations of other non-RPS states in future studies.

HYPOTHESIS #1- The Effectiveness of RPS

Have RPS proven effective at increasing the consumption of renewably derived electricity among the 37 states that have adopted them? In principle, it is plausible that the Georgia energy decision-making process, whether by state legislature or state regulatory agencies, looked for and did not find evidence that RPS actually do increase renewable energy use. Due to their variation in policy stringency, goals, and resource capacity among states, the effectiveness of RPS is indeed hard to assess. As an additional confounding variable, there is also a time lag of several years between adoption of RPS and implementation of renewable energy technologies, and the existent RPS may not have been in place for a long enough time that their value can be sufficiently judged.

In a study conducted by Shrimali et al. (2012), however, they have assessed several econometric models designed to explore this question of RPS effectiveness in achieving implementation of renewable energy sources. Their research removed the confounding influence of outliers in previous experiments and tested the findings of those publications. Shrimali et al found that no definitive conclusion could be made over the effectiveness of RPS as a means to bring about an increase in the consumption of electricity generated from renewable resources.

Noteworthy in Shrimali et al.'s research is the finding that "the presence of RPS schemes in neighboring states apparently has a positive effect" (Shrimali et al., 2012). Therefore RPS approval by one state may influence the adoption of renewables for electrical generation by states in proximity. This occurs because, as one state increases their development of renewable resource technologies, they create an atmosphere conducive to further investment throughout the surrounding area. Therefore, a larger proportion of electricity regionally can be derived from renewables.

Their research also found that state income and wealth have a significant positive correlation with investment into technology that generates “clean” electricity. The outcome is logical, as states with stronger economies are better able to support entrepreneurs and companies who accept the higher upfront costs of purchasing renewable technologies and infrastructure. When evaluating the seven Southeastern non-adopter states, their economic rankings are as follows:

Overall Rank	State	Income Rank	GDP per Capita Rank
32	Georgia	32	37
38	Florida	37	46
41	Tennessee	44	38
46	Kentucky	47	44
48	South Carolina	45	49
49	Alabama	48	47
51	Mississippi	51	51

Each state falls within the lower half of the nation in terms of income and GDP ranking, diminishing their capacities to invest in costly infrastructure and electrical grid changes.

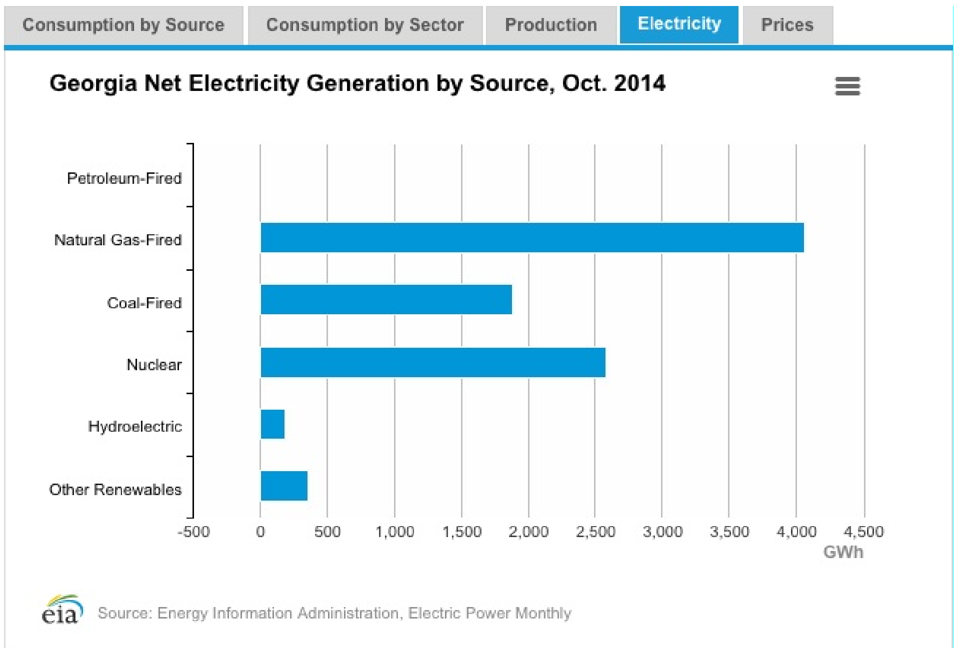
Lastly, Shrimali et al. found that states with political atmospheres that previously supported various environmental policies other than energy have significantly higher levels of renewables-derived electricity development than those without. This final factor may play a significant role in explaining the Southeast’s lack of RPS, as the political climate has been strongly conservative in recent history in environmental matters—a point discussed beneath Hypothesis #4.

In summary, published econometric analyses of RPS are inconclusive in their attempts to establish the effectiveness of RPS in achieving greater development of renewable energy technologies and consequentially in mitigating carbon dioxide emissions. The Schrimali et al study suggests, however, that as the 37 states continue to follow their RPS mandates, they may have a future subtle influence in furthering the adoption of renewable energies. We can conclude, therefore, that Hypothesis #1 cannot be the reason for the absence of RPS, because there is no evidence that they are indeed ineffective. Finding ambiguous results, RPS remain a plausible political tool for requiring investment into renewable technologies. On the other hand, the ambiguous results can be turned around to argue that since you can't show they were effective, why take the risk of conducting an expensive public experiment?

HYPOTHESIS #2: Georgia's Renewable Resource Potential

A primary consideration in evaluating RPS is the solar, wind, and biomass resources available in a state. National accounting of renewable energy includes hydroelectric generation (*Figure 1*). Renewable sources are: solar (0.8 Q), hydro (2.53 Q), wind (1.6 Q), geothermal (0.16 Q), biomass (0.46 Q) for a total of 5.25 Q (*Figure 1*). This list accounts for 13.7% of total U.S. primary energy used in electrical energy generation. Yet very few states have any opportunities to further expand hydroelectric capacities because there are no remaining sites. Thus nationally, renewable energy excluding hydroelectricity currently accounts for about 6% of the U.S. total primary energy for electricity generation. Consequently, the assessment of RPS resources within this study excludes hydroelectricity. In Georgia specifically, hydropower potential (rivers on which dams can be built) is largely tapped out and the state obtains about 4% of its electricity from renewable resources after excluding hydroelectricity.

Graph 3- Electrical Generation by Source



Estimating Georgia's Renewable Resources

The following sections estimate the technical potential of "green" resources, not their economic or political viability. RPS are aimed at replacing fossil-fuel energy, so the estimate begins with determining the electrical energy currently produced by fossil fuels. Important to emphasize however, is that RPS goals are expressed as a fraction of the delivered electrical energy at retail, not the energy required to produce that electrical energy. Phrased another way, most RPS are ultimately expressed as a fraction of the state's retail electrical energy sales.

In 2014, Georgia's retail electrical energy was 131 million MWH. About 4% came from non-hydro renewables. Nuclear power plants generated about 23% (30 million MWH). (Nuclear power in Georgia is examined in detail in a later section in the context of its importance for RPS adoption.) Thus the "target" for RPS in Georgia, excluding nuclear because it cannot be considered either a renewable or fossil fuel, is about 100 million MWH derived from electricity now generated by coal or natural gas and to be replaced by renewables.

Suppose that we aimed for a future goal of 15% from renewables, in line with many state's RPS. Following this, we seek to generate 15 million MWH from renewable resources. I will estimate the requirements for solar, wind, and biomass, individually and ask, what is required if one source alone had to produce 15 million MWH. After running the initial calculations, I found that the problem of generating clean energy for an RPS evolves into a land-use and space problem.

Solar Power in Georgia

The estimate for "solar" is based on current technology available for silicon solar panels (photovoltaic effect.) The calculation proceeds as follows. I used National Renewable Energy measurements for the solar power (watts)/square meter incident at an appropriately oriented surface, averaged over 24 hours, and over a year. The average power multiplied by 24 hours yields the energy collected in 24 hours. The NREL data are expressed as (kilowatt hours)/(square meter of solar panel area) in 24 hours. About half of the incident solar energy cannot be converted to electrical energy either because its energy is less than the band-gap of silicon or its energy is in the range where fundamental physical limitations inherent in the photoelectric effect limit the conversion efficiency

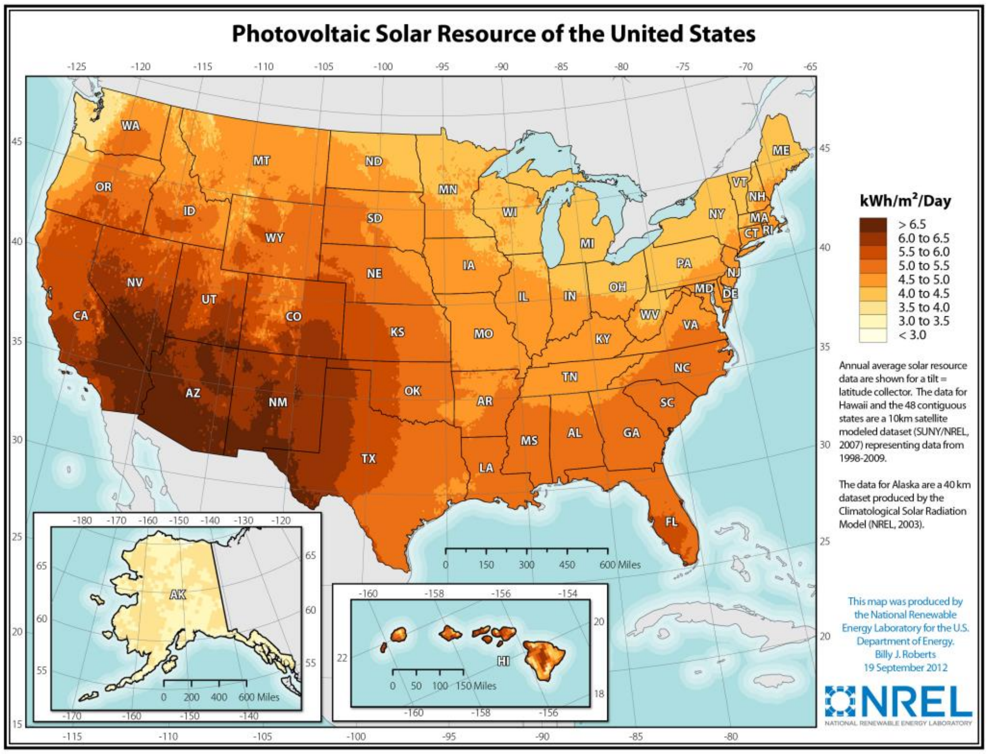
(NREL, 2015). As is conventional in the solar panel industry, we assume that about 10% of the potentially effective solar energy can ultimately be converted to electrical energy by practical devices in the field.

NREL data (*Figure 3*) show Georgia's photovoltaic resources to be in the range of 5 to 5.5 kwH/m^2 /24 Hour day. As described in the above paragraph, about half the energy fulfills the conditions for generation of photocurrent, and the efficiency of that latter conversion is about 10%. Thus solar panels can produce about 0.50 to 0.55 kwh/m^2/day. In terms of a 15% RPS the question becomes how much land area would be needed for a utility-scale solar farm to supply the 15 million MW?

In one year, on average, solar panels would deliver about .0055 MWH/day/m^2 of electrical energy, which corresponds to about 0.182 MWH/m^2 in 1 year. Thus, 15 million MWH annual electrical energy, divided by the 0.182 MWH/m^2, the annual electrical energy produced by 1 square meter of solar panel, yields 82 million m^2 of solar-panel area.

As a means of getting an intuitive sense for 82 million square meters of solar panel, assume that the main customer for this electrical energy is Atlanta. The land area of the Atlanta Statistical Metropolitan area (population 6 million in 39 counties) is 27,000 km^2 (27×10^9 m^2) (U.S. Census Bureau, 2015). Thus a solar farm with panel area of 82 million square meters would occupy about 0.3% of Atlanta metropolitan land area ($82 \times 10^6 / 27 \times 10^9 = 0.003 = 0.3\%$). When put into practice the land area occupied by utility scale solar farms is about double that of the solar-panel area (NREL, 2015). So a utility scale solar farm would require 0.6%, or rounded up, 1% of the metropolitan Atlanta land area.

Figure 3- Solar Resource Potential Across the United States



Wind Power in Georgia

In determining the potential for wind farms to meet Georgia's RPS of 15%, the question is the number of wind turbines that would be required. Nameplate capacity, or the maximum amount of energy that can be generated under ideal conditions, is currently 2.5MW for the state-of-the-art commercially available wind turbines. Under actual operations, turbines operate, averaged over the year, at less than capacity. Economically viable wind-farms typically operate with a yearly average "load factor" (actual power output/name plate) of around 30%, except in a few places (e.g. Texas) where it approaches 40%. Therefore, on average, one wind turbine produces approximately 0.75MW. Over a year's time, 8760 hours, a single wind turbine could deliver 6750MWH. Therefore, generating 15 million MWH would require a minimum of 2300 wind turbines.

The land area required for an on-shore wind turbine ranges from 25-100 acres per turbine, which includes the necessary infrastructure like roads, service areas, etc. (NREL, 2015). Current best technology is 100-meter diameter rotor (propeller) and generator assembly mounted on a 100-meter tower. Wind turbine placement depends on the geometric configuration (lines versus grid)—in grid configurations, about 100 turbine blade diameters spacing is necessary to avoid wind-flow interference between turbines. Assuming a fairly uniform terrain, at 50 acres per turbine, 2300 turbines x 50 acres= 115,000 acres. This 115,000/3,800,000 acres, is equal to 3.73% of Georgia's total land area.

	Offshore Wind	Onshore Wind
GA's potential	220,807,000 MWH	323,000 MWH

Returning to the NREL data, the onshore wind potential energy is 323,000 MWH. Applying the hypothetical RPS standard of 15%, onshore wind has the potential to generate about 2% of the 15 million MWH**.** The above onshore wind data, however, was limited to areas with an annual gross capacity factor of 30% or greater from average utility scale wind turbines at 80-meter heights. Offshore wind measurements were made at heights of 90-meters and within 50 nautical miles of the U.S. coastline. Including these offshore wind sources greatly increases wind power's potential, swelling to 220,807,000 MWH. Cumulatively, a combination of onshore and offshore wind turbines could generate 221,130,000 MWH. Meeting the RPS standard would require 14.72% of this total energy, therefore not even the full technical potential of wind power would need to be utilized to achieve a modest RPS.

BioMass in Georgia

Biomass, plant-based organic materials, can be used to obtain energy either directly (by burning it) or indirectly (by converting it to a liquid or gaseous fuel). Combustible wood and grass biomass are essentially cellulose/lignocellulose, the standard enthalpy of combustion (about 15 kjoule/gram) of which is about 60% that of high-grade coal. As a direct energy source it is combusted to generate heat. Indirectly, biomass is converted to biofuel chemically, thermally, or biochemically (for example, ethanol via fermentation, methane via anaerobic digestion). Deriving the greatest amount of energy possible from biomass therefore requires a fast growing, cultivatable dried plant to substitute for coal or natural gas. Subsequently, the question is: How much land area will be required to grow enough of a biofuel to generate 15 million MWH?

This study will investigate switchgrass, a common contemporary biofuel. To keep costs low, switchgrass farming would minimize expensive synthetic fertilizers, and natural rain will assumedly be sufficient hydration. Switchgrass' yield, measured under controlled study conditions, ranges from 3-10 tons of drymass/acre depending on where it is grown. For purposes of estimating in this thesis, we use an average yield of 5 tons of drymass/acre (Vogel et al., 2002). This converts to 4500kg/acre. Complete combustion of switchgrass produces about 15 megajoules/kg. Therefore, 4500kg/acre x 15MJ/kg= 67500 megajoules/acre. Since 1-kilowatt hour is the equivalent of 3.6 megajoules, therefore, 67500 megajoules x KWH/3.6mJ/acre= 18,750 KWH/acre = 18.75 MWH per acre of land. Using conventional thermal electrical generation, roughly 30% of the combustion energy can be converted into usable electrical energy. Therefore, the effective electrical energy is approximately 6 MWH per acre. Achieving 15 million

MWH of electrical energy (15% of the total Georgia production) by biomass alone would demand 2,500,000 acres of switchgrass. Singularly, this entails 2,500,000/38,000,000 acres, or 6.57% of Georgia. It must be noted however, that this figure does not account for energy loss during harvesting the biomass, processing/drying it, and shipping it to the generator.

The NREL chart below further illustrates the higher efficiency of utilizing a solid biopower, like switchgrass, over a gaseous biopower. Referencing both the below NREL data as well as the above calculation, it would take from 2-2.5 million acres to generate 15 million MWH. These calculations suggest that biopower should not be used as the sole renewable resource, but instead to augment other fuels when the land and farming prerequisites are available.

	BioPower- Solid	BioPower- Gaseous
GA’s potential	14,682 GWh	2,221 GWh

Hydropower in Georgia

Hydropower as a renewable resource in the scope of this study will be excluded for the following reasons: 1) Hydropower has largely been utilized to its utmost extent and offers little increased potential in the future, and there is a lack of opportunity for future growth along the coast. 2) Many hydropower facilities are being closed due to outdated equipment and inefficiency. 3) The economic costs required to update Georgia’s existing hydropower facilities are high, discouraging further development.

Total Renewable Energy Analysis for Georgia

Cumulatively, by combining the energy that could be obtained through solar and wind's nameplate capacities, Georgia could generate 15 million MWH by constructing farms for these renewables on about 4% of the state's land area. The greatest hindrances to achieving the renewables-derived electricity necessary for RPS are therefore the economic expenses and land-use complications. The cost of building and maintaining a utility-scale solar farm for large-scale generation would be in the billions. A single wind turbine costs anywhere from $1-3 million, and a few thousand would entail an investment of several billion. Offshore wind however, is likely to be more expensive and is largely underdeveloped throughout the U.S. The strategy for applying wind power for an RPS would therefore need to consider the energy and fiscal tradeoff between investing in onshore versus offshore wind turbines.

While large tracts of land would be necessary to achieve a 15% reduction in fossil fuel generated electricity, it is unclear if this has been an operational disincentive for RPS in Georgia. I was unable to find any publically available document that invoked land-requirements as a deterrent. It may be the case that consideration of RPS in Georgia never reached a stage of political consideration where land-requirements were brought to attention.

My analysis shows that the development of renewables-derived electricity would require a high upfront investment, but Georgia does indeed possesses the <u>technical capacity</u> to generate substantial proportions of clean electricity by the integration of various resources. However, it must again be noted that resource potential is not the same as the resource itself. Conversion rates, technological efficiency, differences in geography and resource quality must be assessed. Even after noting these variables however, an RPS goal could be achieved through a mixture of solar panels, switchgrass combustion, and offshore wind power. Acknowledging realistic constraints, these three sources in particular could provide Georgia with a substantial proportion of its electricity consumption demands.

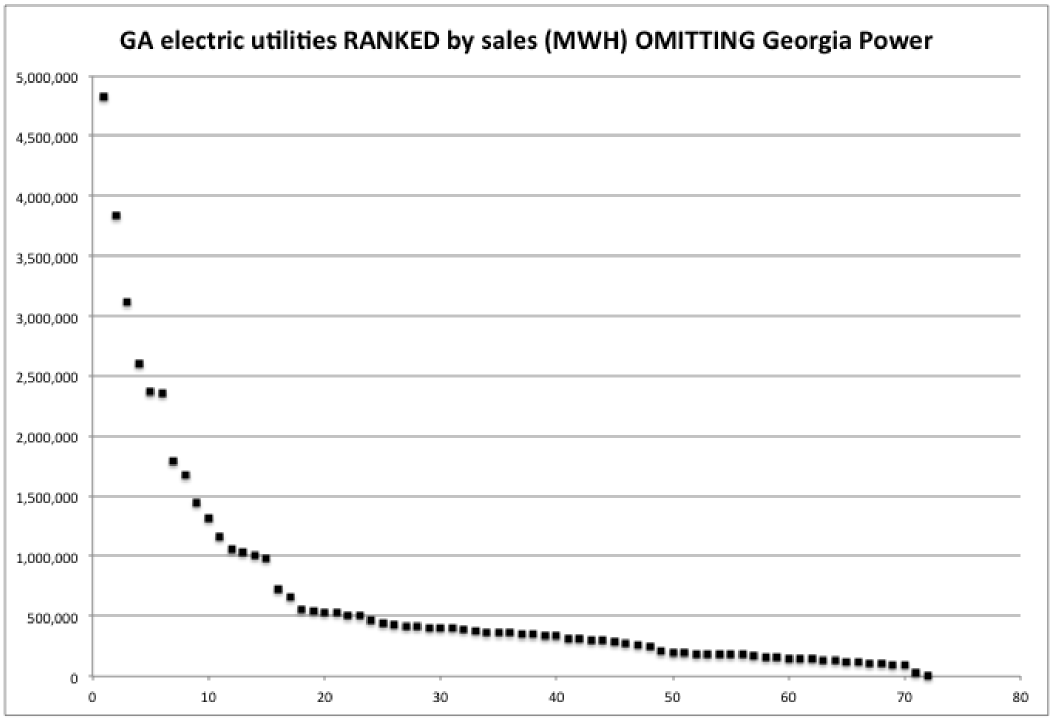
HYPOTHESIS #3: Structure of Georgia Electrical System Today

Georgia Power, a wholly owned subsidiary of Southern Company, supplies approximately 62% of Georgia's electricity, with the majority of their customers residing in the Atlanta area (GAPower, 2015). The rest of Georgia's electricity is generated by 40 cooperatives and 29 municipals, disseminated throughout rural Georgia. The retail energy sold and the number of customers of these cooperatives and municipals span a wide range. Cooperatives play a larger role than municipals in the state, quadrupling them in the amount of retail energy sold. Furthermore, these cooperatives and municipal suppliers can either generate their own electricity, or purchase it from larger generating corporations. It is worth noting again that the ensuing research examines Georgia's electrical layout alone, and detailed comparisons to the situations in other states will require further study to determine common explanatory variables throughout the Southeast.

The Role of Cooperatives and Municipalities

A challenge to implementing RPS would be the role of regulation over small-scale utilities. How could they be ordered to obtain a percentage of their electrical generation from renewable resources if they have neither the storage capacity nor financial ability to invest in solar, wind, or biomass technology? Yet, they generate electricity for 1/3 of the customers throughout Georgia.

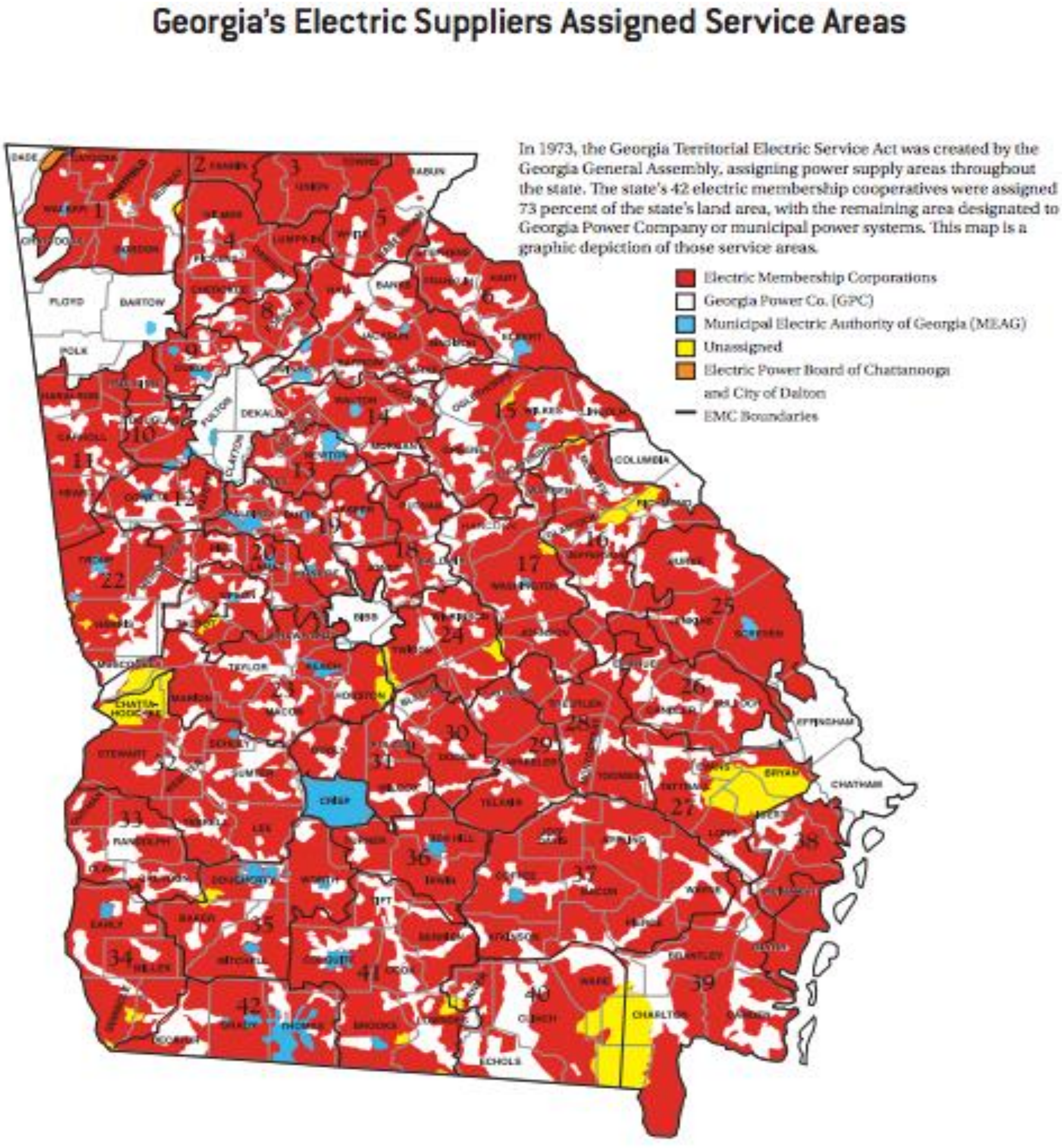
Graph 4- Georgia's Electric Utilities Ranking



The above graph demonstrates that a large number of smaller generating companies exist throughout the state, electricity generating companies completely separate from Georgia Power. It is difficult to envision an RPS mechanism that would equitably bring the cooperatives and municipals under the same regulation imposed on a corporation like Georgia Power. In all likelihood these smaller generating facilities would then not be regulated by RPS legislation, a situation probably not unique to Georgia's electrical layout. If administration was attempted, however, there are several routes for bringing these groups under an RPS mechanism. Georgia's state government could provide fiscal packages to help shoulder a proportion of the upfront cost of developing renewable technologies, easing the challenge of transforming their current methods of electrical generation. These fiscal incentives would require the reapportionment of existing tax revenues, making the passing of such legislation perhaps politically unfeasible. In the context of this thesis, the structure of Georgia's electrical industries may present the barriers that would make such policies, which would ultimately support RPS, politically insurmountable. Additionally, as cooperatives and municipalities already often purchase electricity from larger corporations and then distribute it to their customers, an RPS could require them to only purchase electricity generated from clean sources, instead of obliging them to generate it independently. Lastly, where several cooperatives are concentrated in certain regions, they could be held collectively responsible for generating a pre-determined percentage of clean electricity (*Figure 4*). Some companies generating more clean energy than others could also sell their rights to those generating solely through fossil fuels. Therefore a small-scale exchange system could arise, facilitated by permits and an overall reduction objective.

Neglecting to regulate cooperatives and municipalities by RPS would place a larger burden upon Georgia Power to generate clean energy. Georgia Power would then almost undoubtedly reject RPS, and because they have a larger political clout than the smaller companies, the legislative likelihood of such an environmental mandate passing would diminish.

Figure 4- Distribution of Georgia Electrical Suppliers



Nuclear Power Development in Georgia

The potential influence of nuclear power was discovered in the course of this research, and emerged as a potential explanation for the absence of RPS in Georgia. The nuclear-powered electricity generation process produces no greenhouse gas emissions and accounts for about 20% of the primary energy used for electricity generation in the U.S. (*Figure 1*). Although nuclear energy is “clean” in the sense of carbon dioxide emissions, it is not classified as renewable because uranium and other fissionable elements suitable for fueling electricity generation are in the long term not renewable, and nuclear fission also produces long-lived radioactive waste. Despite this, Georgia Power is currently in progress to open two nuclear power plants in 2017, Vogtle units 3 and 4 that will each add 1700 MW (nameplate capacity). Thus the two plants together will have the capacity to generate about 30 million MWH (each plant: 1700 MW x 8760 H/year = 15 million MWH annually); a typical annualized load factor of 80% (combination of season fluctuations in demand and necessary operating down-time) will yield about 25 million MWH of “new” power—10 MWH more than would be legally required for a 15% RPS.

The new generators will be jointly owned by four Georgia-based electrical companies- Georgia Power (45.7%), Oglethorpe Power Corporation (30%), Municipal Electric Authority of Georgia (22.7%), and Dalton Utilities (1.6%) (GAPower, 2015). Oglethorpe Power’s co-ownership, as they are already an Atlanta-based supplier, suggests that a large proportion of the newly generated electricity will be transmitted to the metro-Atlanta area. Oglethorpe Power’s role as a “supplier” simply means they distribute electricity to their customers that was generated elsewhere. A generating company by contrast, produces electrical energy itself. Construction of Vogtle 3 and 4 is being overseen by Southern Nuclear, which in turn is owned by Southern Company, the holding company that also owns Georgia Power. Southern Nuclear has previously been responsible for six nuclear units in co-operation with both Georgia Power and Alabama

Power. Theoretically then, the newly generated electrical energy could be sold among various subsidiaries of Southern Company, although transmissions would likely be limited predominantly to Alabama and Georgia.

Nuclear Power, Georgia Power, and Southern Company

Southern Company has an established history of nuclear generation, and through its subsidiaries meets 16% of its total electrical generation demands for all states from nuclear power plants. Within Georgia alone, Southern Company operates all four of Georgia's nuclear facilities, two of which, Hatch and the original Vogtle, collectively provide about 20% of Georgia's electrical energy demand. Beyond these and the two new Vogtle constructions, however, there are three main facilities currently in operation, housing six nuclear reactors total. These are the Alvin W. Vogtle Electric Generating Plant, the Edwin I. Hatch Nuclear Plant, and the Joseph M. Farley Nuclear Plant.

Vogtle and Hatch cumulatively produce nearly 20% of Georgia Power's electricity already, and with the supplements of Vogtle 3 and 4, Southern Company declares that future prospects will be even higher. This vision of zero emissions, coupled with increased generation potential, could specifically appeal to Georgia Power and Southern Company after receiving backlash from their ranking as one of the top carbon dioxide emitters in the U.S. in recent years (CGD, 2007).

Considering their heavy investment into nuclear power, the imposition of an RPS would be unacceptable to Georgia Power. Increased nuclear energy generation, as it is not a fossil fuel, would mean that a smaller percentage of the state's electricity is being produced by fossil fuels, and the proportion of energy sources able to be targeted for a transition to renewables would decrease. This increases the challenge to achieving a RPS, as there is a smaller percentage of energy sources to change to renewables. Particularly with the construction of Vogtle 3 and 4, and their venture into developing existing nuclear technology, Georgia Power and the overarching Southern Company have no incentive to accept or encourage RPS. Once the two plants are functioning, the carbon footprint for Georgia Power's electricity generation will be reduced to the extent that the need for more expensive alternatives, such as renewables and RPS, will be negated.

HYPOTHESIS #4: A Hindering Political Atmosphere in Georgia

Georgia's Political Background

The Republican Party has managed Georgia's government in recent years, apparent in GOP Governor Nathan Deal, and his entirely Republican board of elected officials. Acknowledging this political atmosphere, it must be noted that it is the Democratic Party that is usually more favorable than the GOP toward passing environmental legislation. Furthermore, when settings are different and the Democratic Party dominates a state's politics, their influence is found to be a key explanatory variable in RPS adoption (Lyon and Yin, 2010). Demonstrating some flexibility to this pattern however, there are historically Republican and conservative states that have nonetheless successfully passed RPS, such as Texas, Kansas, Utah, and the Dakotas (*Figure 2*). Therefore, although a strong GOP presence in a state may increase the political challenges to implementing an RPS, it is still very possible.

Gathering the political will to pass ambitious legislation, like RPS, often requires the presence of political actors deeply motivated by their personal beliefs. Without political activists, working groups, or state legislatures promoting RPS, like those found in the 37 adopter states, the likelihood of such legislation arising is small. If there has not been a political entrepreneur emphasizing RPS in Georgia, this deficiency could be a key factor in explaining its absence. Or if a political entrepreneur in Georgia exists, perhaps his/her efforts are currently insufficient to garner the political will necessary to pass an RPS through the state's predominantly Republican legislature. Therefore, is it simply a lack of powerful pro-RPS politicians in Georgia or is there a mentality of opposition throughout the state that blocks RPS adoption? The final hypothesis will delve more deeply into this inquiry.

Southern Company Background

As previously mentioned, Southern Company is a holding company that owns Georgia Power. Southern Company is currently the 16th largest utility company in the world, and the 4th largest in the U.S. In the 2007 report released by the Center for Global Development, Southern Company was judged the largest GHG emitter in the U.S. utility industry, with 172 million tons of carbon dioxide equivalent gases emitted annually (CGD, 2007). By 2013, this number was reduced to 100 million tons of carbon dioxide (Carbon Disclosure Report, 2014).

As a whole, Southern Company has largely been moving to displace coal generation by natural gas since 1990. Their overall reduction of carbon dioxide emissions has occurred through both this transition to natural gas-fired plants and the lower electrical generation rates that followed the country's economic downturn in 2008 (SouthernCompany, 2015). Adding further increases to their clean energy production, Georgia Power voluntarily adopted an Advanced Solar Initiative (GPASI) in 2012, a purchase program that contracted the company to obtain an additional 210MW from solar by 2014. Then, in 2013, after approval by the Georgia Public Service Commission, the GPASI added another 525MW of solar power to the earlier commitment (GeorgiaPower, 2015). The electricity produced by this solar generation however, is insignificant on the scale of statewide electricity demand, and may be more of a political statement than a genuine push for renewables-derived energy. If Georgia Power were indeed serious about pursuing cleaner energy and initiatives, why would it not encourage the acceptance of an RPS?

The lack of RPS in Georgia, and perhaps in several other Southeastern states, can potentially be traced back to Southern Company, as they are the parent holding company that would be most heavily impacted by RPS implementation. This corporation is the owner of four subsidiary companies: Georgia Power, Alabama Power Company, Gulf Power Company, and Mississippi Power Company. These vertically integrated utilities are responsible for electricity generation in Florida, Mississippi, Georgia, and Alabama, which are four of the states lacking RPS (SouthernCompany, 2015).

Company	**# Of Customers***	**Southern Company Total Electrical Retail Sales (MWH) 2014**
Georgia Power	2,396,537	84,700,000
Alabama Power	1,444,809	58,637,410
Gulf Power	439,783	2,333,984
Mississippi Power	186,490	1,4592,000
Southern Company (*Total*)	~4,400,000	183,400,000

* The number of customers is the number of electrical meters; meaning, the number of monthly bills sent out by the utility. For example, a household of one person would have one meter, as would an apartment building housing an indeterminate number of people.

These data illustrate the significance of Southern Company in their range of electrical generation throughout the Southeast. Although the focus of this research is on Georgia as a case study, Southern Company's role in other states is discussed to demonstrate the span of their influence.

Georgia Power's Political History

Georgia Power reflects the state's partisan standing and appears to be guided by political preferences that incentivize investments into nuclear power development over renewables. The Democratic and liberal agenda has consistently been more favorable towards environmentally beneficial policy, such as RPS, while the conservative GOP has prioritized economic security. Evidence supporting this political trend, in recent election years, Georgia Power has made significant contributions to the Republican Party of Georgia, and comparatively small contributions to the Democratic Party. While there indeed have been conservative GOP states that nonetheless have adopted RPS, these states are the exception to this political trend. The question then becomes what political roadblock exists in Georgia to prevent their acceptance, or what assistance was present in conservative states that facilitated RPS adoption despite counterintuitive partisan interests?

Georgia's Transparency and Campaign Finance Commission publish all political contributions, including those donations made by corporations. In a report detailing 304 political contributions made by Georgia Power, there were twenty-nine donations to partisan groups. Of these twenty-nine, twenty-six were received by various Republican groups, while three went to the Democratic Party of Georgia.

Georgia Power has given cash gifts to numerous Republican affiliates, markedly the Georgia Republican Party, the Henry County Republican Party, Georgia House Republican Trust, Inc., Georgia Republican Senatorial Trust, and the Georgia Republican Senatorial Committee. In contrast, the three donations received since 2006 by the Democratic Party in Georgia went solely to the Democratic Party. Roughly $181,430 was contributed to the Georgia Republican Party, while only $20,000 was given to the Georgia Democratic Party (Georgia.gov, 2015). Although it may be expected that utilities would inherently support the more fiscally conservative political party, the degree to which Georgia Power appears to be favoring the Republican Party is noteworthy and could perhaps hint at an alliance or regulatory capture between the two. While other GOP-leaning states have passed RPS, either through advocacy groups or other legislative pathways, the extent to which Georgia's companies have been evidenced to support their GOP affiliates could effectively hinder possible enactment. Energy corporations like Georgia Power, motivated to preserve the status quo of electrical generation and distribution, may support conservative political parties as a method of preventing the deregulation of electrical utilities. The initial creation and adoption of RPS in California after all, did not occur until the deregulation of the state's electric utilities in 1998 (Ca.gov, 2015).

Political Leanings of The Southern Company and Georgia Power

As the largest subsidiary of Southern Company, and the producer of the majority of Georgia's electricity (62%), Georgia Power's apparent alignment with the Republican

Party could effectively hinder legislative approval for RPS in the state. A significant advocate against RPS and clean energy standards is the American Legislative Exchange Council (ALEC). The group has claimed that RPS adoption results in negative economic and environmental externalities. Their argument stems from the belief that corporations and utilities are not driven to purchase higher than necessary proportions of clean energy once RPS has been adopted (ALEC.org, 2014). Furthermore, ALEC is a strong supporter and benefactor of nuclear power facilities through their lobbying effort Nuclear Matters. Interestingly, a supporting member of ALEC is Southern Company (Energy&Policy, 2015). Therefore, although Southern Company's relationship with Georgia's Republican Party remains speculative, their connection with pro-nuclear and anti-RPS affiliates is not.

Returning to Nuclear Power

Significant in this research, nuclear energy today is often considered a right-wing platform, according to the American Nuclear Society (ANS, 2012). Typically, environmental groups oppose the creation of nuclear facilities and their radioactive waste. Nuclear power can still be appealing, however, because of its freedom from the pressures and variability of the international energy market. The development of nuclear power therefore offers a reliable source of income and security to Georgia Power. As the Republican Party, as aforementioned, is generally the partisan group more likely to support nuclear power, their likelihood of pursuing nuclear energy as a means of achieving energy stability is higher than that of the Democratic Party.

In a strictly structural sense, nuclear plants have infrastructure costs comparable to those of fossil-fueled generating facilities, posing no exorbitant costs postconstruction. However, after including regulatory expenses and the construction requirements to handle long-term radiation exposure, the upfront expenditures of creating a nuclear facility are 10x greater than that of a conventional thermal plant. But once in place and operating, nuclear power plants are cheaper to operate than conventional thermal plants. Moreover, if at some future date, conventional thermal plants will by Federal regulation be required to capture and sequester carbon dioxide, the nuclear plants will likely have a very large, operational cost advantage over thermal plants.

Investors bear the burden of the “carrying cost”, or upfront capital that cannot be returned until revenue is generated. Here is where supporters like ALEC can be pivotal, providing initial investments for struggling nuclear facilities. If the political and fiscal expenses incurred by the nuclear power plant siting process could be reduced, or the process of creating a new facility expedited, the construction of a new nuclear utility could feasibly be economically competitive with fossil fuel generating facilities. As the GOP agenda is typically more concerned with securing financial stability over environmental health, this could be an enticement to transition to nuclear power over the more costly wind and solar farms (ANS, 2012).

CONCLUSION

Renewable Portfolio Standards have become a key state-level policy tool aimed at mitigating carbon dioxide emissions and legislating a transition to the use of renewable resources for electrical generation. As this tool has been implemented in 37 states across the nation, their potential significance cannot be ignored. Yet, as Shrimali et al. found (Hypothesis #1), studies have been unable to demonstrate that RPS adoption has caused an increased use of renewables or reduced the consumption of fossil fuels. These studies are, however, complicated by outlying variables and the short history of implemented RPS. Incidental to the direct impacts of RPS, Schrimali et al. found that network effects, a state's economic strength and previous political atmosphere are also explanatory in the implementation of renewable energies as a whole. Consequentially, RPS cannot be discounted as a means for reducing carbon dioxide emissions and both adapting to and mitigating climate change.

Technically, although limited economically, there are sufficient environmental resources available to meet Georgia's electricity demands via renewables (Hypothesis #2). Adopting a modest RPS, a 15% reduction goal, is therefore a viable possibility and not the reason for RPS's deficiency. Upon delving into the prerequisites for these resources to provide 15 million MWH, the question of an RPS quickly evolves into a question of land availability. Even accounting for this, the results showed the potential of both wind power and solar power, augmented by biomass in the form of switchgrass, to support at least a 15% RPS mandate.

Georgia's current electrical organizational and technical structures reflect the conflicting reappearance of nuclear utilities (Hypothesis #3). Nuclear power, particularly the creation of Vogtle plants 3 and 4 by Georgia Power, offers an alternative option to RPS toward achieving the specific goal of reducing carbon dioxide emissions. The corporation can produce their necessary electricity to meet consumer demand, 81 million MWH, and supplement it with their previous generation methods without requiring vast tracts of land. By focusing efforts on this means of generation, Georgia Power, and by association Southern Company, are able to lower emissions and gain the commercial label of being “green” and innovative without incurring the high upfront costs of renewables infrastructure, or placing themselves within political constraints.

As Georgia Power’s focus has been to invest in nuclear energy, and their political inclinations have been dominated by a conservative Republican ideology in recent history, the adoption of RPS appears unlikely (Hypothesis #4). Hindered not simply by the lack of a political entrepreneur advocating for RPS, but by the dominance of a political party that stereotypically opposes environmental legislation, this state policy tool has little political foundation upon which to build support in Georgia.

Based upon the findings of this research, the absence of a RPS in Georgia appears to be predominantly the accumulation of factors examined within Hypotheses #3 and #4: Georgia’s investment into nuclear power, coupled with a political atmosphere that would deter the success of passing environmental legislation, supplemented by Georgia Power and Southern Company’s control in generating and transmitting electrical energy throughout the Southeast. Although RPS still have the potential to be adopted throughout the Southeast in the future, political, economic, and environmental hurdles will need to be overcome before the likelihood of proposal and implementation make them a feasible political tool for addressing the dangers of climate change and carbon dioxide emissions.

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