Electricity Market Reform in the Carolinas

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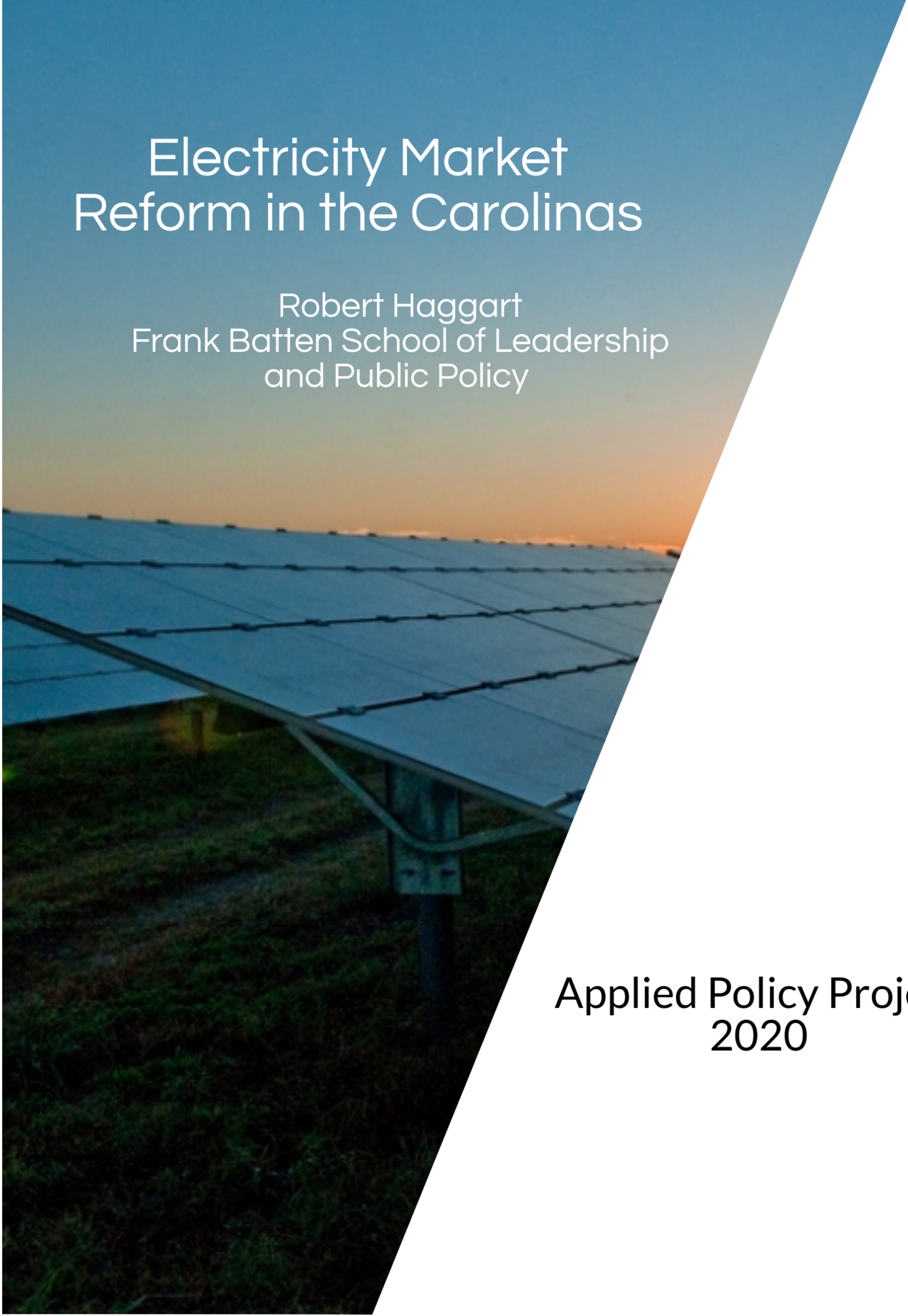

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On my honor, I have neither given nor received aid on this assignment

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Glossary

Relevant Terms Relating to Electricity Production

LCOE--- Levelized Cost of Energy

MW/MWh--- Megawatt/Megawatt hour

NET CONE--- Net Cost of New Entry

Wholesale Electricity—Electricity sold directly from generators onto the electric grid and large-scale consumers

Retail Electricity---Electricity sold by utilities to small-scale consumers

Electric Market Producers (Those involved in electricity generation, transmission, and distribution)

IOU--- Investor-Owned Utility

- SCE&G--- South Carolina Electric and Gas
- Duke Energy
- Santee Cooper
- Lockhart Power

Municipal-Owned Utilities

Electricity Co-Operatives

Regulators and Regulatory Legislation

FERC--- Federal Energy Regulatory Council

NCUC--- North Carolina Utility Commission

PURPA--- Public Utilities and Regulation Act of 1979

SC PSC- South Carolina Public Service Commission

SERC- Southeastern Electric Reliability Council

Market Reform Entities

EIM--- Energy Imbalance Market

Western EIM—Energy imbalance market located in 8 states in the western United States

RTO--- Regional Transmission Organization

CAISO—California Independent System Operator

ERCOT--- Electric Reliability Council of Texas

MISO--- Midcontinent Independent System Operator

NYISO---New York Independent System Operator

PJM--- Pennsylvania New Jersey Maryland Interconnection

ISO-NE--- Independent System Operator of New England

SPP--- Southwest Power Pool

Executive Summary

The current electricity market in the Carolinas is based on a monopolistic model that is over 100 years old. This model is based on assumptions that aren't applicable in the world today. As a result, the current cost of electricity to consumers in both states is potentially higher than necessary due to a lack of reform. Both states combined currently spend more than $2.7 billion annually on electricity. Without reform, there could be significant inefficiencies resulting in higher costs to consumers. This report examines electricity market and ratemaking reform options to decrease the cost of electricity in the region, and ultimately the cost to consumers. This report examines four potential reforms in addition to the current status quo:

1. Performance-based ratemaking
2. Creation of a regional energy imbalance market
3. Membership in the PJM Interconnection
4. Creation of an independent regional transmission organization in the Carolinas

This report analyses these alternatives on 6 criteria: cost-effectiveness, expected growth of renewable energy, political feasibility, implementation feasibility, reliability, and equity.

After analyzing each alternative, this report recommends that the North and South Carolina State Legislatures pass legislation authorizing the North Carolina Utility Commission and the South Carolina Public Service Commission to require utilities in both states to join the PJM interconnection. The opportunity to introduce wholesale competition into the Carolinas electricity market can decrease the cost of energy, which in turn will reduce retail costs to consumers, most notably residential consumers. However, should the legislatures pursue this recommendation, I recommend that both states authorize studies to run a cost-benefit analysis on the option of joining or opting out of the PJM capacity market and using current reserve margins to meet federal requirements.

Background

Problem Statement

The current electricity rates for consumers in North Carolina and South Carolina are too high.

Problem Definition

The current vertically-integrated electricity market structure in the Carolinas is over 100 years old and has seen little reform over that period. As a result, there is a legitimate concern that the current electricity suppliers in each state are inefficiently providing service for consumers. In South Carolina, the gross mismanagement of the V.C Summer nuclear power plant construction project by state-owned utility Santee Cooper and Investor-owned Utility (IOU) South Carolina Electric and Gas led to households paying $400 more in 2017 than the national average (Fretwell, 2018). In North Carolina, concerns surround the current rate approval process that Duke Energy goes through with the North Carolina Utility Commission (NCUC). Opponents to the current system argue that flattening consumer demand, changing technologies, and a need for grid resiliency investment require a change to how IOUs in North Carolina are regulated (Ouzts, 2019).

Recent retrospective studies of market reform have also demonstrated that effective reform can result in a significant saving for consumers and producers (Appendix III). A recent study by the Brattle Group estimated that Duke Energy's North Carolina customers could save $60-$180 million annually if North Carolina joined PJM, a regional transmission organization covering 13 states in the mid-Atlantic (Chang et al., 2019). Market reform has demonstrated success nationally. Regional transmission organizations (RTO) and energy imbalance markets (EIM), both a form of wholesale market reform, have helped member states save hundreds of millions of dollars annually (Appendix III). As a result, it is in the best interest of both states to examine potential avenues of reform and determine if there is a better option than the status quo to decrease costs to consumers and promote a more efficient electricity market structure.

Cost and Cause of the Problem

Based on 2019 data, the average retail price of electricity in North Carolina was 9.25 cents per kilowatt-hour, while South Carolina was 9.66 cents per kilowatt-hour (EIA, 2020). Both of these values are under the national average of 10.53 cents per kilowatt-hour. However, the price of energy alone does not dictate the price that consumers pay in their bills. In 2018, the average monthly residential electric bill in South Carolina was $26.55 higher than the national average (EIA, 2020). In North Carolina, the average monthly bill residential electric bill was $7.52 more than the national average (EIA, 2020).

In the commercial and industrial sectors, retail electricity rates are below the national average for both states. In North Carolina, the average price for the commercial sector was 8.85 cents per kilowatt-hour and 6.19 cents per kilowatt-hour for the industrial sector (EIA, 2020). In South Carolina, the average prices for 2019 were 10.47 cents per kilowatt-hour and 5.98 cents per kilowatt-hour, respectively (EIA, 2020). For both states, the retail price of electricity in the commercial and industrial sectors is below the national average of 10.65 and 6.81 cents per kilowatt-hour respectively. However, past reform in states with low retail energy prices compared to the national average, such as Virginia and Pennsylvania, has resulted in further benefits and cost reductions for consumers (PJM, 2015). There are potentially unclaimed benefits for electricity consumers in both sectors due to the current vertically-integrated market structure. Thus, there are also potential multi-sector economic costs associated with the vertically-integrated model. If electricity consumers in the commercial and industrial sector are paying an inflated cost for electricity, then consumers of those products and services in the Carolinas will bear that cost in the form of increased prices. Unnecessarily high electricity prices in both sectors have potential costs that are shouldered across each state's economy.

Cost to Society

Under the currently vertically-integrated model, the annual cost of electricity in both states combined is approximately $2.7 billion, including the social costs associated with pollution from carbon dioxide, sulfur oxide, nitrogen oxide, and particulate matter emissions. This cost is not born equally across ratepayer classes as well. Residential consumers pay a higher rate for an energy than their commercial and industrial counterparts. While retail cost of energy is subject to many different factors, it is logical to argue that reforming the electricity sector in both states to better align the goals of IOUs with the needs of consumers will reduce costs, most notably to residential consumers.

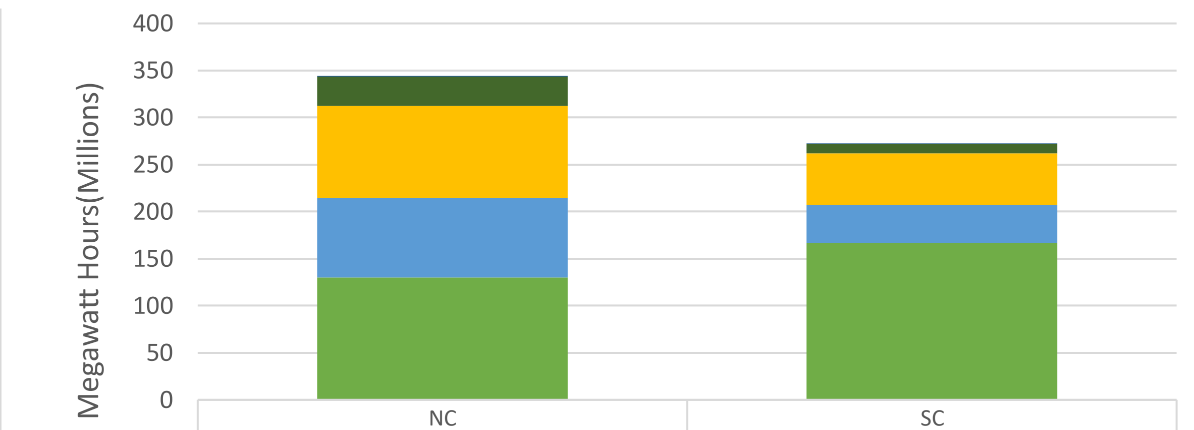
Energy Use of the Carolinas

North and South Carolina have an energy mix that is heavily dependent upon nuclear energy. Based data from the EIA and South Carolina Office of Energy, South Carolina receives 53.5% of its electric power sector energy from nuclear power, while North Carolina receives 37.7% of its electric power sector energy from nuclear power (Figure 1). Both states rank 3rd and 7th nationally in terms of nuclear generation, representing over 11% of nuclear energy output in the United States (Nuclear Energy by State, 2019). According to the Solar Energy Industry Association (SEIA), North Carolina is also the second-highest solar producing state in the country, with a total solar capacity of 5,662 MW. However, for both states, renewables only represent a small portion of electric sector consumption. In North Carolina, renewables represent 9.0% of consumption, while renewables represent 3.7% of consumption in South Carolina. For both states, coal is the most intensive fossil fuel resource for electric power sector use representing 28.5% of total consumption for North Carolina and 20% of total consumption for South Carolina (Figure 1).

The Nuclear Dilemma

In considering potential market reform, regulators must consider the role of nuclear energy in future production. Due to high construction costs compared to other generation sources, nuclear energy possesses a high levelized cost of energy (LCOE); the measurement of lifetime costs divided by megawatt-hours of energy produced. Based on 2019 estimates from the Lazard group, the LCOE for existing nuclear plants in the United States is between \$118 and \$192 per megawatt-hour. In comparison, utility-scale solar sits between \$32 and \$42, modern combined-cycle natural gas is between \$44 and \$68, and coal is between \$66 and \$152 (Lazard, 2019). The high price for nuclear is a problem for any market reform that introduces competition into the electricity market. Due to subsidies and guaranteed return on investment for incumbent utilities, nuclear remains a reasonable option in the current marketplace.

Figure 1. Electric Power Sector Consumption by State by Source



	NC	SC
petroleum	0.791	0.293
Renewables	31.183	10.17
Coal	98.208	54.511
natural gas	84.4	40.913
Nuclear	129.98891	166.581

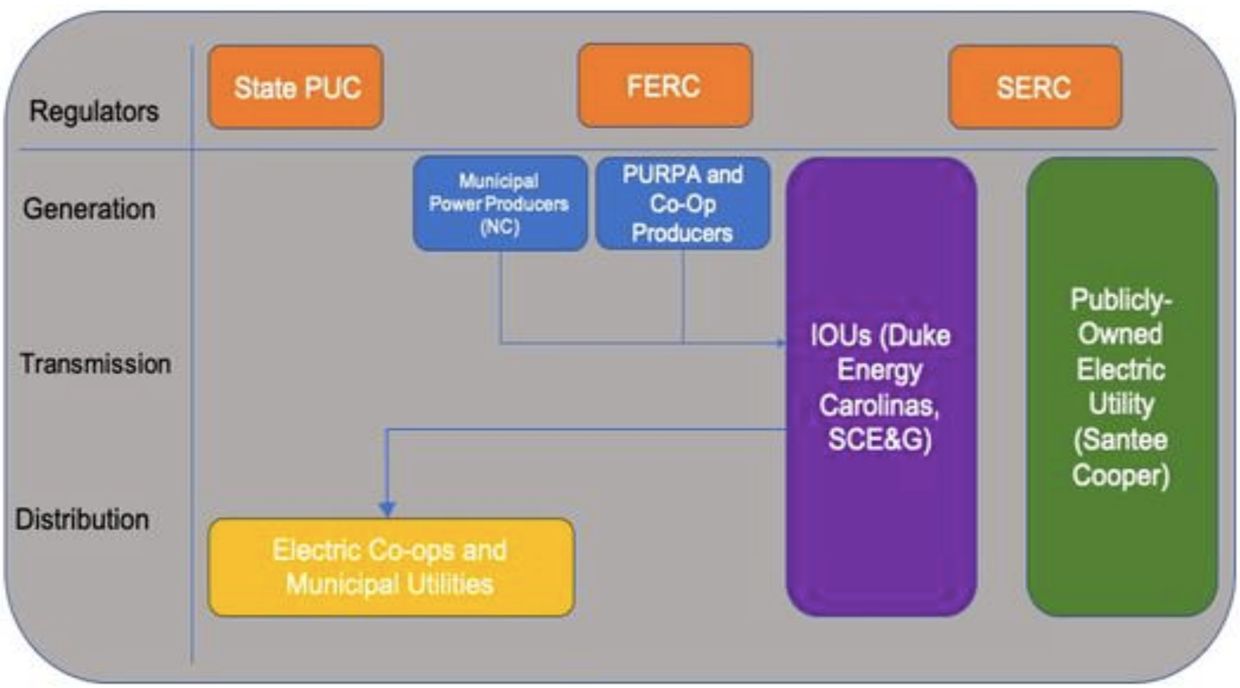
Source: EIA

Governance in the Current Cost-of-Service Model

Electric Market Actors

Entities in an electricity market can be separated into three categories: generation, transmission, and distribution. In both states' IOUs such as Duke Energy and South Carolina Electric and Gas (SCE&G) own generation sources that provide energy to the transmission network. Similarly, independent power producers with generation sources of less than 80 MW, per the Public Utility Regulatory Policy Act (PURPA), and municipal power producers generate electricity into the grid (Figure 2). In both states, IOUs own the transmission network, as well as Santee Cooper a state-run utility in South Carolina (Figure 2). The third category, distribution, involves IOUs, Santee Cooper in South Carolina, electric co-ops, and municipal utilities. These entities are involved in managing the distribution network that carries electricity from the transmission network to commercial and residential consumers. Electric co-ops and municipal utilities differ from IOUs, as they represent a group of constituents that independently operate their own distribution network. In the case of electric co-ops these are a group of individuals and firms. In the case of a municipal utility, a city or town owns the distribution network.

Figure 2. Electricity Market Actors in the Carolinas



Regulation

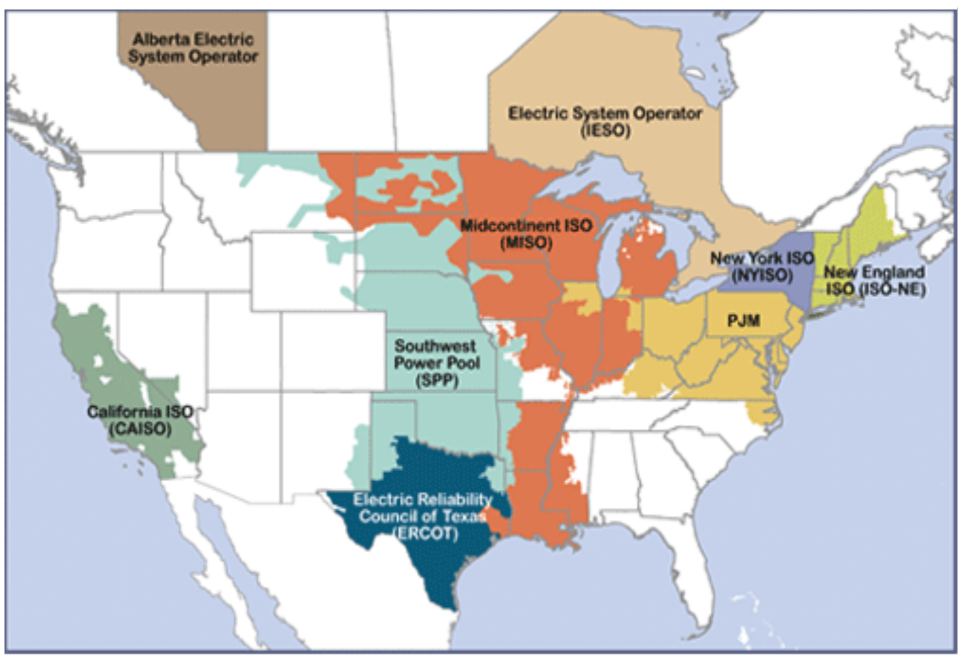
Given the monopolistic nature of the current electricity market, the public utility commission for each state (PUC), the North Carolina Utility Commission (NCUC) and the South Carolina Public

Service Commission (SC PSC), regulate prices set by IOUs. Utilities operate in a cost-of-service regulatory model, where utilities set a price for operation and management costs and a rate of return on capital investment. Those costs are then passed on to the consumer in the form of an electricity rate (McDermott, 2012). The NCUC and SC PSC act as administrative replacements for a free market to protect consumers and ensure costs are efficient (McDermott, 2012). At the regional level, the Southeastern Electric Reliability Corporation (SERC), oversees grid reliability and the adequacy of bulk power transmission (Figure 2). At the national level, the Federal Energy Regulatory Council (FERC) regulates the wholesale of electricity and interstate commerce. However, much of the regulatory power in this model rests with the state PUC. This model was created with the assumption that electricity is a natural monopoly and that the cost of entry is too high for any new firms to enter. The model also rests on the notion that a single entity could more efficiently operate the generation, transmission, and distribution in a market (Michaels, 2006). This model is over a hundred years old and has seen little reform over the past century. Thus, there is a legitimate reason to examine potential opportunities for reform.

Governance in Wholesale Energy Markets

Currently, over 60% of the country's wholesale electricity is distributed in a competitive electricity market, rather than a vertically-integrated market. These markets are known as regional transmission organizations (RTOs), independent system operators (ISO), or energy imbalance markets (EIMs). RTOs are non-profit, interstate, public-benefit corporations that operate the transmission system in their regional territory (Blumsack, 2019). In an RTO model, both utility and non-utility wholesale power producers bid to have their generation sources feed into the grid. Thus, traditional service territories, such as that in the current cost-of-service model in the Carolinas, are expanded significantly (See Figure 3). In an RTO, reform occurs at the generation and transmission levels. However, incumbent distribution networks are unaffected by RTOs. In an RTO setting, incumbent utilities cede authority of grid management to an independent system

Figure 3. Map of RTOs in North America



Source: FERC

operator that dispatches energy across the grid. RTO grid operators are managed by a board of regional stakeholders that are responsible for fulfilling the RTOs regulatory, legal, and business requirements. The motivation behind RTOs stems from FERC Order 2,000 that encouraged transmission-owning entities, such as IOUs, to join an RTO to promote non-discriminatory access to transmission systems and grid reliability (Blumsack, 2019). RTOs, are regulated by FERC.[1] FERC regulates RTOs to ensure that they meet standards for 5 criteria:

1. Sufficient management of bulk power systems within its footprint
2. Ensuring non-discriminatory access to transmission systems for buyers and consumers
3. Dispatch of generation within the RTO's footprint to ensure a balance of supply and demand
4. Regional planning for generation and transmission
5. Creating an efficient market or markets for electric generation services.

IOUs in a Wholesale Model

Of the 33 states currently participating in an RTO, only 18 of them have deregulated electricity models where consumers can choose their electricity provider. States in PJM, SPP, MISO, and NE-ISO operate a cost-of-service model with IOUs as the dominant provider of retail electricity. These states fall into a middle ground where competition exists in the wholesale market to drive down energy costs and more efficiently use energy, while IOUs still claim a monopolistic status in their service territories (Murray, 2019).

[1] ERCOT is regulated by the Public Utility Commission of Texas

Best Practices in Electricity Market Reform

Performance-Based Ratemaking (PBR) Model

Table 2. Characteristics of Successful PBR Implementation

	Traditional Regulation (Cost of Service)	Performance-based Regulation
Goals	Focus on reliability, affordability, adequacy of highly centralized electricity delivery systems. Consumers are protected from monopolistic power through reasonable rates and careful regulatory oversight.	Focus on traditional regulatory goals, as well as specific outcomes defined by policymakers, utilities, and stakeholders. Consumers receive reliable services. Facilitates opportunities for customer and third-party value creation and innovation.
Incentives for Utilities	Revenues (expenses + depreciation + taxes + return on rate base) are designed to match costs. Regulators approve costs, which are recovered in rates, often based on per-unit (volumetric) energy usage. The utility is incentivized to increase usage to drive up revenues.	Revenues are earned through a variety of rates and programs. Incentives are designed, communicated, and evaluated. More sophisticated rates are designed to facilitate reliable services and technology deployment. Utility earnings incentives are aligned with policy outcomes rather than increased usage.
Earnings	Regulators evaluate prudent cost of expenditures for services, with the level of capital expenditure primarily driving earnings.	Utilities optimize total expenditures (capital and operating) and regulators reward valued outcomes. Regulated earnings remain, but can be enhanced based on performance against specific metrics.
Timescale	Short-term focus on cost minimization with a traditional long-term capital planning process.	Balanced focus on short-term cost minimization/near-term grid reliability investments and longer-term investment in future grid architecture, improving performance and achieving public policy goals.

Source: Advanced Energy Economy

PBR is an alternative ratemaking scheme that modifies the cost-of-service model to better align the incentives of utilities with the needs of consumers. PBR models are created and tailored to the needs of the specific jurisdiction. A PBR model uses different rates and programs to incentivize IOUs to put assets toward capital investment outside of new generation such as grid resiliency investment as well as renewable energy investment (Advanced Energy, 2018). A PBR model also gives policy makers a tool to augment the operations of IOUs to meet policy goals(Table 2). Finally, a PBR ratemaking model has the potential to better equip the region for the growth of disruptive technologies such as the lower cost wind and solar generation sources as well as battery and energy efficiency technologies (Littell et al., 2017).

Current Iterations of PBR

The Illinois, Michigan, and New York state legislatures have all passed some form of PBR legislation. In Illinois, the legislation signed in 2011 required utilities Commonwealth Edison and Ameren Illinois to make smart grid and cyber security investments over a ten-year period to increase grid security and resiliency, perform critical transmission upgrades, and ultimately decrease costs to consumers. In Michigan PBR is used to provide IOUs with financial incentives if they exceed energy savings targets for a given year (Little and Shipley, 2017). Similarly, New York's Reform the Energy Vision (REV) plan created financial incentives for utilities who invest in energy efficiency initiatives, meet green energy standards, and grid resiliency measures (New York Public Service Commission, 2016). Well executed PBRs have the potential to better prepare states for a changing energy future while also decreasing costs to ratepayers.

Wholesale Markets

One of the main goals of any wholesale Market is to provide non-discriminatory access to the grid and lower the average price of electricity through using economies of scale to smooth distribution. The section examines current best practices on how different marketplaces structures themselves to promote equitable access to the grid.

Use of an LMP

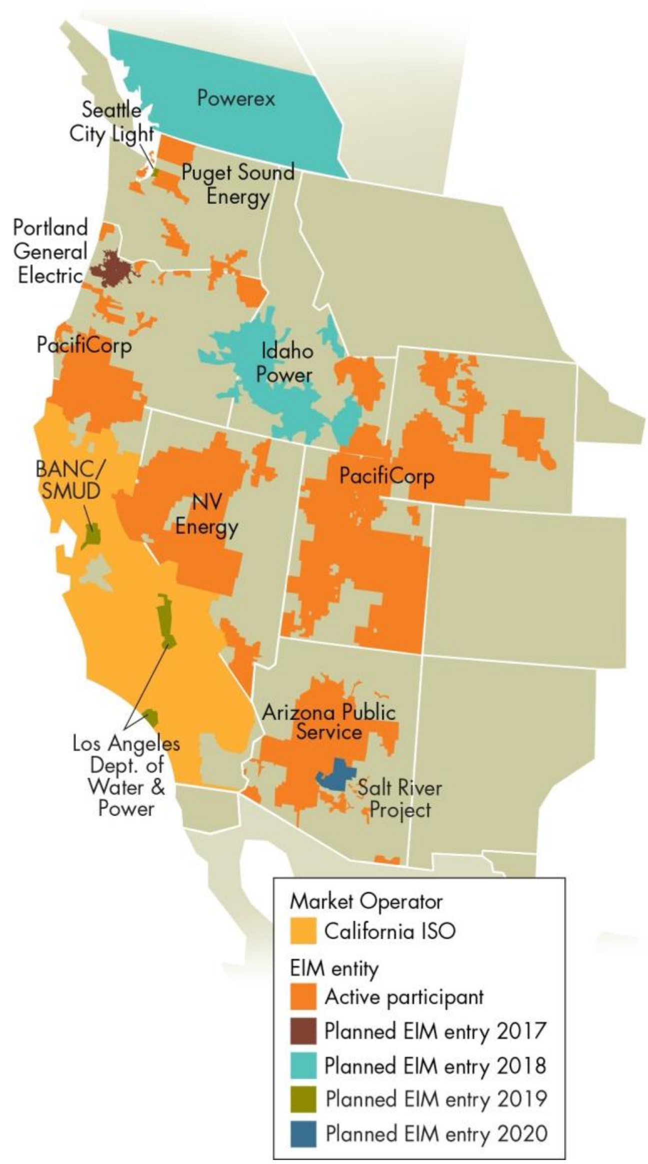
Unlike the cost-of-service model, where the state and IOU agree on fixed returns on capital investment and operations and management costs which are then passed onto consumers, all wholesale markets use a location marginal price (LMP) to determine the price of energy at a given location in the system (Energy strategies, 2017). An LMP provides the grid operator with an understanding of the demand for electricity in real-time. A high LMP indicates that there is high demand. As an LMP increases more expensive generation sources come online and provide energy into the grid. Similarly, if demand is low, then the LMP will reflect this information with a low price, resulting in fewer and cheaper sources of energy being dispatched. The use of an LMP also helps wholesale markets manage congestion and ensure efficient scheduling, commitment, and dispatch of generation in the system (Energy Strategies, 2017). LMP prices signal congestion on the grid and allow the RTO to dispatch electricity accordingly in an efficient manner (FERC, 2015). LMPs also help generators make smart capital investment decisions. Clear price signals allow generating firms to see what generation sources are profitable based on clearing prices in the market, the cost of generation fuel sources, and capital costs.

Energy Imbalance Market (EIM) Model

The EIM model is the most basic, current iteration of wholesale markets in the United States. This model currently exists in the form of the Western EIM which spans across 8 states in the Western United States (Figure 4). The Western EIM is a wholesale marketplace operated by the California Independent System Operator (CAISO). It operates by connecting multiple service territories across a large geography to lower costs and take advantage of variable generation resources such as renewables. Producers, including IOUs and non-utility entities, bid into the marketplace where the cheapest producer receives the bid, based on the LMP. The Western EIM's geographic range allows for it to best utilize variable renewable generation sources, as an oversupply of renewable energy in one region can be used elsewhere in system, allowing renewables to stay on line even if supply is greater than local demand. In the EIM model, individual states are still required to maintain their own capacity requirements to meet peak demand.

Through decreasing economic inefficiencies, dispatching the lowest cost generation in real time, and using competition to promote the growth of cheap energy sources, the EIM has generated approximately $861 million to its participants since November, 2014 (Western EIM, 2020).

Figure 4. Map of Western EIM



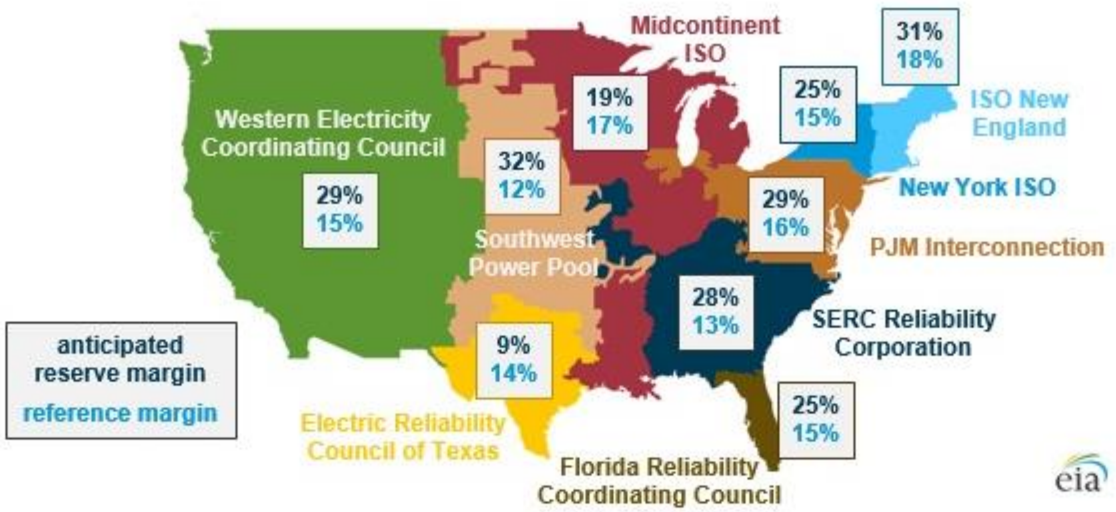
Source: EIA

Energy-Only RTO Structure

Two RTOs in the country, ERCOT (Texas), and the SPP (Southwest) operate energy-only markets in which they rely on the free market to meet demand. They differ from the Western EIM in that they operate both a real-time market, like that of the Western EIM, and also a day ahead market where participants commit capacity a day in advance into the market. Another unique aspect of both of these is the presence of a high price ceiling that is only met during peak demand hours. This high price ceiling theoretically encourages generation, as all generation sources, both cheap and expensive, can be profitable in the marketplace. Supporters of the market structure argue that this is the most efficient market, as energy producers only receive payment when they produce power, unlike the guaranteed income associated with a cost-of-service structure.

Unlike regulated states such as the Carolinas where the reserve margin is set through regulation, ERCOT and the SPP use their market structure to maintain a reserve margin of 14% and 12% respectively for the summer of 2020. (See Figure 5) (Walton, 2019; Watson, 2019).

Figure 5. Anticipated Regional Electricity Reserve Margins for 2019



Source: EIA

Given ERCOT's low anticipated reserve margins (Figure 5), there are concerns surrounding reliability in this market structure. In ERCOT, regulators ensure reliability through a scarcity pricing mechanism that allows real-time electricity prices to reach as high as $9,000/MWh on high demand days. However, the recent influx of wind energy in the state has increased ERCOT's potential reserve margin to 17%, which decreases the potential for high demand days (Bade, 2017). Cheap prices disincentivizes producers from building new generation because they can't gain a sufficient return on investment. There are also, however, as demand in the region continues to grow, generation capacity must grow with it or else future generations may not be able to support demand on high demand days.

Both ERCOT and the SPP report their market structures have resulted in cost savings compared to a cost-of-service model, like that in North and South Carolina. Based on a June 2018 study, ERCOT estimates that its consumers see annual savings between $168 million and $225 million (ERCOT, 2018). Similarly, a study performed by the SPP from 2014-2016 found that the RTO reduced the cost of electricity for consumers over the period by more than $1 billion (SPP, 2016).

Resource Adequacy Model

Five of the RTOs in the United States (CAISO, NYISO, ISO-NE, PJM, and MISO) operate resource adequacy models in which the system operator establishes multiple marketplaces to ensure electricity reliability and competition.

Similar to an energy-only market structure, resource adequacy models operate a day-ahead or real-time energy imbalance market in which producers bid on energy commitment based on projected or real-time LMP (Jenkin et al., 2016).

Real-Time Market

A real-time market is the same market structure used in the Western EIM and energy-only RTO structure. These markets generally schedule generation an hour ahead of the actual commitment and represent approximately 5% of total sales in the energy market (Blumsack, 2019).

Day-Ahead Market

In the day-ahead market, power is bought and sold the day before commitment by a producer. This market is established using LMPs for the next day and allows the RTO to examine the power units committed to the day ahead and ensure sufficient capacity based on projected demand requirements and hourly LMP (Jenkin et al., 2016). In a Resource Adequacy Model, 95% of all energy transactions are scheduled in the day-ahead market, with the rest occurring in the real-time market.

Ancillary Service Market

This market provides the RTO with a portfolio of on-demand back up a generation in cases of unexpected demand, generator outages, or planned generator downtime. These reserves can generally be brought onto the grid within an hour and play a critical role in providing consistent energy in grids with a significant portion of intermittent renewable sources such as wind and solar (Blumsack, 2019).

Capacity Market

This structure ensures supply can meet peak demand through the use of a capacity market. A capacity market is a future procurement market, in which producers bid to provide future peaking energy services, should demand surpass the capacity of the energy imbalance market (Jenkin et al., 2016). Capacity markets also provide a financial incentive for suppliers to keep generation assets online and promote new investment in generation (Blumsack, 2019). Each capacity market is structured differently, but the aim is to ensure that producers can sufficiently provide capacity in the future using financial incentives today to prevent a drop in total potential generation.

Capacity markets act as a solution to concerns surrounding generation production in energy-only markets (See Figure 5). Through ensuring returns on future investments, RTOs can encourage continued production of new generation.

Cost-Savings in a Resource Adequacy Model

The resource adequacy model has resulted in cost savings for consumers nationwide. Entergy, an IOU operating in multiple states in MISO's territory states that its consumers in Mississippi, Louisiana, and Arkansas all saved over $200 million between 2014 and 2018 (Randolph, 2019). PJM the largest RTO in the nation, reports that it saves consumers at least $3.2 billion a year through integrating more efficient resources and ensuring the lowest production costs (PJM, 2019).

Changing Technologies and the Energy Sector

This section examines the current technological trends that are disrupting and changing the way policymakers view the current electricity grid. These technologies could potentially play a critical role in shaping the grid and electricity markets of the future.

Battery Storage

Battery storage, both utility-scale and behind the meter, has the potential to change electricity markets in the coming decade. The Department of Energy estimates that currently in 2020 there are nearly 700 storage projects that are announced, operational, or under construction in the United States (DOE). A study by the National Renewable Energy laboratory in 2019, aggregated projected decreases in the cost of a 4-hour lithium-ion battery pack. Their study found that the cost of a battery pack is expected to drop by 21%-67% in dollars per kilowatt hour (Cole and Frazier, 2019). The cost-associated barriers behind the meter and utility-scale battery storage are decreasing significantly, potentially leading to the widespread use of battery storage in the future. This technology will impact the electricity market as peak demand is smoothed due to more supply coming from saved energy in batteries as well as decreased demand due to consumers using behind solar+storage technologies to curb demand during peak hours.

An increase in the use of utility-scale battery storage will also allow utilities and independent power producers to capture a higher percentage of renewable energy produced through wind and solar. In current conditions, wind and solar farms that generate energy when there is a surplus shut down, as the excess energy is unusable. However, with the addition of battery storage, wind and solar sources can continue to generate energy and then release that energy through storage when supply is unable to meet demand. Utilities can use storage to mitigate the use of gas and coal peaker plants, which are reserved specifically for peak demand periods.

Energy Efficiency in Residential Consumption

Cheap, energy-efficient appliances, light bulbs, and energy-consuming goods are becoming more readily available. The increasing rate of electricity demand at the residential level is decreasing (EIA, Total energy consumption). As households become more efficient the growth of demand is expected to continue to slow down (Reyna and Chester, 2017). Such a change in demand could significantly affect capital investments by utilities and marketplace structure. Similarly, decreased demand may come with the rise of home batteries, behind the meter technologies such as smart meters, and rooftop solar. All of these technologies are becoming cheaper for residential consumers

These technology changes are important to take into account especially when examining an energy-only market structure. As stated, ERCOT relies on variation in demand, specifically high peak demand, to support the continued investment in new generation sources. These technological advances can smooth the variance between off-peak and peak demand. Similarly, these increases in efficiency have played a role in the decreasing growth of demand for electricity nationwide, as consumption is able to grow without the need for equal growth in electricity (Davis, 2017).

Criteria

I've established 6 criteria to analyze potential alternatives to determine the best policy alternative for legislators going forward.

1. Cost-effectiveness (Weight=.40)

This criterion will use current best practices data to determine the potential cost-effectiveness of each proposed alternative over a 20-year period. The criterion will be based on the cost savings per MWh of energy produced for the region. I will scale benefits from the literature to the Carolinas using population comparisons as well as geographic comparisons, where applicable. Each alternative will be compared to the current cost-of-service model using the scaled cost savings. The cost-effectiveness metric will take into the account the cost of energy for incumbent utilities as well as the current social cost of pollution for fossil fuel-based sources. Savings from each alternative will be subtracted from

2. Effective Integration of Renewable Energy (Weight=.30)

Given SEIA's mission of promoting solar energy in the state, this criterion will examine how the proposed alternative is projected to change the composition of the region's energy mix over the next 10 years. This criterion will be measured by examining the current literature on each alternative and estimating the projected change in total kilowatts produced by renewable sources. Finally, this criterion will also project the growth of renewables in the region over the next decade based on the current renewable energy portfolio standard currently in place in North Carolina.

3. Political Feasibility (Weight=.1)

This criterion will evaluate whether the alternative can be reasonably implemented and pursued in the current political atmosphere in both states. This criterion will evaluate how feasible each alternative is in terms of implementation as well as feasibility in the legislative process. This criterion will be assessed qualitatively based on interviews and reports from experts with insider knowledge on the issue. Given that all proposed alternatives require both chambers of each state legislature to pass the bill and then each governor sign the bill, political feasibility also considers the priorities of each chamber, majority and minority leaders, as well as the relevant committees required approval to pass the proposed legislation.

4. Implementation Feasibility (Weight=.1)

Any type of electricity market change requires many stakeholders to effectively implement the proposed reform. This requires reasonable expectations for key stakeholders such as the NCUC, SC PSC, and IOUs to change their current regulatory and business strategies. This alternative will be assessed by examining the literature of each alternative and analyzing best practices for implementation. This criterion will be measured using a qualitative scale of high, medium, or low.

5. Reliability (Weight=.05)

This criterion will explore how the proposed alternative changes the reliability of the current electric grid format. This criterion will examine how a proposed change to the current structure will change how the grid can meet demand. This criterion will be measured qualitatively through how the implementation of each alternative in different regions of the country has affected grid reliability, and each alternative will be given a score of high, medium, or low.

6. Equity Across Consumer Classes (Weight=.05)

Each consumer class (residential, commercial, and industrial) faces different prices and pay structures based on their unique needs. Any proposed reform could disproportionately affect one class of consumers compared to the other two. This criterion will examine each alternative to ensure that one class of consumers is not unduly burdened by any proposed reform. This criterion will examine current best practices for each alternative and adapt them to the Carolinas. The criterion will be measured on a qualitative scale of low, medium, or high.

Alternatives

Alternative #1: Remaining in the Vertically Integrated Model

The current vertically-integrated model allows for each state PUC to have sole regulatory control over their electric grid. In this system, the PUC oversees any propositions from IOUs to change rates to customers as well as any proposed capital investments. Therefore, under the current system, it is not unreasonable to assume that the PUC can internalize the current high cost to consumers through effective regulation. With this regulatory authority, the utility commission in each state has the power to regulate based on the needs of stakeholders in the region. They can quickly respond to the needs of constituents, as utilities are required to file rate cases with the utility commission regarding any rate increases, infrastructure investments, or potential changes in quality of service (North Carolina Utility Commission, 2019). It's not unreasonable to expect the utility commission and the state legislature to address the stifled growth of renewables and high rates to consumers using the current market structure and regulatory model.

Independent power producers can operate under this model through the Public Utility Regulatory Policies Act. The law requires utilities, such as IOUs, to purchase electricity produced by small power producers of less than 80 MW (PURPA). Under the current law, independent power producers can apply through each state's PUC to receive approval to build the project. If approved, the IOU in the region must purchase the energy produced by the facility at the avoided cost of energy; the cost to the utility if it had generated or otherwise purchased that energy (EIA, 2020).

Current laws in both states have also promoted the growth of renewable and low-carbon emitting energy sources. In 2007, The North Carolina State Legislature passed a renewable portfolio standard which requires 12.5% of all retail sales for an IOU by 2021 to come from qualifying renewable energy sources. North Carolina also offered a 35% tax credit to investors in renewable energy resources through 2015, promoting the expanded growth of solar in the region. Similarly, the South Carolina legislature passed the Atomic Energy and Radiation Control Act in 1967 which boosted the growth of nuclear energy in the state through the second half of the 20th century, resulting in over half of the state's current electricity generation coming from nuclear energy sources.

Alternative #2: Reforming the Current Cost-of-Service Ratemaking Model with a PBR Model

PBR aims to better align the actions of an IOU with public interest objectives and consumer benefits. This regulatory framework incentivizes IOUs through rewarding them if they meet certain goals. Regulators can set the model in a way where IOUs earn a greater return on investment or cash incentives through meeting energy efficiency goals, decreased rates to consumers, or transmission resiliency investments. This model in contrast to the current cost-of-service model which incentivizes utilities to invest in capital investments because of the guaranteed return on investment they negotiate with each state's PUC. PBR could be a means of improving the electricity sector without having to spend the entire market.

The North Carolina State legislature recently approved a study to examine a multiyear rate proposal as a type of PBR measure. The study was originally proposed as a bill, but received significant pushback from stakeholders, as multiyear rate cases were seen as decreasing regulatory oversight over Duke Energy (Morehouse, 2019). However, there are many ways to implement a PBR model, and this alternative will focus on implementing a PBR system with performance incentive mechanisms (PIM). This alternative will examine how different states including, but not limited to, Illinois, Massachusetts, and New York have implemented PBR using PIM to meet the needs of the criteria listed above.

While PIMs can potentially better align the motives of IOUs with the needs of consumers, there are potential pitfalls associated with the ratemaking model that implementer have to take into account. PIMs can lead to unintended consequences, as IOUs could underperform in a different metric to meet the requirements of the the PIM (Woolf, 2017). Also implementation of PIMs require sufficient cost-benefit analysis to ensure that the benefits to consumers of setting specific policy goals outweigh the potential costs associated with changes in IOU strategy (Woolf, 2017).

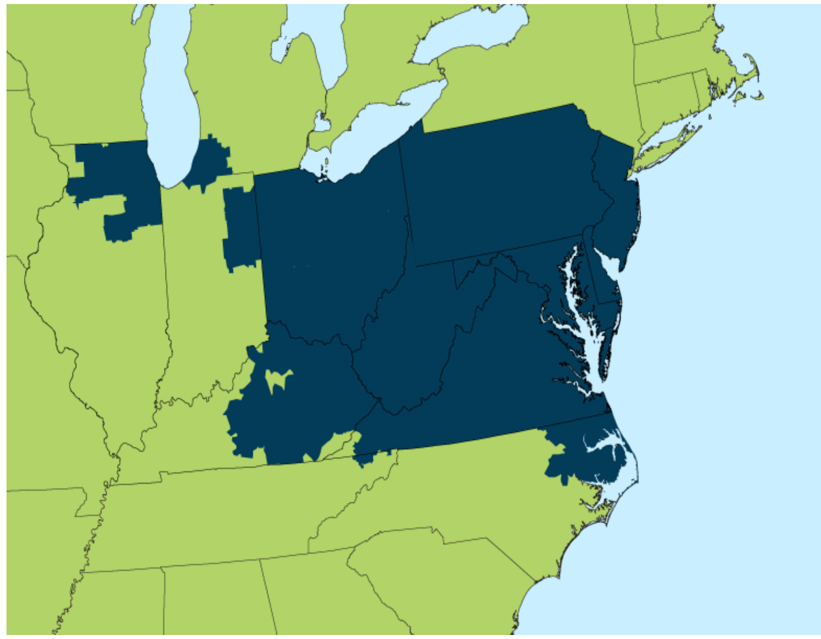
Alternative #3: Creating an Energy-Imbalance Market in the Carolinas

Creating an EIM in the Carolinas would create a competitive wholesale market in the Carolinas where regulated utilities and independent power producers could compete in a real-time market. Doing so would require both state legislatures to pass legislation authorizing each state's respective PUC to apply for the creation of an EIM. Given that an EIM falls under the jurisdiction of FERC in terms of regulation, an independent grid operator (similar to that of an RTO or ISO) would be created. Such a grid operator would be governed by relevant stakeholders in the region, and it would be up to those stakeholders as to how the governance system would operate. NCUC and SC PSC would also require that utilities with balancing authority decouple their generation and transmission control. While utilities would still be able to own their incumbent transmission assets, they would cede the operation of transmission to the independent EIM operator.

In an EIM, each state would still individually be responsible for meeting its federally mandated reserve margin requirement. Each state would also still be responsible for regulating ancillary services.

Alternative #4: Joining PJM

Figure 6. Map of PJM Service Territory



Source: PJM

A third alternative for both state legislatures is to pass legislation to require utilities in both states to join the Pennsylvania-Maryland-New Jersey Interconnection, also known as PJM. PJM acts as the grid operator for a geographical region across the mid-Atlantic from Pennsylvania to Northeast North Carolina, and up to Illinois. (See Figure 6). As the independent grid operator, PJM establishes a marketplace that determines the price of energy in response to demand on the grid. PJM operates in a resource adequacy model, using 4 different marketplaces to meet the electricity needs of consumers and maintain gird reliability (PJM, 2019). This method is in contrast to the current vertically integrated model where the utility is responsible for meeting all consumer demand. However, joining PJM does not mean that the state fully deregulates its entire electricity market. Joining PJM would only introduce competition at the wholesale energy level (Blumsack, 2019). Utilities such as Duke Energy, South Carolina Electric & Gas, and Santee Cooper would be competing with other utilities and independent power producers in the PJM service territory to provide electricity to consumers. Both state utility commissions would still regulate proposed utility investments and rate cases. This competition is what drives down prices for consumers and promotes the growth of cheaper energy technologies such as utility-scale solar power (Chang et. al, 2019). A recent study by the Brattle Group, an independent consulting firm, estimates that Duke Energy's participation in an RTO could result in up to $593 million dollars in annual energy savings for the state (Chang et al., 2019). Under and RTO model like PJM, utilities and independent power providers make infrastructure investment decisions based on market signals. Their investments result from a cost-benefit analysis based on the market, rather than a pre-determined return on equity that's negotiated with the state utility commission (PJM, 2016). IOUs make sounder, more economically efficient investments to stay competitive in the marketplace. Overall, joining PJM could result in decreased economic efficiencies at the wholesale level which would decrease overall costs to consumers, while encouraging the investment of cheap energy sources like solar power.

Alternative #5: Creating an Independent Resource Adequacy Model RTO for the Carolinas

Joining PJM could bring many potential benefits to the Carolinas, but there are concerns over the RTO's market structure. PJM's capacity market, the marketplace used to buy energy in advance from producers to call upon in the event of an unexpected spike in demand, is currently under scrutiny for the RTO's proposed reforms, which would artificially inflate the price at which renewable generation sources can enter the marketplace (Rutigliano, 2019). If FERC pproves the measure, renewable sources could be priced out of the market, disincentivizing utilities and independent power producers from investing in renewable infrastructure. A recent study by Grid Strategies LLC also revealed that PJM keeps 18 gigawatts of coal plants in operation due to the structure of the capacity market (Gramlich and Goggin, 2019). Both states could see unexpected price increases from joining PJM due to their heavy reliance on nuclear energy and its high NET CONE.

An alternative to joining PJM would be to create an independent RTO in the Carolinas. Doing so is not unprecedented in the region. The Carolinas attempted to create their own RTO in 2000, known as GridSouth, but FERC denied their proposal due to concerns surrounding grid reliability and lack of generation sources (FERC, 2001). However, given the significant population growth of the region over the past 20 years, these concerns no longer exist. Creating an independent Resource Adequacy Model-based RTO in the Carolinas would allow relevant stakeholders in the region to construct a marketplace that best meets the needs of the region. Given the energy portfolio of the two states is significantly different from that of the PJM service territory, a marketplace that better supports zero-carbon technologies like nuclear and solar power could drive down costs to consumers while also promoting the growth of renewable energy (EIA, 2019). Stakeholders involved in forming a new RTO would also benefit from the decades of data and analysis on pre-existing RTOs in North America. This data would give stakeholders insight as to how to avoid unexpected market inefficiencies and externalities that could be associated with creating a new RTO.

In running a cost-effectiveness analysis for this alternative, I will base costs on those of MISO. MISO operates a market structure I project would be similar to that of the Carolinas. The majority of states in the region operate vertically-integrated electricity markets. Thus, I expect the market structure and governance for an RTO in the Carolinas to be similar to that of MISO.

Findings

Reliability

Figure 1 shows the anticipated reserve margin for the Southeast as well as the PJM interconnection, the Western Electricity Coordinating Council, which encompasses the Western Energy Imbalance Market, and MISO. Figure 1 demonstrates that the current status quo, as well as the models that the alternatives are based on, have resulted in surplus reserve margins to address peak demand. None of the alternatives present concerns surrounding reserve capacity. However, the current status quo receives a medium in this category because of the incentive structure surrounding the cost-of-service model. As stated earlier in this report, the cost-of-service model overly incentivizes investment in capital infrastructure due to the guaranteed return on equity. As a result, investments in grid resiliency and modernization are not prioritized, leading to concerns surrounding long term reliability.

Implementation Feasibility

Excluding the status quo, each alternative requires the NCUC and SC PSC to implement the proposed rule changes or market reform. However, the difficulty of implementation varies for each alternative. Most notably creating a new RTO in the Carolinas receives a score of "low" in the category because of the complicated nature of creating a resource adequacy RTO model. Doing so, would require the creation of an independent stakeholder's board, loss of jurisdiction to FERC, decoupling of the ownership the current transmission network from IOU ownership to that of an independent entity, and finally the creation of multiple marketplaces. Doing so requires significant coordination between stakeholders across state lines and has potential for future market failures. Creating an EIM in the region faces these problems to a lesser extent, since it only requires the creation of a single marketplace.

Equity

The current status quo presents equity concerns due to the risk shifted onto residential consumers in a cost-of-service model. Residential consumers bear a portion the risk associated with capital investment projects, leading to situations such as that with the V.C summer nuclear plant. All of the reforms proposed attempt to mitigate this risk for consumers. A PBR model financially incentivizes utilities to make prudent investments while both RTO proposals and the energy imbalance market use competition to drive down prices for consumers across each class. However, the proposed North and South Carolina RTO receives a medium in this category due to the risks associated with creating new marketplaces. Unexpected market failures could lead to consumers, particularly residential consumers, paying higher rates due to market inefficiencies.

Political feasibility

After interviewing stakeholders in the state legislatures as well as gathering public comments from state senators and legislators, I rated each alternative based on how often stakeholders discussed the alternative as well as how likely it seemed the alternative could make it through the legislative process. Each proposed alternative must pass through both chambers of each state's legislature and be signed into law by each state's respective governor. Due to this process, no alternative deviating from the status quo received a score of high in this category. The utilities in both states have not demonstrated strong interest in pursuing any of these alternatives, and while there are growing calls for reform in both state legislatures, passing any type of reform will require significant time, effort, and deal making. The PBR model and regional EIM model both received a score of "low" in this category because few key stakeholders have mentioned these alternatives as potential mediums of reform. Rather, both state legislatures have shown stronger interest in pursuing some form of an RTO model. Both state legislatures have also submitted bills (North Carolina HB 958 and South Carolina Joint Resolution H. 4940) to fund a study to explore potentially joining an RTO or creating a new one in the region (Adams III et al., 2020).

Penetration of Renewable Sources.

The growth of renewables from this report is based on data from existing RTOs, energy imbalance markets, and PBR models. Thus, the growth of renewables will be highest in a regional transmission organization or energy imbalance model where competition from both utility and non-utility entities encourage investment in cheap renewable sources, most notably utility-scale PV solar.[2] For the status quo, PBR model, and independent RTO in the Carolinas, the growth of renewable energy sources depends upon implementation of the proposed policy. Both legislatures could use performance incentive mechanisms in a PBR model to incentivize utilities to invest in renewables. Similarly, the structure of the marketplaces in a new RTO in the region will affect the growth of renewables.

Cost-effectiveness

The cost-effectiveness calculation (see appendix I for methodologies) found that joining PJM could significantly reduce the cost of electricity per MWh for each state by nearly $30 over the next twenty years. This drop in the price of electricity is derived from the benefits reported on an annual basis by PJM. Increases in grid management efficiency, more efficient generating sources, and efficient capital investment along with emissions reductions in PJM territory represent potential savings for the Carolinas. Both the EIM and independent RTO models proved more cost-effective than the status quo. However, unlike PJM membership, they don't provide the benefits associated with a large geographic footprint. As a result, consumers benefit less from economies of scale and greater competition. Finally, the PBR model presented a challenge in determining its cost-effectiveness. Given the unique nature of the model, legislatures designing ratemaking schemes to meet specific policy goals, the numbers calculated in this cost-effectiveness study may not represent the true potential cost-savings from the model. The true cost-savings of a policy could not be calculated until the legislature laid out a specific plan, with defined metrics and outcome goals, for the state PUC to implement.

PBR model Cost-Effectiveness Score

The cost-effectiveness measure in this study is ill-suited for estimating the potential saving to consumers associated with the PBR model. Rather a cost-benefit analysis performed with the specific goals of a policy laid out by the legislature would be an effective means of determining if the

[2] This report does not consider the current proposed expansion of PJM's capacity market minimum offer pricing rule, as the proposed rule has not been finalized by the publishing of this paper.

policy is worth pursuing. While the lack of a cost-effectiveness measure results in an artificially low score for the PBR model, the aggregated scores of the other criteria compared to the 4 other alternatives do not change the recommendation of this study.

Outcomes Matrix

Alternative	20 Year Cost-effectiveness ($/MWh) (Weight= .4)	Growth of Renewables (Weight=.3)	Political Feasibility (Weight=.1)	Implementation Feasibility (Weight=.1)	Reliability (Weight=.05)	Equity (Weight=.05)	Total
Status Quo	NC:$99.71 (3) SC:$102.02	Medium (6)	High (9)	High (9)	Medium (6)	Medium (6)	5.4
PBR Model	NC: - SC: -	Medium (6)	Low (3)	Medium (6)	High (9)	High (9)	3.6
Regional EIM	NC:$94.56 (6) SC:$96.63	High (9)	Low (3)	Medium (6)	High (9)	High (9)	6.9
Joining PJM	NC:$64.80 (9) SC:$78.22	High (9)	Medium (6)	Medium (6)	High (9)	High (9)	8.4
New RTO in the Carolinas	NC:$72.10 (6) SC:$81.51	Medium (6)	Medium (6)	Low (3)	High (9)	Medium (6)	5.6

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Recommendation

I am recommending that both state legislatures pass legislation authorizing each state's PUC to require all utilities in North Carolina and South Carolina to join the PJM interconnection. Joining PJM can bring cost savings to electricity production in the Carolinas that will result in decreased costs to consumers. Also given that PJM is one of the largest and oldest RTOs in the country, implementation concerns surrounding the creation of new marketplace balancing authority are addressed. PJM membership also brings with it the benefits of geographic diversity. Given PJM's large geographic footprint, the RTO encompasses a larger number of generation sources than an RTO or EIM created in the Carolinas. The Carolinas can benefit from cheaper electricity associated the economies of scale of the RTO. Finally, PJM membership will result in more efficient decision-making by IOUs due to market forces, mitigating poor investment decisions such as that made with the V.C Summer Nuclear Plant.

Caveats

1. This report does not consider the PJM's pending interpretation of the expanded minimum offer pricing rule in PJM's capacity market. While this report recommends that both state legislatures authorize their respective PUCs to require utilities to join PJM, further research is required to determine whether both states should PJM's capacity market.

2. The cost-effectiveness analysis of this report does not consider implementation of Executive Order no. 80, Governor Cooper's proposed 2050 clean power plan, which calls for North Carolina to become carbon neutral by 2050. Rather, this report assumes a continuation of the current renewable portfolio standard of 12.5% required renewable generation from utilities operating in the state.

Both of these caveats could significantly affect how both states choose to introduce any reform into the electricity market. Thus, further research on the potential benefits from joining the PJM interconnection should be done by the the NCUC and SC PSC.

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Appendix I: Cost-effectiveness Methodology

- I established a baseline energy costs using the current energy mix and total 2019 net generation of electricity from both states. With that data, I used the LCOE for each source of energy and multiplied it by the generation mix percentage and total to determine the annual cost of energy for each state. I also calculated a social cost of carbon and co-carbon pollutants for fossil fuel emitting sources.
- For the PBR Model
- PJM and NC-SC RTO assumptions were made through scaling the 2019 value propositions for PJM and MISO to the population of North Carolina and South Carolina. Those cost savings were then scaled to the population of both states. For the MISO value proposition, the RTO quotes benefits associated with the RTO's geographic diversity. To calculate those benefits accordingly, I scaled the benefits based on the geographic area of North and South Carolina
- Similarly, to the PJM and NC-SC RTO models, I calculated the cost-effectiveness of an NC-SC EIM through scaling benefits based on population from the annual benefits posted on the Western EIM website and then subtracting those cost-savings from the status quo.
- In this cost-effectiveness I analysis I also chose to use a 5% discount rate, as a median between the EPA's standard 3% and 7% discount rates for cost-benefit analysis.

1. Baseline Assumptions:

General Assumtions		**North Carolina Assumptions**		**South Carolina Assumptions**	
Interest Rate	5%	Current North Carolina Population	10.5 million	Current South Carolina Population	5.084 million
Gas CC LCOE ($/MWh)	$68	projected NC population growth rate	1.13% per year	Projected SC population growth rate	1.23% per year
Solar PV LCOE ($/MWh)	$44	Generation Mix:		Generation Mix:	
Nuclear LCOE ($/MWh)	$192	Natural Gas	24.50%	Natural Gas	19.50%
Biomass LCOE ($/MWh)	$97.70	Coal	28.50%	Coal	17.00%
Hydroelectric($/MWh)	$63.90	Nuclear	37.70%	Nuclear	53.50%
Petroleum ($/MWh)	$175.00	Solar	1.90%	Solar	1.60%
Coal LCOE ($/MWh)	$152	Petroleum	0.20%	Petroleum	2.90%
Co-Pollution Cost of Carbon ($/metric	$38.10	Biomass	5.74%	Biomass	0.70%
		Hydroelectric	1.36%	Hydroelectric	1.60%
Social Cost of Carbon ($/metric ton)	$14			Pumped Storage	3.20%
Output	MWh				
North Carolina 2019 Generation	10,448,000	Tons of CO_2 per MWh of Petroleum			
South Carolina 2019 Generation	8,251,000	lbs/KWh	lbs/MWh	metric ton/MWh	
total	18,699,000	2.11	2110	0.941964286	
		Tons of CO_2 per MWh of Coal			
		lbs/KWh	lbs/MWh	metric ton/MWh	
		2.21	2210	0.986607143	
		Tons of CO_2 per MWh of Natural Gas			
		lbs/KWh	lbs/MWh	metric ton/MWh	
		0.92	920	0.410714286	

2. PJM Assumptions:

PJM Assumptions		Demographic Assumptions	
	Projected Annual Savings (2019 Dollars)	NC Population	10,500,000.00
Generation Investment	$1,250,867,258.36	NC population growth (%/year)	1.13%
Reliability	$312,716,814.59	SC Population	5,084,000
Energy Production Costs	$547,254,426	SC Population growth (%/year)	1.23%
Emissions reduction (tons of CO2)	10,000,000.00	PJM Population	65,000,000
Integration of more efficient sources	$625,433,629.18		

3. NC-SC RTO Assumptions (Based on benefits from MISO 2019 Value Proposition)

MISO Assumptions		Demographic Assumptions	
Improved reliability	$278,000,000.00	NC Population	10,500,000.00
Compliance Consolidation	$96,000,000.00	NC population growth (%/year)	1.13%
Dispatch of Energy	$283,000,000.00	SC Population	5,084,000
Regulation Consolidation	$49,000,000.00	SC Population growth (%/year)	1.23%
Spinning Reserve Market	$23,000,000.00	NC Area (Square Miles)	53819.00
Wind Integration	$415,000,000.00	SC Area (Square Miles)	32020.00
Footprint Diversity	$2,195,000,000.00	MISO Area (Square miles)	900,000
Demand Response	$154,000,000.00	MISO Population	37,000,000
Cost Structure	-$296,000,000.00		

4. Western EIM Assumptions

Western EIM Assumptions	
2019 Economic Savings	$296,910,000.00
2019 CO2 emssiosn curtailment (metric tons of CO2)	108,836
Population of the Western EIM	42,000,000

Appendix II: Sensitivity Analysis for Cost-Effectiveness Measure

Table: 1 Discount Rate Sensitivity Analysis

Alternative	3% Discount Rate	5% Discount Rate	7% Discount Rate
Status Quo	NC:$119.04 SC:$121.79	NC:$99.71 SC:$102.02	NC:$84.77 SC:$86.73
PBR Model	NC: SC:	NC: SC:	NC: SC:
NC-SC EIM	NC:$112.84 SC:$115.33	NC:$94.56 SC:$96.63	NC:$80.41 SC:$82.17
Join PJM	NC:$77.07 SC:$93.18	NC:$64.80 SC:$78.22	NC:$55.28 SC:$66.63
NC-SC RTO	NC:$85.85 SC:$97.14	NC:$72.10 SC:$81.51	NC:$61.45 SC:$69.40

Changing the discount rate does not affect the choice outcome for the cost-effectiveness analysis. Over a 20 year period, joining PJM is still the most cost-effective alternative.

Appendix III: Retrospective RTO and EIM Benefit Studies

Entity	Study	Estimated Savings
MISO	2018 Annual MISO Value Proposition Study	\$3.2-3.9 billion in benefits in 2017 \$24 billion cumulative benefits from 2007-2017
Western Energy Imbalance Market	2019 Cumulative Benefits Study	\$565 million in cumulative benefits since 2014
Dominion Energy	2015 Virginia PUC filing on Benefits of PJM Membership	Estimated \$109 million of production cost savings in 2014 Estimated \$75 million in production cost savings in 2013