EXAMINING THE VIABILITY OF SUSTAINABLE PRACTICES FOR A LARGE SCALE PUBLIC UTILITY

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To my parents Gretchen and Christopher Reamy, my sister Allison, my brother Phillip, and all my friends for supporting my academic life

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LIST OF ABBREVIATIONS

AMI	Advanced Metering Infrastructure
Btu	British Thermal Units
CFL	Compact Fluorescent Light
CO_2	Carbon Dioxide
DVP	Dominion Virginia Power
EIA	Energy Information Administration
KW	Kilo-Watt (1,000 watts)
KWh	Kilo-Watt Hours
LED	Light Emitting Diode
MW	Mega-Watt (1,000 kilo-watts
NO_X	Nitrogen Oxide
NREL	National Renewable Energy Laboratory
REC	Renewable Energy Credits
RPS	Renewable Portfolio Standards
SO_2	Sulfur Dioxide

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This thesis examines the sustainability practices of Dominion Resources, a publicly traded utility located in Virginia by scrutinizing past practices as well as future goals. Analysis was done to compare the company's operating metrics to other utilities in the United States. This paper addresses common barriers to implementation of sustainability practices such as legislation, cost-benefit analysis, and customer acceptance concluding with a recommendation to Dominion to circumvent the highlighted barriers.

CHAPTER 1
INTRODUCTION

There is a strong emphasis on “going green” these days. People are striving to reduce, reuse, recycle and conserve all their resources, especially electricity. Companies are feeling the need to “go green” as well. Many are going paperless and moving files to electronic copies while others sponsor “BYOC” policies to bring your own cups to work to eliminate Styrofoam waste. Electric utilities are no exception. Pressures to “green” their image have been growing, initiated by the public’s embrace of the existence of global warming due to increased carbon emissions (IPCC, 2007). In order to reduce carbon dioxide (CO_2) emissions, there is a desire to push forward in two directions.

First, there is an outcry for renewable sources of electricity. Renewable energy is defined by the Environmental Protection Agency as “resources that rely on fuel sources that restore themselves over short periods of time and do not diminish (EPA.gov).” Examples of such energy can be found in solar, wind, geothermal, biomass, and moving water. In August of 2007, The United States House of Representatives passed the Energy Bill that states that 15% of US electricity must come from renewable sources by 2020. Today, just 2.4% of America’s energy comes from renewable sources other than hydroelectric (Lighting the way). However there is a shift in production taking place. In 2006, 2400 megawatts of wind power were added to the grid which is only second to the increase in natural gas. What’s even more surprising is that in the same year only 600 megawatts of coal generating facilities were put online (Lighting the way). This trend is expected to increase in the foreseeable future. Utilities will need to adapt to the “green movement” by changing the ways they produce electricity.

The second direction is a call to reduce power consumption all together through energy conservation practices. These practices include not only utilizing less electricity by not using products, but purchasing energy efficient products as well. Construction sites are using products that insulate structures better, refrigerators are becoming more energy efficient, and even the simple incandescent light bulb is being phased out in favor of compact fluorescent (CFL) or light emitting diode (LED) technologies (US Energy Information Administration, 2008). With reduced power consumption, there is less of a need to generate power which in return reduces carbon emissions.

So if the decision to switch energy portfolios to renewable sources and to reduce energy usage benefits the environment by reducing CO_2 emissions, there should be no hesitation by a power company to do so. There are major barriers still in the way of the shift from taking place. For starters, it is well known that renewable power facilities are more expensive to manufacture and maintain; a cost that is passed down by utility companies to their ratepayers. By relying on more expensive forms of electricity, the price of electricity for the average user would skyrocket, a cost that is already considered a burden during the time of an economic downturn. As for energy conservation, it seems counterintuitive for an electric industry to advertise *not* to use its product. After all, an electric meter that doesn't spin doesn't generate revenue.

Dominion Virginia Power is one of these companies at the forefront of the renewable and energy conservation conundrum. They are a large scale energy company with assets in generation, distribution, and transmission. The company operates generation facilities in ten states as far west as Illinois and as far north as Massachusetts. Dominion distributes power to 2.4 million customers in Virginia and

North Carolina and their power portfolio consists of just over 28,000 megawatts of electricity, of which 1,600 (5.6%) are from renewable sources of energy(Dominion Resources, 2011). They are publicly committed to reaching the US House of Representatives goal of 15% of energy created from renewable sources by 2025. Dominion's company goal is to be environmentally responsible and provide reliable service, while maximizing returns to its investors (Dominion Resources, 2011). By using Dominion as a case study, the following question will be answered in order to aid Dominion in their efforts moving forward:

- How does a publicly traded electric utility company ethically address sustainability while keeping its shareholders in mind?

At first glance there seems to be a common sense disconnect between an electric utility actively seeking a way for its customers to reduce energy consumption. This paper connects the dots to make this issue clear. Dominion's current strategies will be analyzed through interviews and research of their past practices in order to compare them to goals set forth by the United States government and other utilities to make a sound recommendation for Dominion's future.

CHAPTER 2
LITERATURE REVIEW

Public electric utilities provide an essential service for a lifestyle that humans have grown to know. People expect lights to turn on at the flip of a switch, and don't interact with the resources needed for this simple action. In order to examine barriers to sustainability with regards to generating electricity, it is necessary to examine how an electric utility is regulated, including the laws that they must follow, how utilities make their business decisions, and the basics in the technology of alternative, sustainable forms of energy.

Going "Green"

The reason why going "green" is such a hot topic is two-fold. First, it is recognized that eventually non-renewable resources will be depleted, and a new energy source must be utilized to take its place. After all that is the definition of a non-renewable resource. The second reason to "green" the energy industry is to reduce the emissions created as a byproduct of fuel combustion. Numerous studies have proven the harmful effects of common emission gasses.

The three main sources of non-renewable energy are coal, oil, and natural gas. Coal is of great abundance in the United States as it holds 28.8% of the world's reserves (US Energy Information Administration, 2011). However, as of 2010, the United States contained enough recoverable coal, which at its current rate of consumption would equal 249 years worth of resources (US Energy Information Administration, 2011). It is expected that energy consumption will rise approximately 1.1% annually from 2009-2035, bringing the available coal to only 119 years (US Energy Information Administration, 2011).

Oil follows the same story; though, the United States has less of the world's total supply. The US has taken steps to decrease its dependence on foreign oil supplies through legislation (US Energy Information Administration, 2008). Regardless, the world's production will top out between 2021 and 2112, rapidly declining until 2125, giving the world 114 years of consumption left assuming that consumption increases by 2% annually (John H. Wood, 2004).

Natural Gas levels have risen in the past decade due to new technology that allows for extraction from once locked away regions of shale (US Energy Information Administration, 2011). The US contains the sixth largest amount of natural gas reserves at 3.7% of the world's resources (US Energy Information Administration, 2011). The 2,543 trillion cubic feet of gas is enough to last for just over 100 years if used at the same rates of 2010 (US Energy Information Administration, 2011).

By combining uses of these natural resources, the United States will be able operate at current practices for another century and half, but what happens after that? This is where the issue of sustainability comes into play. New energy technologies are being researched and an added emphasis is being put on energy conservation to buy more time until new sources of energy can be utilized.

The negative side effect of these sources of fuel is the creation of gaseous byproducts that are released into the atmosphere. The burning of carbon based products expels carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxides (NO_X), and particulate matter (PM) into the atmosphere (US Energy Information Administration, 2011). Each fuel source varies in ratios of release of each of these compounds. CO_2 is the leading greenhouse gas (US Environmental Protection Agency, 2011). Increases in

CO_2 emissions from 1906 to 2005 have been scientifically proven to have had an influence in the increase of the warming of the planet by 1.0º to 1.7º F (US Environmental Protection Agency, 2011). This increase in temperature has had an effect on climates around the world. CO_2 release varies from 117 pounds of CO_2 per million Btu of natural gas, 160 pounds of CO_2 per million BTU of fuel oil, to 200 pounds of CO_2 per million Btu of coal (US Energy Information Administration, 2011). As natural gas becomes more abundant and its emissions improve compared to coal and oil, the uses of natural gas are increasing (US Energy Information Administration, 2011). SO_2 contributes to acid rain which is harmful to plants that live in water (US Energy Information Administration, 2011). NO_X and PM contribute to smog and haze which has been linked to respiratory illnesses (US Energy Information Administration, 2011).

These reasons for greening the energy industry have initiated the public to demand changes to the status quo by way of political advocacy. Through political involvement, rules and regulations can be instituted. Laws and regulations ensure entities are doing what the people desire.

Political Overview

In order to understand where decisions are made for utilities, one must have an understanding of United States politics. Policies are drafted and enforced by each level of the government; national, state, and local. National government gives general guidelines which address national interests such as energy independence set forth by the Federal Energy Regulatory Commission (FERC) (SCC, 2010). US Congress can enact laws that utilities must follow.

State governments create their own energy laws and policies that are more specific and beneficial to each individual state, for example, laws that aim to attract

businesses and jobs to the state. This level of government has the greatest direct impact between utilities and ratepayers. Utilities must submit their business strategies and rates that they are seeking to the state level. This is called a rate case (SCC, 2010). Commissions review, deliberate, and approve or deny the requests. This process is open to the public and is much like court proceedings to guarantee due process (SCC, 2010). The public may participate by submitting written or electronic comments to the commission, as well as cross examine witnesses at the hearing (SCC, 2010).

Local governments create legislation for communities which often times address zoning and energy use. In essence the energy policy at each level of government is decided on by its citizens. If a citizen is unhappy with the direction of energy policy, their rates, or even a nuisance complaint, they may elect a new representative to speak on their behalf in legislature.

Legislation

Representatives, in the legislative branch of each level of government, must represent their constituents fairly. A representative's constituents are not only the citizens whom elect the representative into office, but the corporations and utilities that are located within their designated district. When a bill is proposed, the representative must weigh both sides of arguments and make a fair and balanced policy that benefits both his/her citizens as well as corporations.

The history of the United States promoting sustainability in its energy policy dates back to 1963 with the implementation of the Clean Air Act. While this Act did not specifically address the sustainability in the electric utility industry, it laid the groundwork for environmental stewardship and was the first piece of governmental legislation

seeking to control emissions. Its focus was on the emissions from automobiles, and was amended significantly in 1970, 1977, and 1990 (Clean Air Act of 1963, 1963). The first amendment in 1970 began to limit industrial pollution which led to the creation of the Environmental Protection Agency in 1971 to directly monitor the requirements set forth (Clean Air Act Extension of 1970, 1970). The amendments in 1977 redefined the standards of air quality (Clean Air Act Amendments of 1977, 1977). The most extensive set of amendments came in 1990 when the United States once again became more stringent on standards by specifically aiming to limit 189 toxic pollutants (Clean Air Act Amendments of 1990, 1990). Controls were placed to eventually phase out ozone depleting chemicals (Clean Air Act Amendments of 1990, 1990). There was a flurry of conservation laws in 1978 that specifically sought to focus on renewable energy sources for the first time. The National Energy Conservation Policy Act of 1978 required utilities to provide energy audits to encourage slower growth of electric demand (National Energy Conservation Policy Act of 1978, 1978). This was the first time energy conservation was addressed by Congress. Shortly after, Congress passed the Energy Tax Act which first promoted wind, solar, and geothermal applications for residents at a local level. Tax credits were for $2000 which covered around 30% of the installation costs (Energy Tax Act, 1978). Included in the Energy Tax Act was the Public Utility Regulatory Policy Act (PURPA), which allowed regulated electric utilities to buy a portion of their portfolio from another company that utilized renewable energy in order to meet goals (Energy Tax Act, 1978). However this act never took hold because it was left up to the states to regulate. Those states that did not have abundant renewable sources abandoned their support for the act. In 2005, Renewable Energy Standards

(RES) replaced PURPA. The period between 1978 and 1990 focused mostly on oil and nuclear as forms of power, but in 1992 renewables again became popular with the introduction of the Energy Policy Act of 1992. This act aimed at reducing dependence on foreign energy, increasing conservation, and promoting clean coal (Energy Policy Act of 1992, 1992). PURPA was amended to allow for a greater choice and leniency for electric utilities when it came to purchasing renewable sources (Energy Policy Act of 1992, 1992). The Energy Policy Act of 2005 to date has been the most extensive piece of legislation impacting electric utilities. It offered broad tax incentives and subsidies to the public (Energy Policy Act of 2005, 2005). The law offered aid to energy companies in every form of generation giving $2.7 billion of tax credits to invest in renewable sources, $500 million in bonds for renewable energy projects, $1.3 billion in tax credits to promote conservation and energy efficiency, and $1.6 billion for investment in clean coal (Energy Policy Act of 2005, 2005). This law even mentions tidal and wave energy as a valid source of energy for the first time (Energy Policy Act of 2005, 2005). In 2007 President Barack Obama signed Executive Order Number 13423 that set the guidelines for the United States Government. This order set out to reduce governmental greenhouse gas emissions by 30% by 2015, increase the use of renewable facilities on government owned properties to half, and mandated that every new building was built to follow *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings set forth in the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (2006)* in achieving sustainable certification of 15% of all government owned buildings by 2015 (Obama, Executive Order 13423—Strengthening Federal Environmental, Energy, and Transportation Management, 2007).

Two years later Executive Order 13514 expanded on E.O. 13423 by making mandatory greenhouse gas reductions by 2020 as well as refined definitions for energy efficiency within government owned buildings (Executive Order 13514, 2009). Lastly, the most recent law passed by congress is the American Recovery and Reinvestment Act of 2009. The ARRA expanded tax credits for renewable energy by $13 billion, provided $6 billion in loan guarantees for renewable projects, $800 million to fund biofuel research projects, $500 million in training of "Green-collar" workers, $400 million for the Geothermal Technologies Program, $190 million investment in solar and wind projects, $115 million to develop and deploy new solar power technologies, and $6.5 billion for transmission delivery improvements(American Recovery and Reinvestment Act of 2009, 2009).

The Virginia State Corporation Commission

Utilities in Virginia are governed by the State Corporation Commission or SCC. This group of three judges is elected by the General Assembly for six-year terms, which are staggered by two years (SCC, 2010). The three judges, assisted by over 600 employees, oversee business with "direct impact to Virginia customers" that include not only utilities but insurance companies, retail franchising, and railroad companies (SCC, 2010). Their mission consists of the following:

- Carry out the duties prescribed by the Constitution and the laws enacted by the General Assembly of Virginia fully and to the best of its ability;
- Ensure that all parties and persons who appear before the Commission receive due process of law;
- Provide reliable information and assistance to Virginians in a consistent and high-quality fashion;
- Provide assistance to Virginians who have valid disputes with regulated companies; and

- Adopt rules and regulations that keep pace with legislative, business, economic, social and technological changes.(SCC, 2010)

The General Assembly in Virginia has approved a number of important state codes that are relevant to utilities. Va. Code §§ 56-235.2 and 56-585.1states that a utility has the right to charge its customers "just and reasonable" rate of return for the generation, transmission, and delivery of electricity (SCC, 2010). This guarantees that utilities are made whole for the services they provide for customers. Virginia state laws maintain that utilities is only allowed to keep 25% of its profit, while the other 75% must go back to its customers in a fuel-cost proceeding (Va. Code § 56-249.6 D 1). This code protects the customer from price gauging by the utility. Utilities are also allowed to collect for the costs of environmental and reliability costs, conservation programs, and renewable energy programs (Va. Code § 56-585.1 A). This code is extremely relevant to how a utility addresses alternative energy production.

Skepticism and Opposition to Governmental Requirements

Bipartisan support for reducing harmful gasses, such as carbon dioxide that are released to the atmosphere is growing. However, there is division on how to reduce said gases. Renewable Energy Standards (RES), also known as Renewable Portfolio Standards (RPS), were proposed in the Energy Bill of 2007, which when passed became the Energy Independence and Security Act of 2007. RES's are specific goals for utilities to address sustainable sources of energy. While addressing this subject of the Energy Independence and Security Act of 2007, which specifically calls for a 15% renewable energy portion of a utilities' portfolio by 2025 (United States, 2007), Representative F. James Sensenbrenner from Wisconsin explained his skepticism of the House's bill to mandate a renewable goal:

> I firmly believe that if we were to find realistic global warming solutions, Congress should encourage technological competition, but must not pick who wins and who loses. By requiring electric utilities to generate a portion of their energy through renewable sources, the government is picking the winners and in these cases the winners will be certain types of renewable sources. The problem with the renewable portfolio is that it emphasizes the means and not the ends. After all, the goal is to reduce greenhouse gas emissions. And in July, the House passed legislation that requires utilities to use renewable sources to produce 15 percent of its electricity.
>
> I am skeptical of most regulation. But this one is particularly onerous because it discounts the progress some electric utilities have made and only because they use methods not favored by certain congressional leaders.
>
> …the Southern Company has big worries and so should all of its rate payers with 15 percent of its electricity generated by nuclear power and another 3 percent from hydropower, Southern Company has already met the emissions cuts required these proposed regulations seek to create. But because the utility doesn't employ the use of wind turbines or solar panels, it will be forced to pay government fees for its failure to comply. And that will likely cost the company a billion dollars a year which will be passed on in every rate payers' monthly bill." (United States, 2007)

Representative Sensenbrenner's remarks show one side of the argument. The other side maintains that a Renewable Energy Standard (RES) is a proven strategy to jumpstart innovation. During a House of Representatives Hearing in 2007, Mike Sloan a former member of the Texas Energy Council testified that:

> Renewable Energy Standard has expedited market action. There are nine investor-owned utilities in Texas, and if you look at those that had a requirement under the RES and those that didn't, those that had the requirement voluntarily bought more renewable energy for those that didn't buy any voluntarily. And it just shows that it's really a catalyst. You're forcing these companies to look at it. When they get more experience, they get comfortable with it and move on. It has had a lot of benefits. It is saving consumers' money and really helps the rural areas. (United States, 2011)

Cap and Trade

The debate over RESs has created a compromise called Cap-and Trade, and for now seems to be accepted by all parties involved in lowering carbon emissions. In

2009 the House passed the American Clean Energy and Security Act of 2009 which had a Cap-and-Trade provision (Ott, 2009). This provision is based on a free market approach to curbing the release of carbon into the atmosphere. In order to do so, a number is decided upon which represents the total amount of carbon the US can release into the atmosphere. Electric utilities would be allocated permits from the government that would allow for the release of carbon. If one utility was highly dependent on coal, they would pay a premium to purchase the permits from another company that was less dependent on coal. The price of these permits would then be sold by the simple principles of supply and demand. The House added a section to the bill which would distribute 85% of the permits and allow 15% of the permits to be sold openly to collect a profit directly to the government (Ott, 2009).

Renewable Energy Technology

The renewable energy sector is expanding rapidly. In 2009, it represented a market of $55 billion and was expected to quadruple over the following 10 years to $226 billion by 2019 (United States, 2007). This expansion is introducing thousands of jobs, and is therefore not only an energy topic but an economic one. Renewable energy is found in the form of solar, wind, geothermal, biomass, and moving water. This technology is currently still in its infancy and the costs are higher than conventional forms of power such as coal.

Solar

Solar panels, also known as Photovoltaics (PV), use sunlight, usually in concentrated levels by using mirrors, to reflect onto panels which convert sunlight into electricity (The National Renewable Energy Laboratory, 2005). The solar industry has been growing by 20% for the last 25 years and has grown by 40% per year since

2000(United States, 2011). A 100 megawatts/year facility's cost and efficiency varies on the type of crystalline technology used as well as the geographic location which could cause the costs to vary from $30-$300 million per facility (The National Renewable Energy Laboratory, 2005). Arizona has embraced solar because of the state's landscape. The state has required that 1.1% of all electricity come from renewable sources, and 60% of that be from solar sources (The National Renewable Energy Laboratory, 2005).

Wind

Wind power is generated by building towers with fans that harness the wind via a blade which rotates a turbine to generate electricity. As of 2007 16,000 MW of wind power was installed across the United States (Milligan, 2008). Wind energy has been more readily accepted in Europe with the EU having a 56,535 MW capacity (Milligan, 2008). Because wind is intermittent, wind power must be backed up by additional power, for example a hydro pumping station or a natural gas backup generation such as XCEL energy uses in Colorado. These backup units go online when extended calm periods of weather are predicted (Milligan, 2008). More steady wind conditions are located offshore, and there is a push to invest in the location because there are no residents to complain about aesthetics. With towers reaching a height of nearly 300ft and fan blades adding another 200ft., turbines can be seen for miles (J. Jonkman, 2009). Recently in Virginia, a push has been made to endorse these offshore projects by labor unions (Nealon, 2011). They envision a 3,200 MW wind farm could provide up to 10 percent of Virginia's electricity and provide nearly 10,000 jobs over 20 years (Nealon, 2011). Even by utilizing local manufacturers in Hampton Roads, VA would decrease the cost difference between the wind farm and a conventional coal power

station (Nealon, 2011). A wind turbine costs on average $1,915/kWh to install (P. Schwabe, 2011). While offshore construction would be more costly than onshore construction, the higher efficiency of 40% by the turbines would result in a 2% quicker payback over 20 yrs compared to that of onshore construction (I K Bhat, 2009).

Geothermal

Geothermal power comes from using the Earth's ambient warmth to heat water (or another separated liquid) into steam to rotate a turbine to generate electricity (NREL, 2011). The heat that is found in thermal pockets raises the temperature of water to about 225°–360°F (NREL, 2011). The price of geothermal electricity is somewhat unknown because it is dependent on drilling to find heat pockets. According to the US Geological Survey, 70-80% of these pockets are hidden (Mims, 2009). Geothermal is operational between 62% and 90% of the time (Mims, 2009).

Comparing Other Energy Options

Public electric utilities across the country will be faced with a striking a delicate balance between public demands to combat climate change and generating reliable, cost effective service. In order to be viewed successful by the public, a utility must address its carbon output, however it must do so by being financially responsible. It is Important to examine the costs associated with building renewable sources of electricity, especially of those options that emit less CO_2 than coal power plants.

The end goal is reducing the amount of carbon released to the atmosphere that causes global warming while obeying laws such as the Clean Air Act (Clean Air Act Amendments of 1990, 1990). Of course increasing the reliance on renewable resources directly relates to the decrease in atmospheric emissions. However, it must be recognized that renewable resources are not the only way to address the public's

desire to curb carbon discharge. Nuclear energy is not deemed as a renewable product because nuclear sources are finite and solid nuclear waste is generated, however, emissions from nuclear plants are nearly zero (Farrell, 2011). While the production of electricity from nuclear sources has zero emissions, there are carbon releases from mining, processing, and transporting uranium before it is used at the generation facility (Kleiner, 2008). The drawbacks for nuclear plants are that they cost nearly double the amount of capital compared to coal (Parsons, 2009). A study by MIT in 2009 found that building a nuclear based plant would cost between $5,500 and $8,200/kW, or otherwise between $12 and $18 billion (Parsons, 2009). In comparison, the same size coal generated plant would cost $2,300/kW or roughly $5 billion (Parsons, 2009).

Another carbon cutting option is making a switch from coal to natural gas as a source. In recent years technology has made it possible to access large deposits of natural gas in shale rock formations (Farrell, 2011). The rise in abundance of natural gas makes it an affordable energy option; all the while releasing about half the carbon content of coal (Farrell, 2011). According to the same MIT study conducted in 2009, a natural gas facility would only cost $850/kW, or approximately $1.8 billion (Parsons, 2009).

A third major option that often goes without recognition as a carbon reducing source of power is Combined Heat and Power or CHP. In a conventional power plant layout, water is boiled into steam and the steam pressure is used to rotate turbines which generate electricity. During this process, nearly two-thirds of the original energy is wasted in the form of heat (Gereffi, 2009). In a CHP setup, that waste heat is captured to boil a second water source to spin an additional smaller turbine, thus

making the most of the original fuel source. The costs associated with such a system are minimal since most of the infrastructure exists in place (Gereffi, 2009). It is estimated that efficiency can be bolstered from 34% up to between 60 and 90% (Gereffi, 2009). CHP would therefore instantly add 32 GW, or roughly 3.5% to the current grid (Smith, 2009) and avert 136 million metric tons of CO_2 into the atmosphere (Gereffi, 2009). This additional power is able to be added to the base load, meaning that the facility can be utilized 24 hours a day, 7 days a week (Kleiner, 2008).

Technology has been advancing in the field of generation which has lead to increases in efficiency and effectiveness to reduce the amount of pollutants released to the environment. As a direct result from the institution of the Clean Air Act, generating facilities have found ways to decrease their emissions (US Energy Information Administration, 2011). The coal industry has found more effective ways to clean coal after it has been mined to reduce the amount of sulfur content in the fuel even before it is burned, which reduces the SO_2 output (US Energy Information Administration, 2011). Installation of gas desulfurization equipment, known as “scrubbers,” cleans SO_2 from the exhaust exiting the generating facilities while catalytic converters clean NO_X (US Energy Information Administration, 2011). Although, often times these pieces of equipment are voluntarily installed to maintain goals, and not regulated across the board (Dominion Resources Services, Inc., 2010-2011).

These options are not 100% sustainable, but they do impact the end goal to reduce emissions which is what Congress desires. However, there is another aspect any public electric utility must address; their shareholders. To be financially successful, a public utility must upgrade its existing facilities economically to cope with demand

increases in the upcoming years. The average miscellaneous residential electric use will increase by 2.7% a year due to new electronics (Sanchez, 1999). Because America is so reliant on fossil fuels, it will take decades and trillions of dollars of improvements to implement renewable energy as a major contributor of power (Farrell, 2010). By examining the technology, the costs, and desires of their customers a public electrical utility can make a decision that is compliant with current laws and regulations.

CHAPTER 3
METHODOLOGY

This chapter aims to identify barriers that exist which are hindering public electric utilities from manufacturing green electricity by assessing how valid the obstacles are, especially those barriers which impede Dominion Virginia Power. Public utilities look to operate in a cost effective way that is beneficial to its shareholders. It is therefore important to analyze the implementation of sustainable electricity in the forms of a cost/benefit analysis as well as interviewing the company to determine its direction.

Results were found by three methods. First, direct questions were posed to Dominion's Media Relations Spokesperson, and were forwarded to their Alternative Energy Group for response. The questions centered on the paradoxical nature of an energy utility promoting conservation, as well as understanding the future of renewable energy in the electric utility field. A follow-up conversation took place with Lisa Moerner, Director of Environmental Policy and Sustainability and Brandon Stites, Director of Energy Conservation and Advanced Metering Infrastructure. Dominion's answers provide insight on how a utility views the environmental, economical, and social barriers that stand before them. The second method used was to examine company publishing by Dominion in the form of Corporate Responsibility Reports, Annual Investor Reports, and SCC filings. All of these documents are public knowledge and presented to investors as well as citizens by request. These pieces of information are vital to understanding the past, present, and future direction of the company. Thirdly, other utilities' were examined for comparison to rate whether or not Dominion was favorable or unfavorable in multiple categories including rates, environmental stewardship, and customer participation in Renewal Energy Credits (RECs). It is through examining

these three sources of information that a knowledgeable recommendation can be achieved.

CHAPTER 4
RESULTS

Price of Generation

Costs to invest in renewable sources of energy are widely known to be higher than conventional forms of electricity. In order to fund these more expensive forms of electricity, power companies charge premiums to offset the higher costs (E. Blank, 2002). As of 2002, 95 utilities in 31 states offered renewable purchasing programs (E. Blank, 2002). This number rose to more than 850 utilities in 2010, accounting for more than 5% of all electric sales (NREL, 2011). It can be expected that if a customer chooses to pay for these premium services that they will be paying on average an extra payment between $5-20 per MWh for wind energy (E. Blank, 2002). If a customer desires solar they should be prepared to shell out up to $176 per MWh (Brown, 2005). Between 2001 and 2004, the average premium price fell 16%, which is a beneficial for both the consumer and the utility who desire renewable forms of electricity (Brown, 2005). As with any new technology prices will eventually fall to affordable levels. The investments made by energy companies are greater than that of the rate payer. Offshore wind costs the utility $243 per MWh requires high capital investments (Dominion Resources, Inc., 2011). Even though this is extremely high, the operating and maintenance budget is extremely low, because there is no fuel source. The other extreme end of the spectrum is advanced natural gas combined cycle and conventional combined cycle at approximately $63 per MWh (Dominion Resources, Inc., 2011). These forms of electricity require low start up costs, but have higher variable operations and maintenance (O&M) costs. A utility provider must make the decision to pay the

upfront costs, or invest in the average 50 yr lifespan of a facility (Dominion Resources, Inc., 2011).

Benefits of sustainable power can range from monetary to impacts on public relations; from items with easy metrics to those which are very hard to measure. As a direct result of participants opting for premium services, 700 MW of renewable capacity was added with another 225 MW planned in 2005 (Brown, 2005). These added power plants cut down on the emissions of nitrogen oxide (NO_X), sulfur dioxide (SO_2), mercury, and carbon dioxide (CO_2) from carbon producing plants, all of which are included in the emissions reductions proposed by congress(E. Blank, 2002). There can even be a cost analysis done on the carbon emission reduction (See Table 6-2). The cost to reduce CO_2 by installing typical renewable sources would range from $90/ton of carbon for off-shore wind to $310/ton of carbon for solar photovoltaic power (Smith, 2009). By examining the table, there are savings that could be accomplished through combined cycle generation, which recycles lost heat in the generation process. This strategy will be addressed later in this paper. Another benefit for renewable installation is portfolio diversification. By commercializing new technologies, such as wind energy, the overall electric supply mix becomes more diversified and less subject to fuel price increases and tighter environmental regulation on fossil fuel plants (E. Blank, 2002). If the price of oil were to rise, then other generating units can be brought online to avoid paying exorbitant amounts for oil, thus preventing excessive fuel charges.

Power consistency and reliability are major factors when an electric utility plans on adding new sources of generation. Most forms of renewable power, with the exception of biomass and geothermal cannot be rated as “base load power plants” because they

do not reach a running rate of 75% (Hynes, 2009). Coal, natural gas, and nuclear plants achieve anywhere between 90% to 98% load factors therefore they are viewed as very reliable (Hynes, 2009). Wind power operates 20-30% of the year, solar is between 25-40%, and tidal current averages 27% (Hynes, 2009). Of course, these forms of generation depend on their location, but even these running rates for renewable are hardly reliable and has consequences if considered by a utility. If a customer loses power at the fault of the utility, the state's governing body can claim damages by imposing fines. In 2008, a Florida utility company was fined a $25 million penalty for causing a blackout that left nearly a million customers in the dark (Wald, 2009). Since a utility must strive to keep the lights on, they must select sources of power which are consistent and dependable.

Evaluating Carbon Output

The carbon output for power facilities vary immensely by type of facility. Every power plant has some type of emissions, whether it is from the smokestack, the building materials, or the decommissioning of a facility (Kleiner, 2008). This analysis is considered the "lifecycle emissions" (Kleiner, 2008). For example, 38% of a nuclear plant's carbon is used in the mining and enriching of uranium and 14% to discard of the waste product. Investigation was done to compare industries to the status quo of coal fired generation's baseline of 960 grams of carbon dioxide equivalent per kilowatt-hour (gCO_2e/kWh) and natural gas' average of 443 gCO_2e/kWh (Kleiner, 2008). Nuclear power uses an average of 66 gCO_2e/kWh which is well below the average of the main source of energy in the United States, however when looking at renewable options, they are between 1-5% of the carbon output of coal (Kleiner, 2008). Solar options average

32 gCO_2e/kWh, half the amount of carbon output that nuclear emits, and better yet is onshore wind at 10 gCO_2e/kWh (Kleiner, 2008).

It is up to each utility to weigh the options when deciding to build new generation facilities based on costs and environmental impacts. If their customer base wants the company to invest in renewable sources of power, then a company has an easier time in justifying price increase per kWh to the customer. The costs of the relatively new technology in renewables will come down, and it's up to the individual utility to justify its trigger point.

Case Study: Dominion Resources

Dominion is well on its way to being successful both environmentally and financially because they have sought symmetry between the two. Their Chief Executive Officer Tom Farrell has focused on keeping the balance between economic prosperity and environmental quality (Farrell, 2011). He states, "The country's best bet, in my view, is to focus on diversifying our energy sources; making use of every resource at our disposal- coal natural gas, oil, nuclear and renewable power- as well as smarter and more aggressive conservation and energy efficiency programs" (Farrell, 2011) Dominion has invested over $5 billion to improve "the environmental performance" of its fossil fuel stations which by 2015 will have cut emissions by 80% below 1998 levels(Farrell, 2011). By striking this balance between financials and the environment, Dominion has proven itself as a model for companies across the United States.

Utility's Strategy

By looking specifically at Dominion Power, which serves Virginia as well as part of North Carolina, the perspective of a utility can be observed. Dominion states publicly that they "are committed — and will remain committed — to full compliance with all laws

and regulations of local, state and federal governments that affect our operations (Dominion Resources, 2011)." They continue by saying, "Given that new generation units have useful lives of up to 55 years, we consider CO_2 and other GHG emissions when making these long-term decisions. We are committed to meeting VA's Renewable Portfolio Standards (RPS) goal of 12% renewable power by 2022 and 15% by 2025 and NC's Renewable Energy Portfolio Standards of 12.5% by 2021. We also meet retail RPS obligations in these states: Connecticut, Maine, Massachusetts, Maryland, New Jersey, Pennsylvania, Ohio, New York and Texas" (Dominion Resources, Inc., 2011)

However, some of these RPSs are viewed as a stretch in some states. Dominion published the following in their annual Carbon Disclosure Project:

> In July 2008, Massachusetts passed the Global Warming Solutions Act (GWSA). Among other provisions, the GWSA sets economy-wide GHG emissions reduction goals for Massachusetts, including reductions of 10% to 25% below 1990 levels by 2020, interim goals for 2030 and 2040 and reductions of 80% below 1990 levels by 2050. Although Massachusetts has recently chosen 25% below 1990 levels by 2020 as its first goal, all regulations requiring the implementation of the GWSA have not yet been proposed. Dominion operates two coal/oil-fired generating power stations in Massachusetts and acts as a retail electric supplier in Massachusetts and all of these entities are potentially subject to the implementation of the GWSA. On May 11, 2011 Dominion announced it will cease to operate two of the four fossil-fired units at Salem Harbor Power Station located in Massachusetts by the end of the 2011 and plans to retire all four units on June 1, 2014, because pending environmental regulations and market conditions are making the power station uneconomical to operate (Dominion Resources, Inc., 2011).

At the same time as promoting green infrastructure, Dominion must remain focused on maximizing returns to their investors by being financially responsible. Dominion supports Cap-and-Trade. Cap-and-Trade is defined by the EPA as "an environmental policy tool that delivers results with a mandatory cap on emissions while providing sources flexibility in how they comply. Successful cap and trade programs

reward innovation, efficiency, and early action and provide strict environmental accountability without inhibiting economic growth (US Environmental Protection Agency, 2010)." CEO Tom Farrell sees Cap-and-Trade as the lowest-cost option to achieve lower greenhouse gas emissions and points to the success that a previous model had under the 1990 Clean Air Act (Farrell, Shifting Political Winds: Change Forecast for Cap-and-Trade Emissions Bill, 2010). Like other electrical utility heads, Farrell does not see the United States cutting its dependence on coal power, but does point that scientists are calling for investment of federal funds to spark the private sector in technological advances (Farrell, Shifting Political Winds: Change Forecast for Cap-and-Trade Emissions Bill, 2010). This option is a definite free-market approach to achieving a more affordable renewable generation unit, thereby making renewable investment worthwhile in pursuing while satisfying the shareholders.

Portfolio

Dominion is responsible for operating 31 generation facilities with a combined output of 28,200 Megawatts. Stations are located in Michigan, Illinois, Indiana, Massachusetts, Rhode Island, Connecticut, Pennsylvania, West Virginia, Virginia, and North Carolina. Each facility is responsible for abiding by local laws and regulations while contributing to the totalized portfolio of Dominion (Dominion Resources, 2011). Forty percent of this output is created by fossil fuel stations 28% by nuclear stations (Dominion Resources, 2011).

According to the Carbon Disclosure Project, Dominion submitted the following examples of their efforts to reduce their overall carbon output.

- Retirement of 2 oil-fired units in VA that were replaced with a new 559 MW combined-cycle natural gas (NG) unit.

- Since 2000, addition of over 2,600 MW of non-emitting nuclear generation (although in April 2011, we announced plans to sell our 556 MW Kewaunee Power Station) and over 3,500 MW of new NG-fired generation.

- Over 800 MW of wind energy in operation or development and added 83 MW of biomass since 2004.

- New 580 MW Natural Gas-fired facility went into operation in May 2011.

- Announced plans to develop the Warren County (WC), natural gas-fired power station, expected to generate more than 1,300 MW of electricity and closure of another 74 MW coal fired plant located in WV, once WC begins commercial operations. Dominion and 510nano Inc. have signed a 15-year power purchase agreement for the electric output of a 1.4 MW photovoltaic 7 acre solar power station.

- Announced closure of State Line (515 MW fossil-fuel facility).Generation Development: We have announced a growth program of new multi-fuel, multi-technology generation capacity to meet the anticipated growth in demand in our core market of VA.

- We own and operate an 83 MW biomass power station in VA.

- In June 2010, announced plans to develop a 4 MW integrated solar and battery storage project in VA, subject to VA State Corporation Commission approval. The proposed facility would manage, store, and optimize solar energy to regulate intermittency, enable peak shaving and increase grid reliability.

- We are 50% owner of NedPower, a 264 MW wind energy project in WV.

- We are 50% owner with BP of the first phase of a 300 MW Indiana wind energy project.

- In March 2011, we initiated a scoping study for a high-voltage underwater transmission line from VA Beach into the ocean to support multiple offshore wind farms; the first of many steps with the goal being the design, construction, operation and maintenance of a transmission line to make offshore wind resources available to our customers. A 2010 Dominion study of our existing transmission system in eastern VA showed that it is possible to interconnect large scale wind facilities up to an installed capability of 4,500 MW.

(Dominion Resources, Inc., 2011)

Virginia's Alternative Energy Resources

Virginia's location is between 36º N and 39º N and is along the eastern seaboard of the United States. The state is sunny approximately 63% of the time (NOAA, 2004), allowing for some small solar power installations, but not enough for the required 6kWh/m^2/day needed for large scale generation (US Energy Information Administration, 2009). By examining Figure A-22, it can be found that the majority of the state is able to support biomass generation (>=50tons/sq km/yr) as well as enough wind for potential generation (>=3 power class) (US Energy Information Administration, 2009). However these locations which contain viable alternative energy options are found within protected national forests that are seen as valuable tourist attractions for Virginia.

Emissions

From 2000 to 2009 Dominion's carbon output per MWh of energy has decreased 16% while its energy production has increased by 44% (Dominion Resources, Inc., 2011). This is due to increases in performance efficiency and the conversion of coal fired units to natural gas (Dominion Resources Services, Inc., 2010-2011). Dominion produced 1,089.4 pounds of carbon dioxide ("CO2") per megawatt-hour ("MWh") of electricity generated in 2008, which is about 27 percent below the reported industry median emissions of 1,489.8 pounds of CO2 per MWh for the nation's 100 largest power producers.(Dominion Resources, Inc., 2011)

Incentives for Green Projects

Dominion stresses concerns for lowering consumption because they recognize that energy conservation could negatively impact Dominion's financial results (Dominion Resources, Inc., 2011). "Certain regulatory and legislative bodies have introduced or

are considering requirements and/or incentives to reduce energy consumption by a fixed date. Additionally, technological advances driven by federal laws mandating new levels of energy efficiency in end-use electric devices, including lighting and electric heat pumps, could lead to declines in per capita energy consumption (Dominion Resources, Inc., 2011)." However in 2009, Virginia House Bill 2506 was adopted by the state. This bill:

> Authorizes investor-owned electric utilities to recover, through a rate adjustment clause, the costs of designing and operating energy efficiency programs that have the effect of decreasing the total amount of energy used over time and of delaying the need for construction of new generation facilities. The utility may earn the same enhanced rate of return on energy efficiency programs that is currently provided for renewable powered generation facilities, as well as net lost revenues for the program's full service life (Pollard, 2009).

This bill enacted §§ 56-576, 56-585.1, and 56-585.3 of the Code of Virginia to allow for collection of lost revenue from promoting conservation efforts. This ensures that Dominion would collect the same amount of profit from either meters spinning or collection by riders on a customer's bill.

Comparing to Other Companies

There are more than 850 utilities that offer green power programs (NREL, 2011). The top 10 ranked companies in multiple categories have been ranked based on amount of MW sales, total number of participants in the program, percent of green power sales of the total retail sales, the price premium charged to customers per kWh, and customer participation rates by the National Renewable Energy Laboratory (NREL). By comparing Dominion to these benchmarks, one can understand Dominion's practices.

Dominion started its green power program in January of 2009, which is later than many of the top 10 companies in these categories which started as early as 1997(NREL, 2011). As of August 1, 2011, Dominion boasts a customer participation of 13,314 for a percentage of .5% (Dominion, 2011). 13,136 members of the program are residents while only 178 are businesses/other (Dominion, 2011). Dominion's customer participants have supported more than 175 million kWh of green power, which is equivalent to eliminating emissions from over 23,000 cars per year (Dominion, 2011).

By comparing these figures to the top 10 companies, it is easy to see where Dominion stacks up. Portland General Electric had the most participants as of December 2010 with 77,907 participants or 12.6% of its customers (NREL, 2011). This is nearly six times the amount of participants and twenty-five times the percentage of participation. The leader in price for RECs is Indianapolis Power and Light Company with a premium of .14 ¢/kWh. This is compared to the national average of 1.75 ¢/kWh (NREL, 2011). Dominions cost is more favorable than the average cost, with the cost of their RECs at 1.5 ¢/kWh (Dominion Resources, 2011).

Dominion has stated that they compare themselves to their peer group defined as other large southern utilities. Duke Energy offers 100kWh blocks green RECs for purchase for $4(Duke Energy, 2011). This comes out to 4 ¢/kWh. If a customer would like to purchase at least 100 blocks (10,000 kWh), the price drops to 2.54 ¢/kWh. Progress Energy (Carolinas), as well as South Carolina Electric and Gas, also follow the same rate structure as Duke of 4 ¢/kWh for renewable energy credits(US Department of Energy, 2010). CPS Energy of San Antonio offers 3 ¢/kWh, Georgia Power offers 5 ¢/kWh for solar credits, Alabama Power offers 4.5 ¢/kWh REC, and Entergy Gulf States

as well as Tampa Electric Company's rate is 2.5 ¢/kWh (US Department of Energy, 2010). Florida Power and Light's REC program Sunshine Energy was originally priced at .975 ¢/kWh but was canceled in 2008 after being listed on NREL's top 10 list of enrollment due to inadequate transfer of funds (only 20% of the purchases were going toward renewable projects as opposed to the mandatory 100%)(US Department of Energy, 2010). Florida Power and Light does not currently have a Green Power program. Dominion's Green power rates of 1.5 ¢/kWh are the best among its peer group.

In terms of overall renewable production, Dominion produces just over 28,000 megawatts of electricity, of which 1,600 (5.6%) is from renewable sources. At the end of 2010, the US Department of Energy found that 10.76% of the energy produced in the United States was created from renewable sources (Department of Energy, 2011). Dominion is well below the national average in terms of power production as a percentage of total production.

There is a misconception that there are regional differences in attitudes of customers of how they view renewable energy. In April 2011, the National Renewable Energy Laboratory commissioned a report to examine the regional differences in renewable energy. When customers were asked whether they agreed with the statement "I care about the use of renewable energy sources," the regions were separated by only a few percentage points (See figure 6-9 Percent of general population by region indicating that they care about the use of renewable energy sources(Natural Marketing Institute, 2011)). This fact is somewhat surprising because there is not a single southern electric utility represented on any of the top 10 lists of

REC purchases. The report does find that residents of the west are more aware and educated on the topics of renewable power and the term carbon footprint, as well as less price sensitive when it came to the subject (Natural Marketing Institute, 2011). Fourteen percent is the national average of households that understand their renewable options, which poses a challenge for utilities companies to overcome (Natural Marketing Institute, 2011).

Also included in the NREL's report 69% of households were found to have cared about the price of renewable energy on their bill (Natural Marketing Institute, 2011). Twenty-six percent would pay an additional $5-$20 per bill for renewables and 16% were willing to pay over 20% more for renewable sources. However the same study found that nationwide only 7% of households actually do purchase some or all of their electricity from renewable sources (Natural Marketing Institute, 2011). Even this figure is inflated from the 1% of households that actually do purchase RECs (Natural Marketing Institute, 2011). This difference could be attributed to using solar garden lighting, solar water heating, or other onsite renewable systems (Natural Marketing Institute, 2011). Again comparing the national average of 1% participation to Dominion, it is found that Dominion's .5% is unfavorable.

Dominion Programs

Dominion does participate in and promote energy conservation programs to their customers. By lowering demand, lower peak electrical load is needed, thereby reducing the amount of carbon produced through the generation process. Even though Dominion is promoting the reduction of its product, they are made whole by SCC rate filings which allow the company to recoup its potential earnings in additional riders. It is through these programs that Dominion plans to meet Virginia's voluntary goal of reducing

electrical consumption 10% of 2006 levels by 2022 (Dominion Resources, Inc., 2011). In Dominion's Carbon Disclosure report, they include five major demand side management programs to address energy conservation

- Residential Lighting Program—in-store discount on the purchase of certain compact fluorescent light bulbs
- Home Energy Improvement—energy audits and improvements in homes of income qualifying customers
- Smart Cooling Rewards—incentives for residential customers who voluntarily enroll to allow us to cycle their air conditioners and heat pumps during periods of peak demand
- Commercial HVAC Upgrade Program—incentives for commercial customers to improve the energy efficiency of their heating and/or cooling units
- Commercial Lighting Program—incentives for commercial customers to install energy efficient lighting

(Dominion Resources, Inc., 2011)

Dominion also promotes carbon reduction through embracing Advanced Metering Infrastructure (AMI). Also known as "smart meter" technology, meters are able to toggle on and off equipment which requires a large draw of electricity such as heating and air conditioning units, refrigeration units, etc. These meters have the ability to communicate to one another within a certain radius, in order to cycle equipment on and off through the neighborhood so that never at one time will all the appliances be running in all the buildings. AMI has proven to lower voltage on distribution lines by 5% during off peak hours (Dominion Resources, Inc., 2011). Communication is greatly increased with the installation of smart meters. Customers can view an up to the minute usage report as well as choose to pay electric prices based on demand (Dominion Resources, 2011). Installation of the meters also reduces carbon emissions by eliminating truck

rolls to read meters. The meter info is sent via the internet back to Dominion for billing (Dominion Resources, 2011). Currently Dominion has installed 46,500 meters in Charlottesville, Virginia with programs underway for installation in Arlington, Midlothian, and Norfolk Virginia (Dominion Resources, 2011).

With the introduction of electric vehicles, Dominion has plans in place to embrace the additional consumption on the system when residents come home from work at the end of the day and plug in their vehicles. In January of 2011, an application of a pilot program was submitted for the SCC for review (Dominion Resources, Inc., 2011). The pilot program would offer a time-of-use rate structure to encourage off-peak charging. The program is designed to address a maximum of 1,500 customers (Dominion Resources, Inc., 2011).

Also included in the Carbon Disclosure Project is the endorsement of Electronic Billing, which saves energy associated with the mailing of bills and customer notifications (Dominion Resources, Inc., 2011). A study found that fewer customers nationwide are receiving their bill by mail. JD Power and Associates found that the percentage has dropped from 54% in 2010 to 48% in 2011(J.D. Power and Associates, 2011). It was also mentioned that customers who use electronic bill pay find the method considerably more satisfying than paying by mail (J.D. Power and Associates, 2011). Along with this program Dominion has been participating in Project Plant It since 2007. Through this project, students learn about the environment in the classroom as well as taking part in a planting program. Over 100,000 tree seedlings have been planted in 7 states creating more than 250 acres of forest to mitigate carbon emissions (Dominion Resources, Inc., 2011).

The last carbon addressing program is the installation of Carbon Burnout Facilities (CBO). CBO facilities improve efficiencies in the process of burning coal by re-firing the waste product called fly ash to return additional heat back to the power station (Dominion Resources, Inc., 2011). CBO units process the ash to completely burn coal to allow for use as a cement replacement. Because the byproduct can be used instead of cement, approximately a ton of CO2 emissions from cement production is avoided (Dominion Resources, Inc., 2011). Dominion operates 2 of only 4 CBO units in the U.S (Dominion Resources, Inc., 2011).

Customer Education

As discussed before, the 2011 NREL report found that only 14% of households are aware of their renewable purchasing options. Dominion believes "that a key component of achieving energy conservation goals is educating customers to increase their awareness about energy conservation in order to influence consumer behavior towards energy consumption (Dominion Resources, Inc., 2011)." Dominion has six forms of education for the customer.

The first form of education is through the company's Corporate Communication Department. They have created a 30 second television commercial and similar print advertisement titled "Every Day." This campaign stresses the importance of energy conservation and renewable energy (Dominion Resources, Inc., 2011). This form of advertisement is reiterated in the Customer Connection newsletter which is distributed along with customers' bills. Every month, the newsletter discusses topics such as managing electric bills, conservation programs, environmental stewardship, and other short pieces of relevant information (Dominion Resources, Inc., 2011).

Dominion formally prepares news releases and formal reports regarding the company's conservation initiatives. These news releases are posted to their website, distributed to newspapers, and often times sent to other forms of media. They provide clear and concise updates on the progress of their energy efficiency programs (Dominion Resources, Inc., 2011).

Dominion is actively involved with directly educating the community through its Speakers Bureau Program (Dominion Resources, 2011). The company offers free outreach programs organized mostly by volunteers within the company that present on various topics targeted at varying audiences complete with materials and information for the customers. Programs range from environmental programs for elementary, middle, and high school students all the way to informational seminars on energy conservation presented at town halls and libraries for community members (Dominion Resources, Inc., 2011).

Dominion recently started an Energy Efficiency Blog in 2008 to informally communicate with customers about various topics about saving time, money, and energy all through conservation efforts. It is a forum for customers to ask questions, and experts to respond with answers (Dominion Resources, Inc., 2011). The topics presented cover a wide array of information including heating and cooling, energy myth busting facts, lighting, and seasonal tips.

The last form of educating their customers about energy conservation is Dominion's participation in trade shows, exhibits, and other speaking engagements (Dominion Resources, Inc., 2011). These formal events allow Dominion an opportunity to showcase themselves as industry leaders. With all these education modes

combined, Dominion is striving to communicate its corporate message of conservation and environmental stewardship effectively to every customer.

Political Stance

Dominion is actively involved with the political process that shapes its everyday practices. Often times, company representatives are actively sought after to clarify policies and procedures to local, state, and federal governments. Through their Carbon Disclosure Project, Dominion states their political stances as the following:

- Since 2007, we have supported Federal climate change legislation that:
- Regulates GHG emissions economy-wide.
- Establishes a system of tradable allowances.
- Slows the growth of GHG emissions in the near term and reduces GHG emissions in the long term.
- Sets a realistic baseline year and schedule of compliance that is coordinated with anticipated commercial availability of advanced coal technologies that can capture and store CO2 emissions.
- Promotes technology development and deployment.
- Includes a “price collar” that stabilizes the annual price of emission allowances.

(Dominion Resources, Inc., 2011)

Dominion is focused on President Obama’s recent call to Congress to present a Clean Energy Standard (CES) which would put a goal in place that would require 80% of the total U.S. production be from “clean” energy technologies by 2035. Dominion has sent responses to congress addressing the issue with its recommendations on how to structure the federal CES, mainly “its purpose must be to promote the deployment of

advanced energy generation technologies and to ensure a diverse supply of lower-emitting fuels for electricity generation (Dominion Resources, Inc., 2011)."

According to Dominion, key design elements of a CES must include:

- A robust list of qualified resources, including methane capture projects and supply and demand side energy efficiency programs.
- A tradable credit system for existing, new and incremental generation of all qualified sources that allows credits to be sold, banked, or borrowed.
- A regional-based system that establishes each utility's "clean energy" baseline using existing generation.
- The inclusion of state renewable electricity programs.
- Cost containment mechanisms.

(Dominion Resources, Inc., 2011)

Interview

Dominion's Alternative Energy Solutions group is responsible for the research and implementation of alternative energy technology. The group is comprised of three units: financial analysis, policy and business evaluation, and research and program development. The group's operating mantra is,

> For long-term success, Dominion intends to be positioned at the cutting edge of any new technologies. We plan to harness the full potential of alternative energy as it matures to commercial viability and gains prominence in the operating, regulatory and policy arenas (Dominion Resources, Inc., 2011)."

Dominion utilizes this group to research and create policies addressing cutting edge generation (including wind, solar, geothermal, tidal, and biomass), distribution techniques, as well as new technology such as hybrid vehicles and electric storage.

Lisa Moerner, Director of Environmental Policy and Sustainability, was interviewed on August 3, 2011. Her answers give a sense of direction in which Dominion is headed. Lisa was asked, "What does Dominion stand to gain by going 'green?'"

> Dominion gains a few things. First is a positive public image. Second is it lowers our carbon footprint. If we voluntarily lower or carbon impact, then we are less of a regulatory risk. Third, studies show that employees stay longer and are retained if Dominion is green. Lastly, we promote conservation to keep our customers happy. A happy customer is a customer with a low bill. That's why we offer budget billing.

When asked to expand on the customers, Lisa responded,

> The vocal customers are not the green customers. We don't hear from green customers at rate case time. We find that our customer base is not clamoring for green energy at this time.

Q: What is Dominion doing to promote the environment?

A: We have invested in our wind farm in West Virginia, our hydro plant in Bath County, and we have numerous conservation programs that are ongoing.

Q: What barriers exist for renewable sources of electricity?

A: The two major barriers are the cost of renewables and the current availability of natural gas.

Q: Where does the future business lie for Dominion?

A: The future is in gas. That is the bulk of our business. However, we have announced solar distributive generation. With respect to electric cars, there is a special tariff approved by SCC. I don't think we will get into the charging station business, but we have looked into helping facilitate charging for others (Moerner, 2011).

On September 21, 2011 Brandon Stites, Director of Energy Conservation and Advanced Metering Infrastructure, explained why Dominion would want to reduce energy usage and lower customers bills through conservation initiatives.

> Dominion can invest in conservation because we can recoup our money that we would otherwise have received in electric bills. The house bill [HB2506] states that we can collect for advertising, and the cost to run the program as well. We however retain the 'burden of proof' and must provide an independent measure to prove that the savings is real. Any customer that is using over 10mw is exempt from the conservation rider. After a rate case is instituted, it is trued up every year with new rate cases to ensure that the proper money was collected (Stites, 2011).

The Customer

Lisa Moerner was quick to point out that Dominion's customers are not "clamoring" for green energy (Moerner, 2011). Dominion began offering customers an option to easily purchase RECs on their bill in 2009. The price premium of 1.5 cents/kWh which is lower than the average of 1.75 cents/kWh, and on average would cost the average homeowner $2 a month on their bill to ensure electricity was purchased from a renewable source (Milligan, 2008). Ninety-nine percent of Dominion's RECs were used toward wind power, while the remaining 1% was used to purchase electricity from biomass facilities (Dominion Resources, 2011). From a 2009 survey by the US Energy Information Administration (EIA), Virginia paid 10.61 cents/kWh for electricity, ranking the state 27th cheapest out of all the states plus the District of Columbia (McDaniel, 2010). By adding the 1.5 cent/kWh premium to the bill, the customer will be paying 12.11cents/kWh. By doing so, the state would only drop 7 spots to 34th cheapest state. This is a very affordable addition that customers don't realize. But the average customer does not want to make the commitment nor add any price to their bill, especially if they don't visually see anything in return. As of August 1, 2011, Dominion had 13,314 participants enrolled in their Green Power Program; this is just .5% participation from the total 2.4 million customers in the state (Dominion, 2011). Although the program is nearly 3 years old, it is still way behind in both the top 10 utilities which boast between 21.5% and 5.3% customer participation and participation numbers of the top 10 between 77,907 and 21,475 customers (NREL, 2011). This low number of participants for Dominion could be due to the lack of customer education on the topic of green power, or it may be due to a customer base that doesn't view green power as a worthwhile investment.

When looking at how the customer views Dominion as a company, JD Power and Associates surveyed customers which concluded Dominion is about average among large utilities in the southeast for both residential and overall categories for customer satisfaction(J.D. Power and Associates, 2011)(J.D. Power and Associates, 2011). On a scale of 1 to 1,000, residential customers rated Dominion at 644 with the average at 643. The range of scores went from Oklahoma Gas and Electric at 669 to Progress Energy Florida at 612(J.D. Power and Associates, 2011). When all customers were polled, including commercial and industrial, Dominion was rated 663 of 1,000 with the average at 655. Alabama Power was the high end at 683 and Progress Energy Florida scored a 627(J.D. Power and Associates, 2011).

CHAPTER 5
RECOMMENDATION

After researching every aspect of Dominion's corporate mission, as well as their actions, it is easy to see that Dominion's strategy to incorporate conservation and renewable sources of energy is a firm, balanced, and safe approach that provides stability to its investors and consumers. They have proactively approached sustainability in a politically correct way while staying true to its core business of making money by setting its own goals to strive for. It will be interesting to continue to follow Dominion to see whether or not they achieve their goals of 12% of renewable power by 2022, 15% renewables by 2025, and a reduction of power usage by 10% by 2020. If Dominion is able to meet these targets on their own, then it proves that companies can voluntarily do the right thing when it comes to sustainability.

Dominion is consistently found within the top tier of southern energy providers especially in terms of rates and renewable energy credit prices; however these price points should result in a JD Power rating near the top rather than the middle. But customers often times don't view the prices of neighboring electric utilities, so their only care is that of their own price going down. Customers don't want their prices to increase especially if they don't see a difference in what they are paying for.

Due to the low participation rates in the green energy program, and the Director of Sustainability's comments about the "customer being happy with their bill", Dominion is prepared to stand pat when it comes to risky innovation. Understandably, they do not want customers complaining about their bill growing especially in tough economic times nor in times of increasing rates. Dominion touts itself at the "cutting edge" of renewable technology, but they could be pushing it further. They have succeeded in showcasing

AMI metering pilots and have implemented positive policies regarding electric vehicles and energy conservation. But in all honesty, this is far from cutting edge any more. “Cutting edge” is endorsing tidal energy, offshore wind, and creating programs that no other company in the nation has. “Cutting edge” is often times risky in nature, because you don’t know whether or not a product will work. Based on their history, Dominion would much rather monitor another company taking that risk, and evaluate the technology’s pros and cons. By the time the analysis is complete, the technology is no longer “cutting edge.” From everything that Dominion has published, they have not kicked off anything new products or way of thinking within the industry. They seem to be perfecting the tried and true, which is an admirable business model, but just not one for a new energy technology sector.

This business model is echoed in their balanced portfolio which includes nearly a third coal, a third nuclear, and a third natural gas. If Dominion were to truly embrace renewable energy as a form of generation, then you would expect the percentage to equal nearly a quarter and not its current rate of 5.6%. It is understood that this technology takes a while to install and maybe Dominion’s renewable generation mix is on its way to being dramatically increased. But as it stands, Dominion is satisfied to state that its goal is to provide 15% of power by 2025.

In order to successfully address sustainability, Dominion needs to educate its customers thoroughly. It is true that the company does not want to provide a service that the customer does not want, but sometimes it’s up to the company to decide what the consumer wants and needs. Dominion’s customer participation rates are below average, even if their program is relatively new. By examining the NREL study, nearly a

quarter of customers would be willing to pay extra for their power to come from a renewable source. But this study does not ask the opposite question of how many customers would be upset if their power came from a renewable source? Based on assumptions and customers support of the environment, it is doubtful that three-quarters of customers would be upset. Another way to test this would be by automatically enrolling customers into the green power program, and letting them opt out manually. How many customers would do so? Would customer participation decrease to 25% as the National Renewable Energy Laboratory (NREL) study indicates?

Dominion could benefit in acquiring or partnering with a research and development department, responsible for developing products that would optimize their system, potentially influencing other electric companies. An R&D department could actively seek alternative energy solutions as well as conservation techniques instead of passively waiting for others within the energy industry to create new technology. By testing, piloting, and thinking outside the proverbial “box,” Dominion can achieve the “cutting edge” title that it advertises.

It is recommended that Dominion focus on satisfying its customer by giving customers a product that is unlike any other on the market. In order to do this, there must be a concerted effort to research and implement new technology more quickly with a willingness to accept the risks of failure involved. The company must continue to increase its renewable portfolio. Dominion must educate its customers more completely on the topics of renewable resources of energy, to allow for customers to embrace added costs of building more costly facilities. If these action items are fully achieved,

then Dominion will rank very favorably not only in their peer group, but across the nation as well.

Further Research

To continue with this research, it would be vital to study utilities worldwide and make an assessment of those companies that lead in the field of sustainability. By learning from industry leaders, Dominion could make appropriate improvements by using those successful companies as case studies. Not only could the "cutting edge" companies be researched, but the mindset of those that make decisions within the organizations. How do their leadership's thoughts differ from Dominion's leaders? Other case studies for research would revolve around other companies outside of utilities that embrace sustainability practices, and their reasons in doing so. Why would companies whose largest expenditure is energy, spend more money to purchase green power?

Additionally, it would be extremely interesting to examine the thoughts of Dominion's customers by doing polling specific to Virginia residents and businesses in order to study their mindset when it comes to sustainability within the power company. An in depth analysis would be able to provide a true indication of consumer choices. How would customers react to Dominion investing their own profits into renewable resources without seeking compensation through riders? Would Dominion see overwhelming support or apathy by their customers if they were to take a larger step into the sustainable field? These would be the depth of knowledge that would be sought after in the polling to provide a clear direction to take action.

Conclusion

Dominion neither profits nor loses money by instituting renewable and sustainable practices, so movement forward really does depend on their ratepayers. If the customer base would begin asking for environmental improvements and would be willing to pay for the added costs of electricity, all signs point to Dominion being willing to provide jobs, infrastructure, and investment in advancing forward. This all relies on the education of the customer about their bill, and their activism in wanting to be a part of change in the industry.

With this said, times are changing and the energy field needs a leader that is willing to take a greater step further than shuffling along with the status quo. Although the industry is rich with regulations, politics, and other economic barriers, there is still room for creativity to be inserted into an engineer's world. Not only could this be foreseen as helping the environment, but would increase the company's reputation with its customers while creating a standing within the energy utility world.

APPENDIX

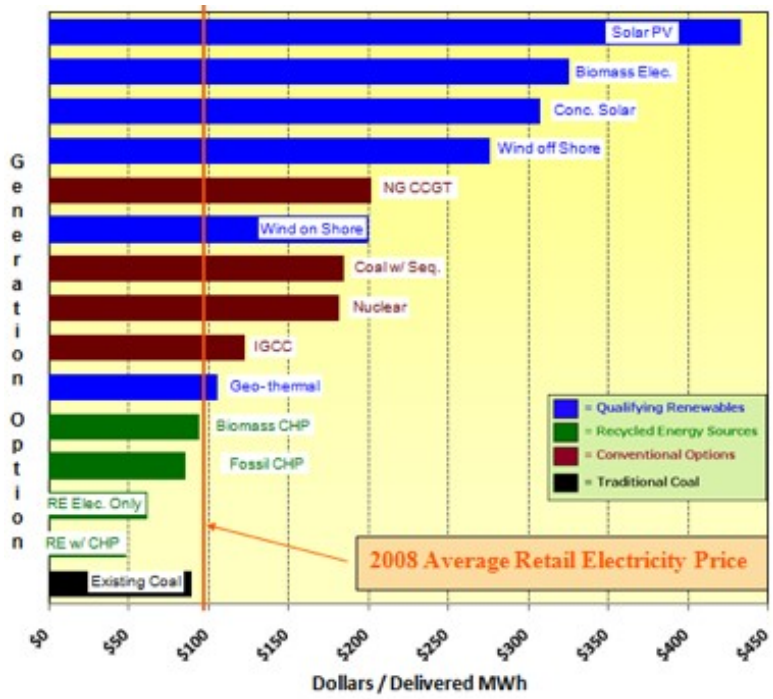

Figure A-1 Clean Electricity Generation Options: Cost / Delivered MWh (Smith, 2009)

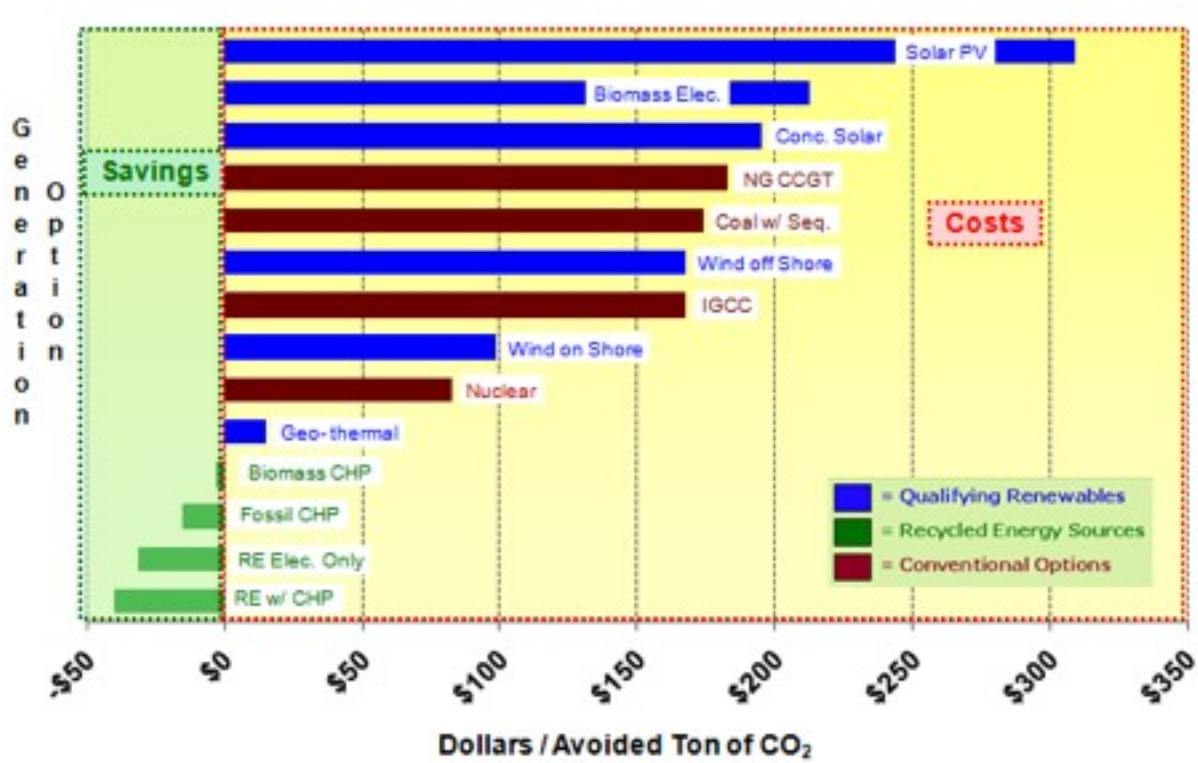

Figure A-2 Cost per ton of CO_2 reduction vs. Existing Coal (Smith, 2009)

Customer Participation Rate (as of December 2010)

Rank	Utility	Program(s)	Customer Participation Rate	Program Start Year
1	City of Palo Alto Utilities[a]	Palo Alto Green[b]	21.5%	2003
2	Portland General Electric[c]	Clean Wind, Green Source, Renewable Future	12.6%	2002
3	Farmers Electric Cooperative of Kalona	Green Power Project	11.2%	2009
4	Madison Gas and Electric	Green Power Tomorrow	9.0%	1999
5	Sacramento Municipal Utility District	Greenergy[b]	8.7%	1997
6	City of Naperville, IL[d]	Renewable Energy Program	8.0%	2005
7	Silicon Valley Power[a]	Santa Clara Green Power[b]	7.8%	2004
8	Pacific Power — Oregon Only[f]	Blue Sky Block[b], Blue Sky Usage[b], Blue Sky Habitat[b]	6.9%	2000[g]
9	River Falls Municipal Utilities[e]	Renewable Energy Program[b]	6.4%	2001
10	Lake Mills Light & Water[e]	Renewable Energy Program[b]	5.3%	2001

[a] Marketed in partnership with 3Degrees Group Inc.
[b] Product is Green-e Energy certified.
[c] Marketed in partnership with Green Mountain Energy Company.
[d] Marketed in partnership with Community Energy Inc.
[e] Power supplied by WPPI Energy.
[f] Some products marketed in partnership with 3Degrees Group Inc.
[g] Blue Sky Habitat & Blue Sky Usage programs began in 2002.

Figure A-3 Customer Participation Rate in Green Power Programs (NREL, 2011)

Total Number of Customer Participants (as of December 2010)

Rank	Utility	Program(s)	Participants
1	Portland General Electric[a]	Clean Wind, Green Source, Renewable Future	77,907
2	PacifiCorp[bc]	Blue Sky Block[d], Blue Sky Usage[d], Blue Sky Habitat[d]	76,322
3	Xcel Energy[e]	WindSource[d], Renewable Energy Trust	66,401
4	Sacramento Municipal Utility District	Greenergy[d]	51,498
5	PECO[f]	PECO WIND	32,629
6	Puget Sound Energy[g]	Green Power Program[d]	29,398
7	Connecticut Light and Power/ United Illuminating	CTCleanEnergyOptions	24,283
8	Iberdrola USA: NYSEG and RG&E[f]	Catch the Wind	23,011
9	We Energies	Energy for Tomorrow[d]	22,306
10	National Grid[h]	GreenUp	21,475

[a] Marketed in partnership with Green Mountain Energy Company.
[b] Includes Pacific Power and Rocky Mountain Power.
[c] Some Oregon products marketed in partnership with 3Degrees Group Inc.
[d] Product is Green-e Energy certified.
[e] Includes Northern States Power, Public Service Company of Colorado and Southwestern Public Service.
[f] Marketed in partnership with Community Energy Inc.
[g] Residential product marketed in partnership with 3Degrees Group Inc.
[h] Includes Niagara Mohawk, Massachusetts Electric, Narragansett Electric, and Nantucket Electric.

Figure A-4 Total number of customer participants (NREL, 2011)

Price Premium Charged for New, Residential Customer-Driven Renewable Power (as of December 2010)

Rank	Utility	Resources Used	Premium (¢/kWh)
1	Indianapolis Power & Light Company[a]	Wind	0.14
2	Edmond Electric[bc]	Wind	0.27
3	Avista Utilities	Wind, landfill gas, hydro	0.33
4	City of Onawa	Wind	0.40
5	Flathead Electric Cooperative[d]	Wind	0.50
5	Moorhead Public Service	Wind	0.50
5	Sacramento Municipal Utility District[a]	Wind, hydro, biomass, solar	0.50
8	OG&E Electric Services[e]	Wind	0.72
9	Emerald People's Utility District	Landfill gas, wind, biomass	0.80
10	Xcel Energy (Minnesota only)[ac]	Wind	0.84

[a] Product is Green-e Energy certified.
[b] Power supplied by Oklahoma Municipal Power Authority.
[c] Premium is variable; customers in these programs are exempt or otherwise protected from changes in utility fuel charges.
[d] Power is supplied by Basin Electric Power Cooperative.
[e] 0.72¢/kWh represents the average price premium paid. The premium varies from .7 ¢/kWh to .9 ¢/kWh, based on purchase quantities.

Figure A-5 Price premium charged for residential customer renewable power (NREL, 2011)

Peaking Power Capital Costs Table 1

Peaking Technology	Capital Cost
Internal Combustion Engine	$580/kW to $910/kW
Combustion Turbine	$700/kW to $1,075/kW
Pumped Hydro Storage	$2,000/kW to $3,500/kW
Battery Storage	$2,500/kW to $3,000/kW
Wind on Land	$1,600/kW to $2,200/kW
Thin Film Photovoltaic Solar	$3,000/kW to $3,500/kW

Figure A-6 Peaking Power Capital Costs (Hynes, 2009)

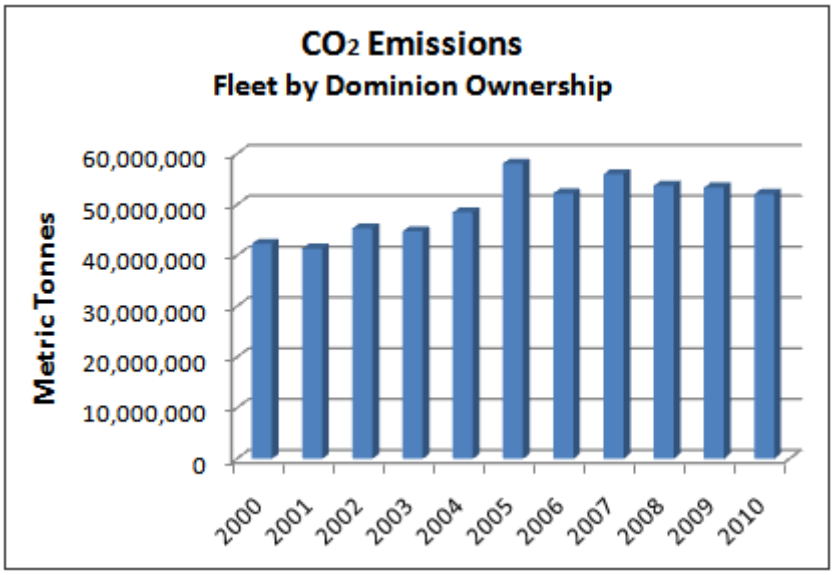

Figure A-7 Dominion CO_2 Emissions (Dominion Resources Services, Inc., 2010-2011)

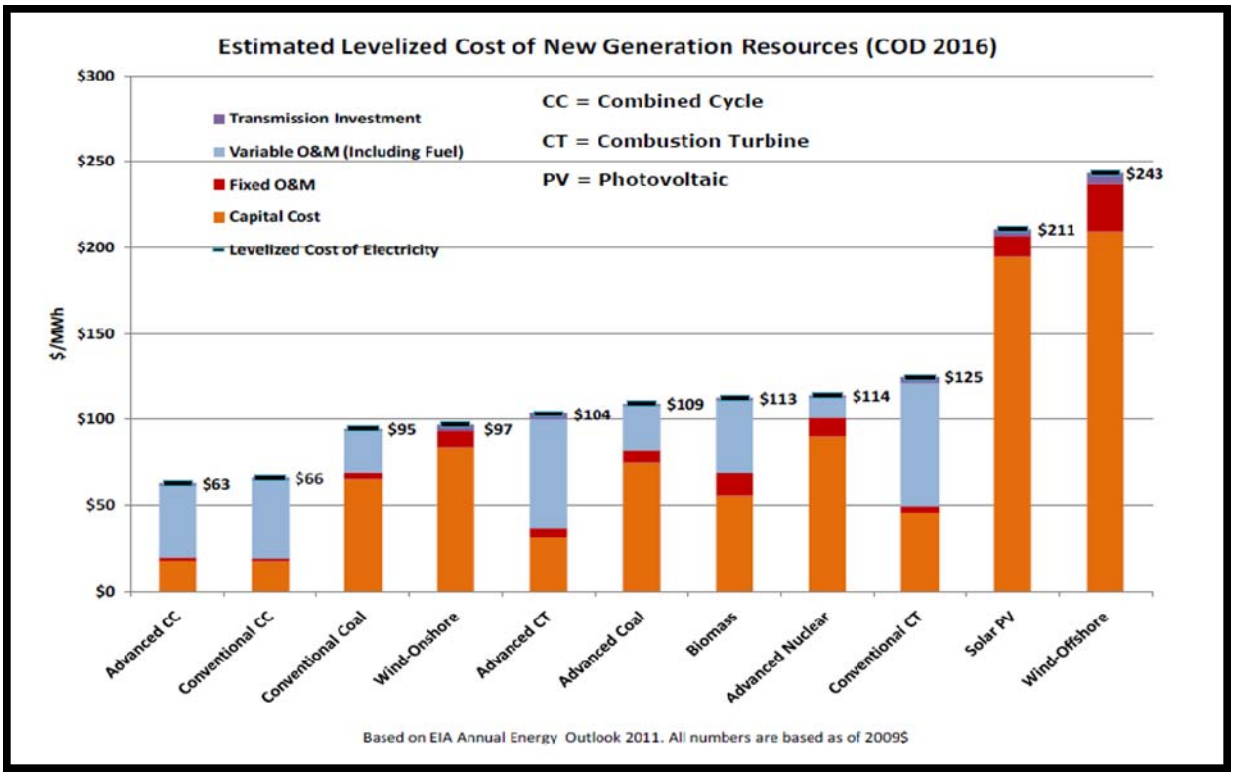

Figure A-8 Dominion Estimated Cost of New Generation (Dominion Resources, 2011)

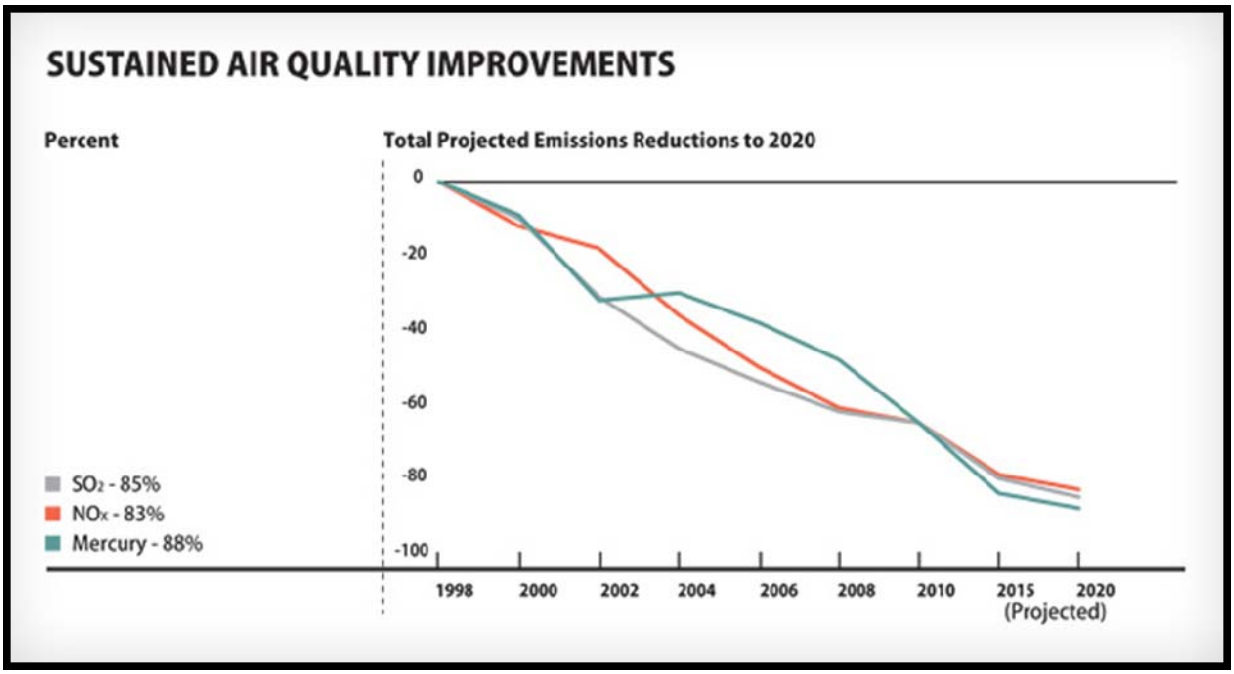

Figure A-9 Dominion Sustained Air Quality Improvements (Dominion Resources, 2011)

Table A-10 Average Electric price of 2009 by state (McDaniel, 2010)

	(Cents per kilowatthour)					
	Census Division	Residenti	Commerci	Industri	Transportatio	All Sectors
1	North Dakota	7.58	6.81	5.25	-	
2	Washington	7.68	6.96	4.43	5.91	15.65
3	Idaho	7.80	6.49	5.17	-	18.06
4	West Virginia	7.90	6.77	5.24	7.56	13.09
5	Louisiana	8.10	7.69	5.25	10.09	15.45
6	Kentucky	8.37	7.63	4.91	-	15.13
7	Utah	8.48	6.96	4.81	8.31	14.23
8	South Dakota	8.49	7.14	5.65	-	12.75
9	Oklahoma	8.49	6.76	4.82	-	12.94
10	Nebraska	8.52	7.33	5.75	-	14.52
11	Missouri	8.54	6.96	5.42	5.83	15.52
12	Wyoming	8.58	7.28	4.83	-	9.60
13	Oregon	8.68	7.49	5.45	6.83	8.89
14	Montana	8.93	8.32	5.45	-	9.08
15	Arkansas	9.14	7.56	5.76	12.32	9.40
16	Tennessee	9.32	9.61	6.76	10.69	9.01
17	Indiana	9.50	8.32	5.81	9.65	9.38
18	Kansas	9.53	7.87	6.10	-	7.57
19	Iowa	9.99	7.55	5.27	-	7.98
20	North Carolina	9.99	7.98	5.99	6.83	8.14
21	Colorado	10.00	8.15	6.39	8.14	7.35
22	New Mexico	10.02	8.40	5.72	-	7.21
23	Minnesota	10.04	7.92	6.26	7.73	6.63
24	Georgia	10.13	8.94	6.12	7.03	7.39
25	Mississippi	10.22	9.50	6.61	-	12.14
26	South Carolina	10.44	8.74	5.79	-	12.97
27	Virginia	10.61	8.06	6.91	8.42	11.49
28	Alabama	10.66	10.05	5.96	-	8.81
29	Ohio	10.67	9.65	6.71	10.73	13.08
30	Arizona	10.73	9.35	6.65	-	8.48
31	Illinois	11.27	8.99	6.84	8.32	6.65
32	Michigan	11.60	9.24	6.99	10.79	6.52
33	Pennsylvania	11.65	9.54	7.21	7.77	8.85
34	Wisconsin	11.94	9.57	6.73	-	8.69
35	Texas	12.38	9.66	6.74	9.83	7.57
36	Florida	12.39	10.77	9.32	10.48	7.06
37	Nevada	12.86	10.64	7.97	9.95	6.94
38	District of Columbia	13.76	12.96	8.41	12.77	9.86
39	Delaware	14.07	11.98	9.34	-	8.41
40	California	14.74	13.42	10.07	8.43	9.56
41	Vermont	14.90	12.93	9.21	-	6.51
42	Maryland	14.98	11.97	9.92	10.43	7.57
43	Rhode Island	15.60	13.67	12.25	-	10.36
44	Maine	15.65	12.55	9.95	-	8.09
45	New Hampshire	16.26	14.55	13.83	-	6.77
46	New Jersey	16.31	13.83	11.81	12.37	6.08
47	Massachusetts	16.87	15.37	14.08	6.23	11.04
48	Alaska	17.14	14.46	13.15	-	13.24
49	New York	17.50	15.51	8.98	13.13	6.60
50	Connecticut	20.33	16.86	14.92	11.96	18.87
51	Hawaii	24.20	21.86	18.14	-	21.21

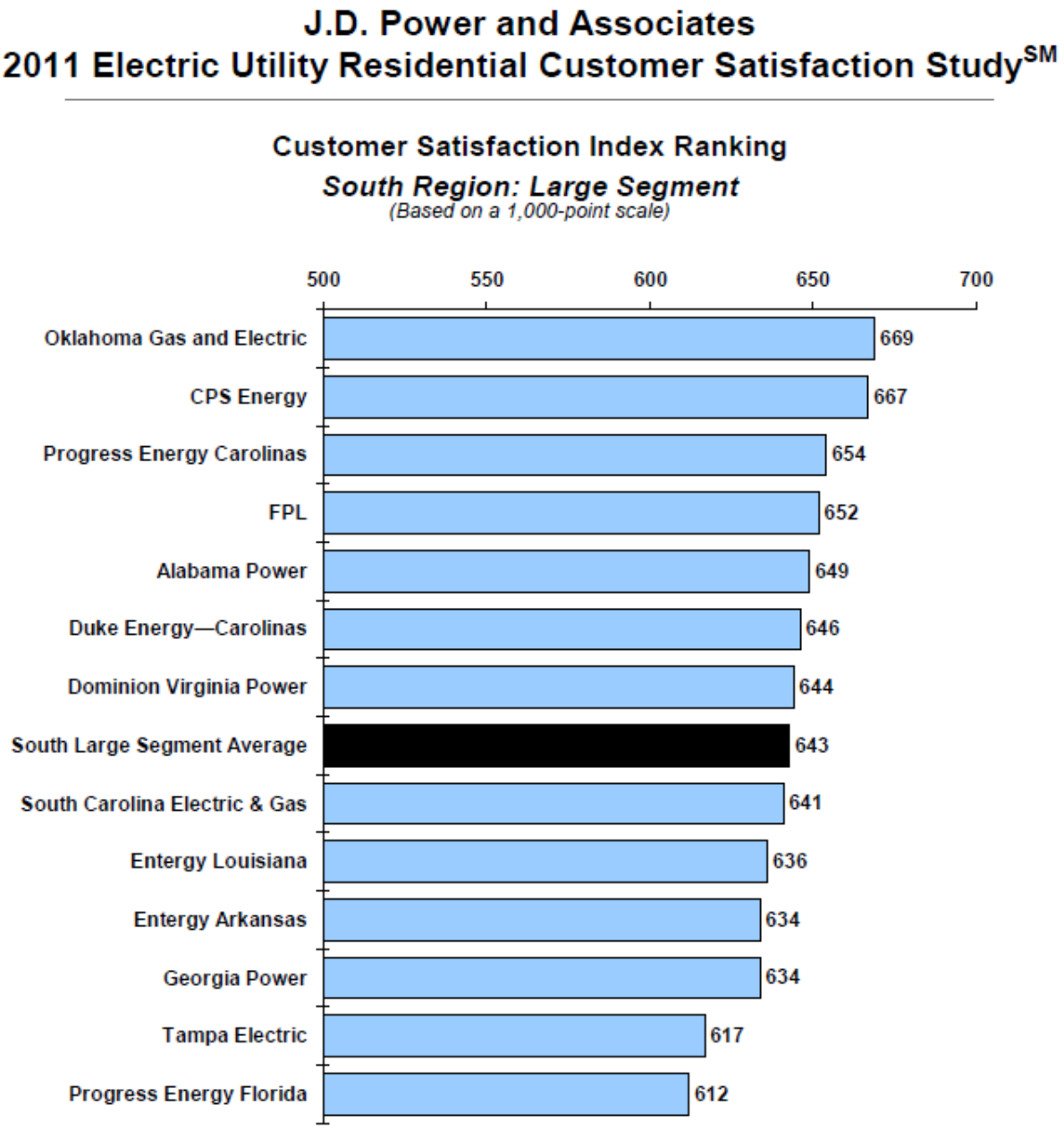

Figure A-11 2011 Electric Utility Residential Customer Satisfaction Study (J.D. Power and Associates, 2011)

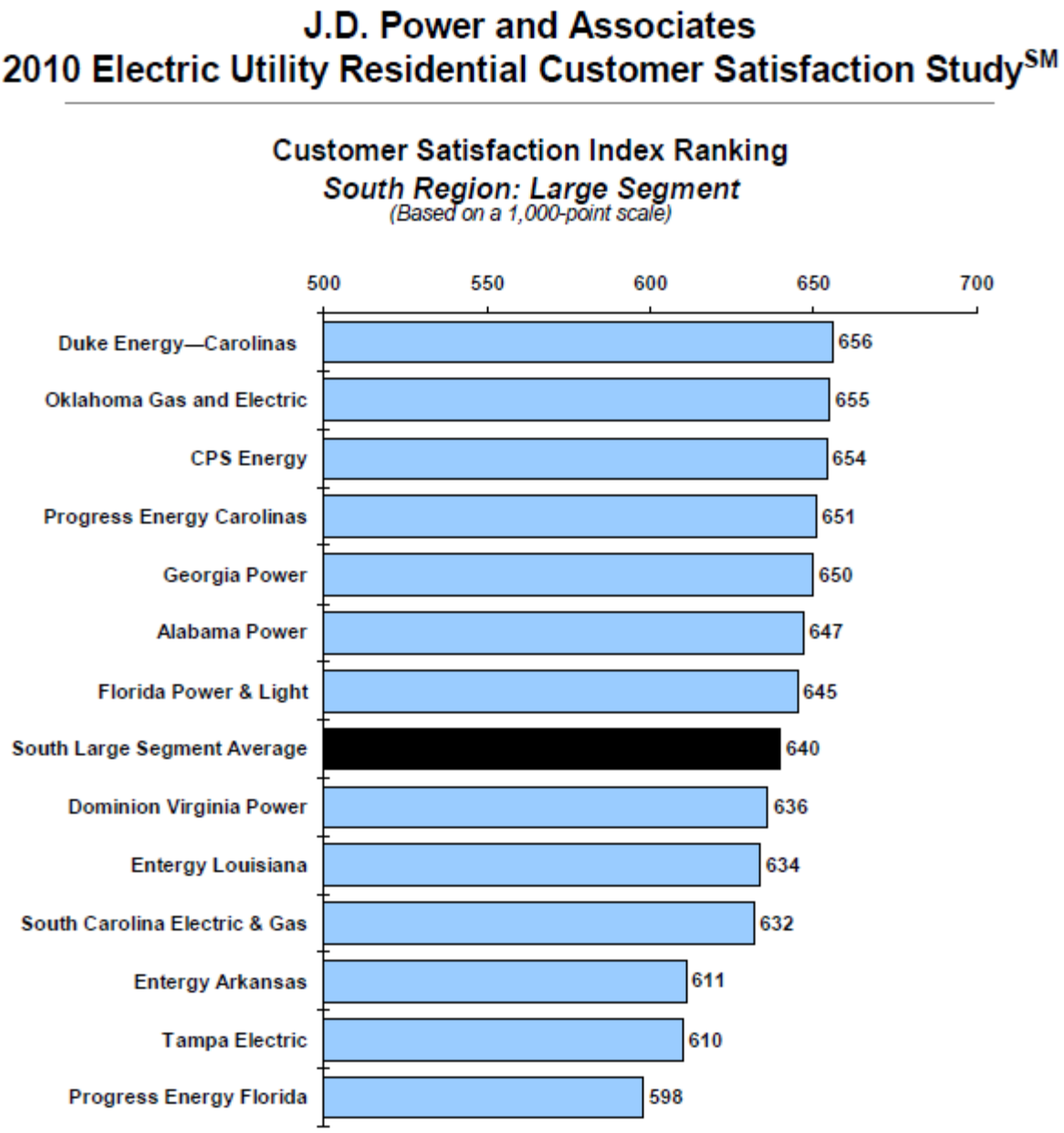

Figure A-12 Cost 2010 Electric Utility Residential Customer Satisfaction Study (J.D. Power and Associates, 2010)

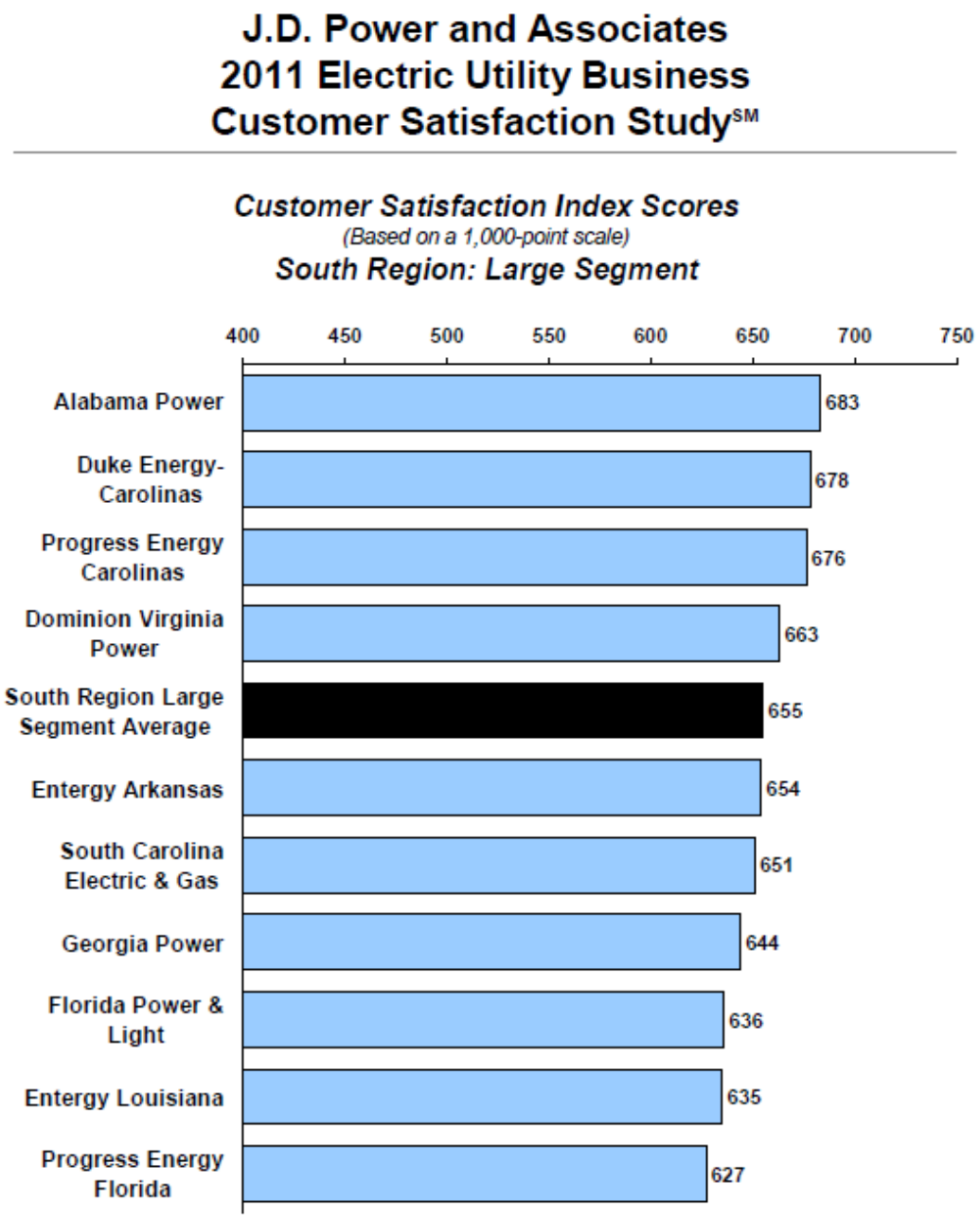

Figure A-13 Cost 2011 Electric Utility Business Customer Satisfaction Study (J.D. Power and Associates, 2011)

Table A-14 Report Categories by Geographic Region (Natural Marketing Institute, 2011)

Northeast	Midwest	South	West
• Connecticut	• Illinois	• Alabama	• Alaska
• Delaware	• Indiana	• Arkansas	• Arizona
• District of Columbia	• Iowa	• Florida	• California
• Maine	• Kansas	• Georgia	• Colorado
• Massachusetts	• Michigan	• Kentucky	• Hawaii
• New Hampshire	• Minnesota	• Louisiana	• Idaho
• New Jersey	• Missouri	• Maryland	• Montana
• New York	• Nebraska	• Mississippi	• Nevada
• Pennsylvania	• North Dakota	• North Carolina	• New Mexico
• Rhode Island	• Ohio	• Oklahoma	• Oregon
• Vermont	• South Dakota	• South Carolina	• Utah
• West Virginia	• Wisconsin	• Tennessee	• Washington
		• Texas	• Wyoming
		• Virginia	

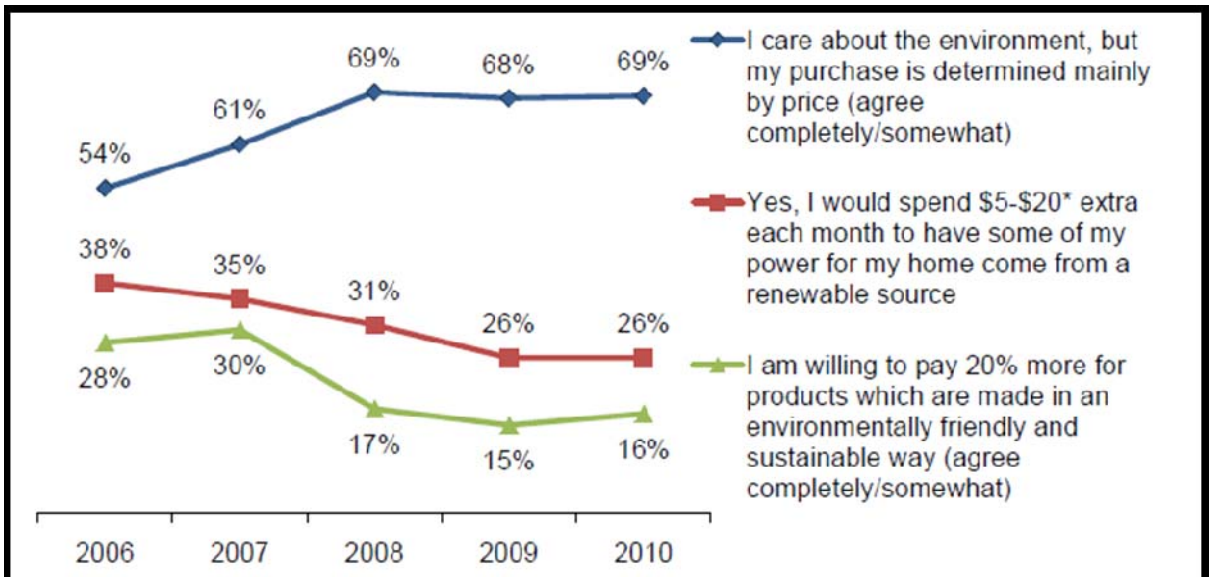

Figure 8. In Q.122, percent of the general population indicating their price sensitivity regarding renewable energy (trended); Q31, percent of the general population agreeing with each statement

*$5–$10 prior to 2009

Source: 2010 LOHAS Consumer Trends Database

Figure A-15 Consumer Price Sensitivity for Renewable Energy Treneded(Natural Marketing Institute, 2011)

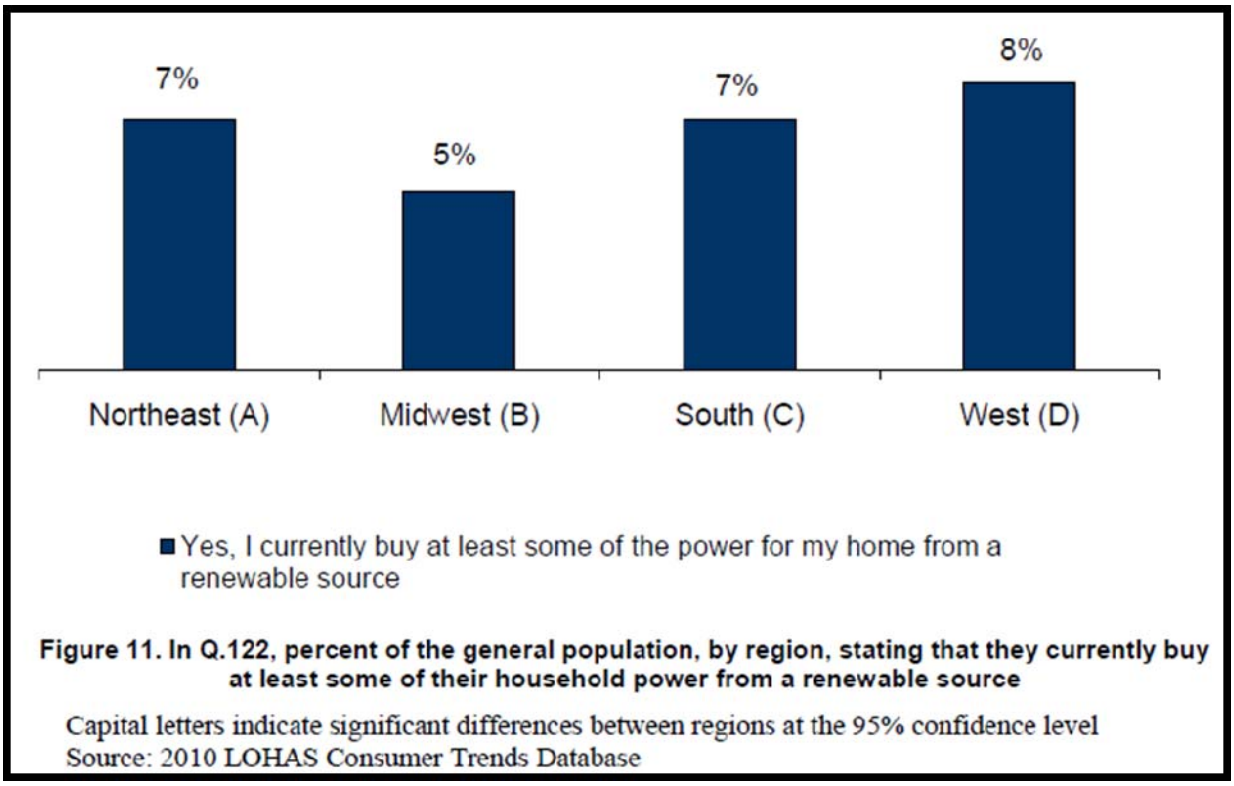

Figure A-16 Percentage of General Population by region stating that they currently buy some household power from a renewable source (Natural Marketing Institute, 2011)

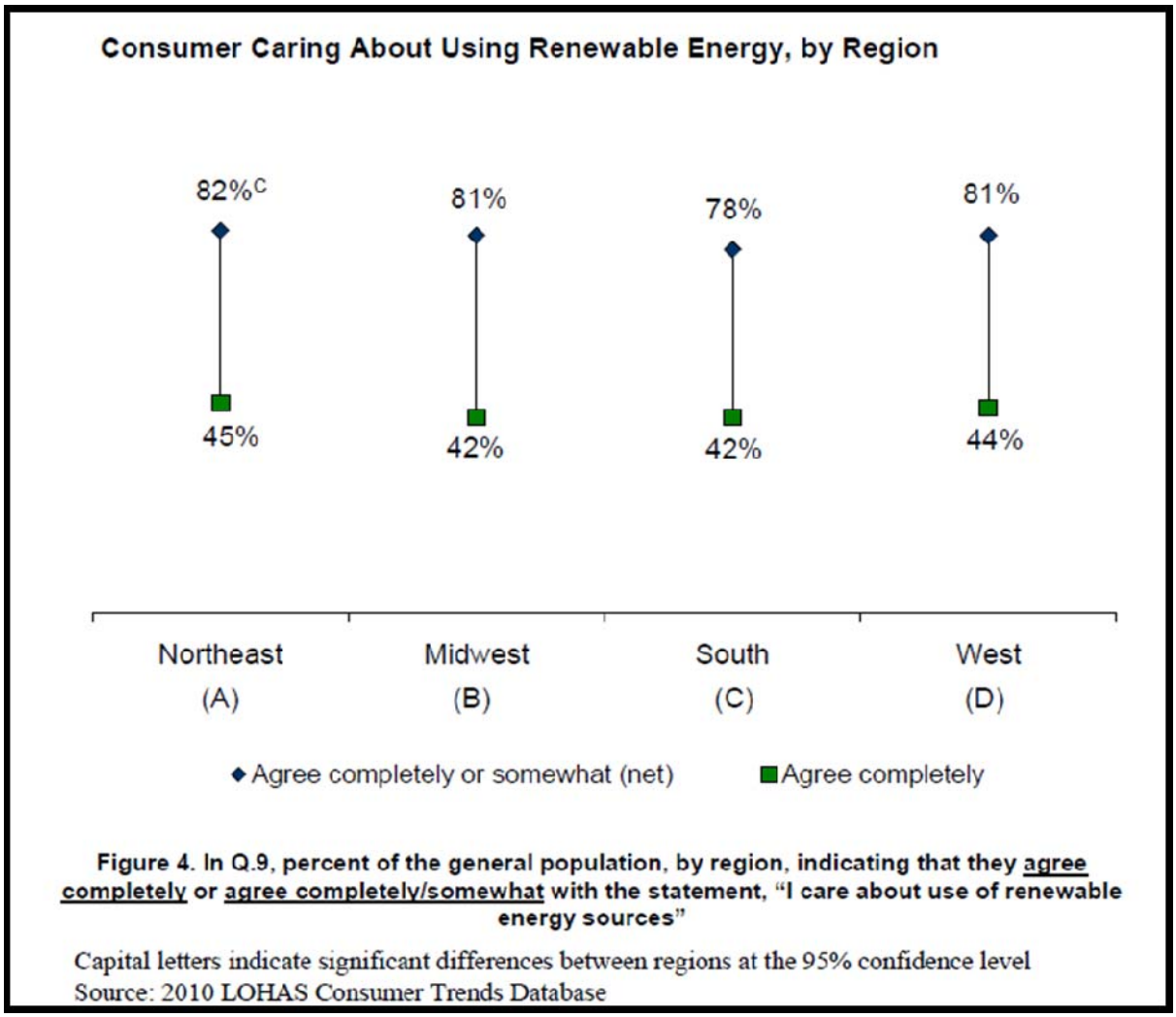

Figure A-17 Percent of general population by region indicating that they care about the use of renewable energy sources (Natural Marketing Institute, 2011)

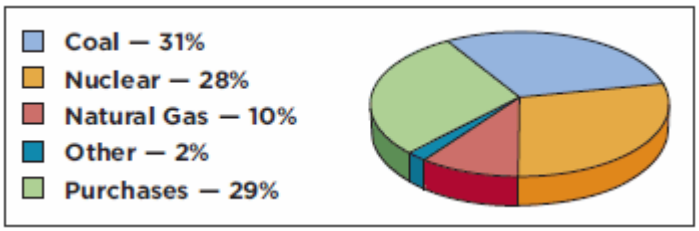

Figure A-18 Dominion's Generation Portfolio (Dominion Resources, 2011)

Table A-19 Primary Energy Production by Source (Department of Energy, 2011)

	Fossil Fuels						Renewable Energy[a]						
	Coal[b]	Natural Gas (Dry)	Crude Oil[c]	NGPL[d]	Total	Nuclear Electric Power	Hydro-electric Power[e]	Geo-thermal	Solar/ PV	Wind	Bio-mass	Total	Total
1973 Total	**13.992**	**22.187**	**19.493**	**2.569**	**58.241**	**0.910**	**2.861**	**0.020**	**NA**	**NA**	**1.529**	**4.411**	**63.563**
1975 Total	**14.989**	**19.640**	**17.729**	**2.374**	**54.733**	**1.900**	**3.155**	**.034**	**NA**	**NA**	**1.499**	**4.687**	**61.320**
1980 Total	**18.598**	**19.908**	**18.249**	**2.254**	**59.008**	**2.739**	**2.900**	**.053**	**NA**	**NA**	**2.475**	**5.428**	**67.175**
1985 Total	**19.325**	**16.980**	**18.992**	**2.241**	**57.539**	**4.076**	**2.970**	**.097**	**(s)**	**(s)**	**3.016**	**6.084**	**67.698**
1990 Total	**22.488**	**18.326**	**15.571**	**2.175**	**58.560**	**6.104**	**3.046**	**.171**	**.059**	**.029**	**2.735**	**6.041**	**70.705**
1995 Total	**22.130**	**19.082**	**13.887**	**2.442**	**57.540**	**7.075**	**3.205**	**.152**	**.069**	**.033**	**3.099**	**6.558**	**71.174**
1996 Total	**22.790**	**19.344**	**13.723**	**2.530**	**58.387**	**7.087**	**3.590**	**.163**	**.070**	**.033**	**3.155**	**7.012**	**72.486**
1997 Total	**23.310**	**19.394**	**13.658**	**2.495**	**58.857**	**6.597**	**3.640**	**.167**	**.070**	**.034**	**3.108**	**7.018**	**72.472**
1998 Total	**24.045**	**19.613**	**13.235**	**2.420**	**59.314**	**7.068**	**3.297**	**.168**	**.069**	**.031**	**2.929**	**6.494**	**72.876**
1999 Total	**23.295**	**19.341**	**12.451**	**2.528**	**57.614**	**7.610**	**3.268**	**.171**	**.068**	**.046**	**2.965**	**6.517**	**71.742**
2000 Total	**22.735**	**19.662**	**12.358**	**2.611**	**57.366**	**7.862**	**2.811**	**.164**	**.065**	**.057**	**3.006**	**6.104**	**71.332**
2001 Total	**23.547**	**20.166**	**12.282**	**2.547**	**58.541**	**8.029**	**2.242**	**.164**	**.064**	**.070**	**2.624**	**5.164**	**71.735**
2002 Total	**22.732**	**19.439**	**12.163**	**2.559**	**56.894**	**8.145**	**2.689**	**.171**	**.063**	**.105**	**2.705**	**5.734**	**70.773**
2003 Total	**22.094**	**19.633**	**12.026**	**2.346**	**56.099**	**7.959**	**2.825**	**.175**	**.062**	**.115**	**2.805**	**5.982**	**70.040**
2004 Total	**22.852**	**19.074**	**11.503**	**2.466**	**55.895**	**8.222**	**2.690**	**.178**	**.063**	**.142**	**2.998**	**6.070**	**70.188**
2005 Total	**23.185**	**18.556**	**10.963**	**2.334**	**55.038**	**8.161**	**2.703**	**.181**	**.063**	**.178**	**3.104**	**6.229**	**69.427**
2006 Total	**23.790**	**19.022**	**10.801**	**2.356**	**55.968**	**8.215**	**2.869**	**.181**	**.068**	**.264**	**3.226**	**6.608**	**70.792**
2007 Total	**23.493**	**19.825**	**10.721**	**2.409**	**56.447**	**8.455**	**2.446**	**.186**	**.076**	**.341**	**3.489**	**6.537**	**71.440**
2008 Total	**23.851**	**20.703**	**10.509**	**2.419**	**57.482**	**8.427**	**2.511**	**.192**	**.089**	**.546**	**3.867**	**7.205**	**73.114**
2009 January	1.953	1.823	.927	.196	4.898	.775	.229	.017	.008	.058	.315	.627	6.300
February	1.802	1.661	.854	.189	4.506	.672	.174	.016	.007	.057	.291	.545	5.722
March	1.932	1.825	.940	.216	4.913	.703	.213	.017	.008	.069	.316	.624	6.240
April	1.791	1.737	.918	.209	4.654	.621	.252	.016	.008	.073	.300	.649	5.924
May	1.715	1.795	.967	.224	4.701	.684	.289	.017	.009	.061	.315	.690	6.075
June	1.785	1.746	.919	.213	4.663	.729	.285	.016	.008	.055	.318	.683	6.075
July	1.829	1.780	.971	.218	4.799	.763	.228	.017	.009	.048	.340	.643	6.205
August	1.818	1.795	.974	.220	4.807	.756	.191	.017	.009	.053	.345	.615	6.178
September	1.774	1.690	.965	.217	4.647	.688	.169	.016	.008	.045	.329	.568	5.903
October	1.771	1.770	.989	.226	4.756	.607	.192	.016	.008	.067	.343	.627	5.990
November	1.722	1.711	.944	.221	4.599	.618	.205	.017	.008	.067	.345	.642	5.859
December	1.737	1.760	.980	.224	4.701	.740	.241	.018	.008	.067	.357	.692	6.133
Total	**21.627**	**21.095**	**11.348**	**2.574**	**56.644**	**8.356**	**2.669**	**.200**	**.098**	**.721**	**3.915**	**7.603**	**72.603**
2010 January	1.742	[E] 1.812	.972	.230	4.756	.759	.216	.018	.008	.068	.359	.670	6.185
February	1.686	[E] 1.661	.906	.210	4.463	.682	.200	.016	.008	.054	.328	.606	5.752
March	1.967	[E] 1.865	.990	.236	5.059	.676	.201	.018	.009	.085	.365	.678	6.413
April	1.850	[E] 1.808	.938	.227	4.823	.603	.182	.017	.009	.096	.351	.655	6.081
May	1.739	[E] 1.867	.969	.238	4.814	.697	.243	.018	.010	.085	.360	.716	6.227
June	1.804	[E] 1.782	.944	.226	4.756	.714	.288	.018	.010	.078	.355	.749	6.219
July	1.853	[E] 1.854	.951	.227	4.884	.752	.236	.018	.010	.065	.368	.696	6.333
August	1.905	[E] 1.888	.978	.236	5.007	.749	.193	.018	.010	.065	.371	.656	6.411
September	1.903	[E] 1.843	.983	.232	4.962	.726	.165	.017	.009	.069	.356	.617	6.305
October	1.870	[E] 1.906	1.002	.242	5.020	.656	.170	.017	.009	.078	.364	.637	6.313
November	1.865	[E] 1.866	.966	.235	4.933	.655	.190	.018	.009	.096	.366	.678	6.266
December	1.891	[E] 1.942	.990	.242	5.065	.771	.226	.019	.009	.086	.375	.714	6.550
Total	**22.077**	**[E] 22.095**	**11.589**	**2.781**	**58.542**	**8.441**	**2.509**	**.212**	**.109**	**.924**	**4.319**	**8.073**	**75.056**
2011 January	1.860	[E] 1.932	[E] .986	.230	5.008	.761	.251	.019	.009	.087	.374	.740	6.509
February	1.741	[E] 1.720	[E] .911	.197	4.570	.678	.238	.017	.008	.101	.336	.700	5.947
March	1.963	[E] 1.975	[E] 1.013	.247	5.198	.687	.306	.019	.009	.102	.368	.805	6.689
April	1.761	[E] 1.936	[E] .973	.238	4.908	.571	.305	.018	.010	.120	.353	.806	6.285
May	1.723	[RE] 1.999	[E] 1.009	.253	[R] 4.985	.596	.320	.019	.010	.113	.361	.824	[R] 6.405
June	1.765	[E] 1.936	[E] .979	.240	4.920	.683	.313	.018	.010	.106	.365	.812	6.415
6-Month Total	**10.814**	**[E] 11.498**	**[E] 5.871**	**1.405**	**29.589**	**3.975**	**1.734**	**.109**	**.057**	**.628**	**2.158**	**4.687**	**38.251**

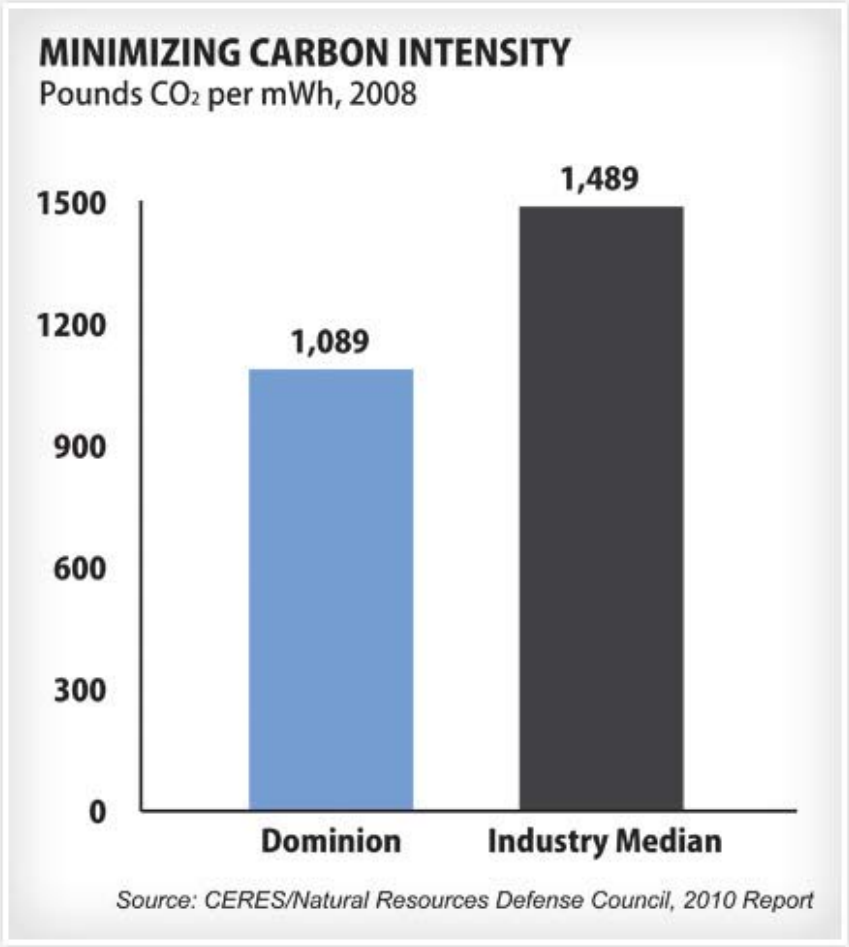

Figure A-20 Dominion's CO2 Company Comparison (Dominion Resources, 2011)

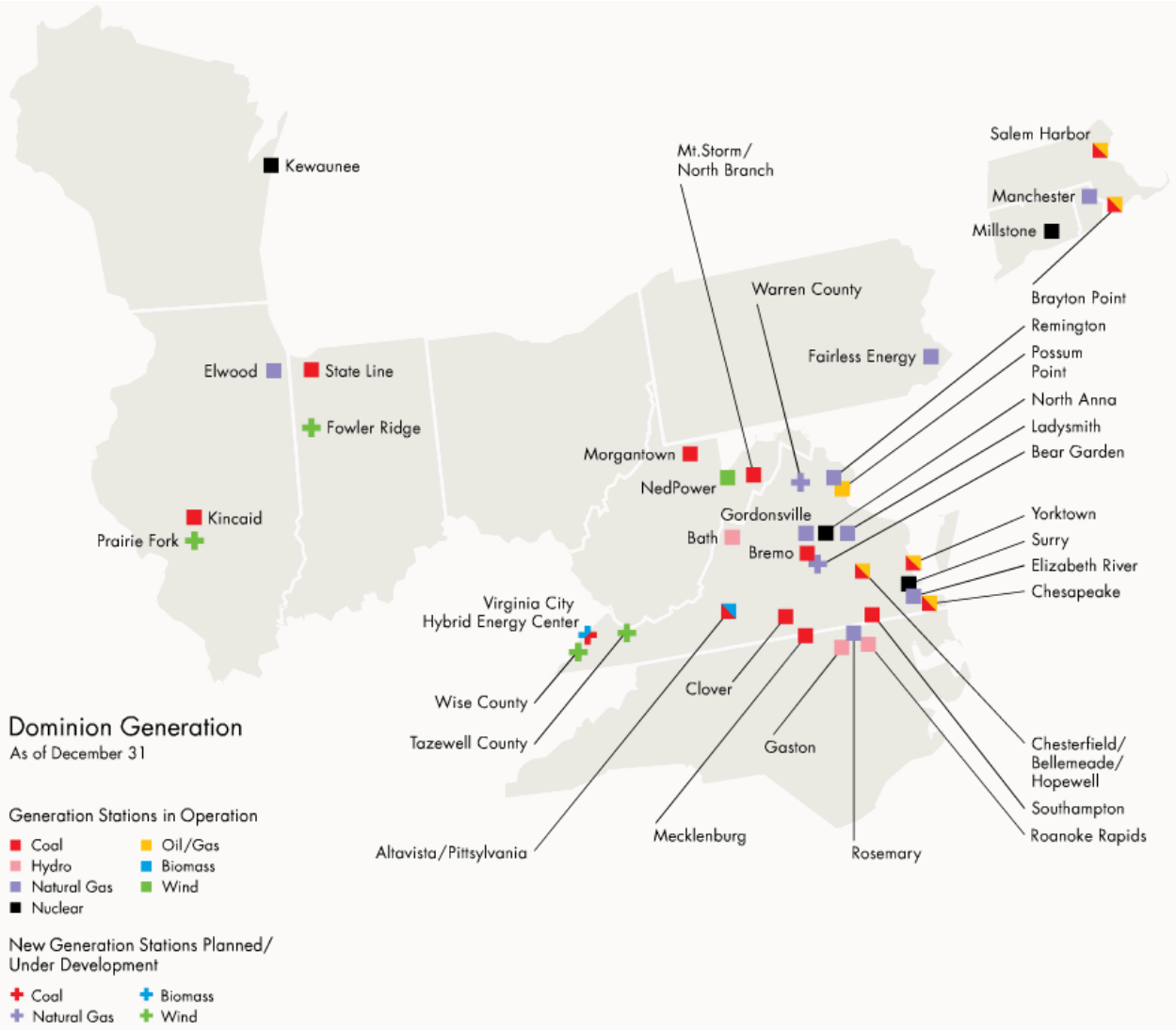

Figure A-21 Dominion Asset Locations (Dominion Resources, 2011)

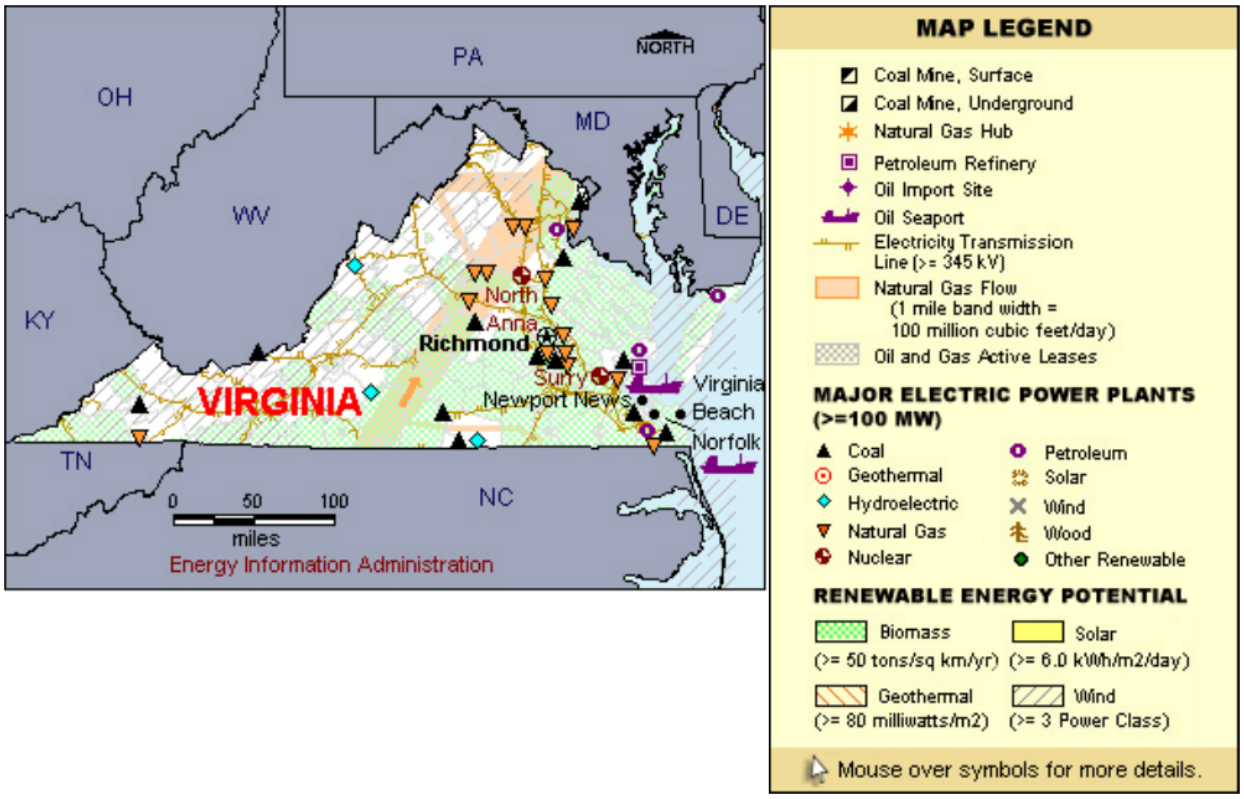

Figure A-22 Virginia Energy Potential (US Energy Information Administration, 2009)

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BIOGRAPHICAL SKETCH

Scott Reamy graduated with honors from James Madison University in 2006 with a Bachelor of Science in industrial design. He is the son to his parents Gretchen and Christopher, and a brother to his sister Allison and brother Phillip. He has been employed by Dominion Virginia Power, a large-scale, public electrical utility in Virginia since September 2006, for whom he has achieved a certification of Six Sigma Black belt. Scott currently resides in Arlington, Virginia and spends most of his time playing and coaching high school level travel volleyball. He is an avid console gamer.