Evaluating the Economics of Power Market Restructuring in North Carolina:
A case study of the Roxboro coal-fired plant

by
Xiaoyuan Gu

Dr. Martin D. Smith, Advisor
May 2011

Master project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

2011
ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my advisor, Dr. Martin D. Smith, Nicholas School of the Environment and Earth Sciences, Duke University, for supervising this research project and providing valuable feedback and advice; Dr. Timothy Johnson, Office of Research and Development, U.S. EPA and for giving me inspiration and original thoughts on power market restructuring; and most importantly my parents and my good friends Ting Lei and Songtao Zhang, who supported and encouraged me throughout this endeavor.
# LIST OF ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAU</td>
<td>Business as Usual</td>
</tr>
<tr>
<td>CBA</td>
<td>Cost-Benefit Analysis</td>
</tr>
<tr>
<td>DSM</td>
<td>Demand Side Management</td>
</tr>
<tr>
<td>EE</td>
<td>Energy Efficiency</td>
</tr>
<tr>
<td>EIA</td>
<td>Energy Information Agency</td>
</tr>
<tr>
<td>FERC</td>
<td>Federal Energy Regulatory Commission</td>
</tr>
<tr>
<td>IECM</td>
<td>Integrated Environmental Control Model</td>
</tr>
<tr>
<td>IOU</td>
<td>Investor-Owned Utilities</td>
</tr>
<tr>
<td>JOA</td>
<td>Joint Operating Agreement</td>
</tr>
<tr>
<td>NC</td>
<td>North Carolina</td>
</tr>
<tr>
<td>NPV</td>
<td>Net Present Value</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>PEC</td>
<td>Progress Energy North Carolina</td>
</tr>
<tr>
<td>PE&amp;G</td>
<td>Pacific Gas and Electric Company</td>
</tr>
<tr>
<td>PJM</td>
<td>PJM Interconnection LLC</td>
</tr>
<tr>
<td>REC</td>
<td>Regional Electricity Companies</td>
</tr>
<tr>
<td>RTO</td>
<td>Regional Transmission Organization</td>
</tr>
<tr>
<td>T&amp;D</td>
<td>Transmission and Distribution</td>
</tr>
<tr>
<td>TLC</td>
<td>Total Levelized Cost</td>
</tr>
<tr>
<td>NCUC</td>
<td>North Carolina Utility Commission</td>
</tr>
</tbody>
</table>
ABSTRACT

In the last century, the electric power market has been transformed to be more competitive around U.S. Several states have deregulated the industry and expect lower energy prices and higher social benefits to result. However, the electric industry is still operated in a regulated market in many states, including North Carolina (NC). Proposals for power market restructuring have been declined by governments for more than ten years and the legislation and utility commission of North Carolina is still under investigation.

This master project is designed to evaluate the costs and benefits of power market restructuring in NC from the perspective of suppliers using a case study of a coal-fired plant. It uses the Roxboro plant, which belongs to Progress Energy. The basic Cost-Benefit Analysis model and sensitivity analysis considering uncertain energy prices and sales amounts have been conducted to estimate the power plant’s annual net benefit and total Net Present Value in the next two decades under three scenarios. The results indicate that integrating the Roxboro plant into a competitive market will bring the most profits, while merging to Duke Energy and keeping operation in a regulated market will bring the least ones. However, further studies including financial and environmental performance, transmission expansion and other major related factors are necessary for the analysis about power market restructuring’s influence at the company scale.
Table of Contents
INTRODUCTION........................................................................................................................... 4
Previous Studies on Power Market Restructuring ................................................................. 7
NC Power Market Restructuring Status ................................................................................... 9
IOUs and PJM ........................................................................................................................... 11
1. Progress Energy ............................................................................................................. 11
2. Duke Energy .................................................................................................................. 12
3. Dominion North Carolina .............................................................................................. 12
OBJECTIVE............................................................................................................................ 13
METHODOLOGY .................................................................................................................. 13
Why Roxboro ............................................................................................................................. 14
1. Coal- Fired ..................................................................................................................... 14
2. Neglect of Transmission Line Expansion ...................................................................... 15
Model Structure ..................................................................................................................... 17
1. Cost Stream-IECM Model ............................................................................................. 17
2. Revenue Stream ............................................................................................................ 19
3. Base Cost-Benefit Analysis (CBA) Model ...................................................................... 22
Sensitivity Analysis .................................................................................................................. 22
RESULTS................................................................................................................................. 26
Cost-Benefit Analysis-Business as Usual ............................................................................. 26
Net Benefit Comparisons under 3 Scenarios ....................................................................... 27
Sensitivity Analysis-Price and Sales Rates of Change ........................................................... 28
DISCUSSION ......................................................................................................................... 32
REFERENCE ......................................................................................................................... 36
APPENDIX ............................................................................................................................. 39
Appendix I: Main Suppliers’ Coverage in North Carolina ...................................................... 39
Appendix II: PJM Coverage in North Carolina ........................................................................ 40
Appendix III: Nominal and Real Electricity rates for US average, NC and VA 1996-2006 (in 2008 dollar) .......................................................................................................................... 41
Appendix IV: Total Net Present Value from all Status (2009-2030) in 2009 constant dollar... 42
INTRODUCTION

In the last century, the electric power industry, which was once considered to be a natural monopoly, has been transformed to be more competitive. Compared to regulated prices and capacity with long term contracts, energy transactions driven by the market are more flexible and not strictly limited by geographic boundaries. In some states, the final customer can select an electricity company even from other states according to the energy rates and their own energy consumption. Many experts, economists and regulators have studied the benefits from power market restructuring. One expected advantage of electricity industry deregulation is that free markets can reduce costs and prices by raising efficiency. The report *Electricity Prices in a Competitive Environment, August 1997* from Energy Information Administration (EIA) states that competitive prices based on marginal costs rather than regulated “cost-of-service” pricing have a long-run reduction effect. In the case of Preetum Domah and Michael G. Pollitt’s study on social cost-benefit of power market restructuring in England and Wales, they indicate that consumers are expected to gain £1.1 billion from restructuring and privatization of the regional electricity companies (RECs) rather than having them publicly owned. Furthermore, the advanced technologies could be incentivized by more investments and competitors, thus the competitive markets are intended to be more efficient. The study on energy network efficiency conducted by Aoife Brophy Haney & Michael G. Pollitt points out that “in the regulated electricity industry, there is a more clear trend towards the use of process/activity in both transmission and distribution over other advanced benchmarking techniques; however alternatives to best practice techniques are prevalent, particularly in the electricity distribution.”

---

To date, almost half of the states in the U.S. have passed major legislation and/or regulations to restructure their electric power industry, moving away from regulated price sets to competitive ones. The states with higher rates such as California, Pennsylvania, and New Jersey began the restructuring process at the end of last century. However, the failures of California restructuring (large-scale blackouts, the bankruptcy of Pacific Gas and Electric Company (PG&E), the unreasonable electricity tariff and astronomical bills for ratepayers) arguably due to a few power companies’ manipulation drive regulation back into the electricity market, especially on the transmission network. To guarantee a reliable and competitive market and avoid manipulation, the network for power transmission is being reorganized from a balkanized system with many transmission system operators to one where only a few organizations operate the system. Within the regulatory process, the Federal Energy Regulatory Commission (FERC) has promoted the development of competitive wholesale power markets and opening the transmission system to all qualified users. “In December 1999, FERC issued Order 2000 calling for electric utilities to form regional transmission organizations (RTOs) that will operate, control, and possibly own the Nation's power transmission system. The potential benefits of RTOs are the elimination of discriminatory behavior in using the transmission system, improved operating efficiency, and increased reliability of the power system.”

Another issue worth researching is how power market restructuring will affect electricity companies. Both the consumer energy bills and higher energy efficiency contribute to the positive effects of deregulation. However, in the new electricity markets with more independent power suppliers and energy traders, the power suppliers are experiencing unprecedented competitive pressure. The paper by Paul L. Joskow about the regulatory reform in the U.S. electricity sector claims that the well-organized central economic dispatch and system operation

---

are hard to be duplicated by transmission and generation companies in the deregulated market when governmental coordination and regulation are limited. The overlap between generation and transmission companies may also lead to inefficiencies both in investment and operation if the market fails to coordinate among different industrial sectors.

There are more than 3,170 traditional electric utilities supplying power in the U.S. These utilities aim to ensure an adequate and reliable electricity capacity to final consumers in their service territories at a reasonable cost. Utilities are categorized into four types: investor-owned, publicly owned, cooperatives, and Federal utilities. The investor-owned utilities (IOUs) own more than 75 percent of the Nation's generating and transmission capacity and serve about 75 percent of ultimate consumers. However, these major suppliers will be challenged more in the deregulated power market because of the unstable energy resource prices, uncertain payback profit, and expensive information technology and distribution network updated. To be more competitive among the market based on their higher operating efficiencies, more companies are merging to gain economies of scale. Since 1995, the FERC has approved 50 mergers between IOUs. More mergers and further consolidation of the power industry are expected in next decades and economic and environmental analyses are necessary to evaluate these activities.

---

5 EIA: Electric Power Industry Overview
Electric power market deregulation is spreading across the U.S. and the world. Research has been performed to evaluate these initiatives in the fields of market structure, economic and environmental performance, and related legislative system. One early study by Kristen H. Engel (1999) uses the case study of electricity restructuring to evaluation the influences from market deregulation. Besides the inter-state energy transaction, the power company can also trade the green products and even emission permits under the competitive market. On the economic ground, better environmental performance has been achieved with high efficiency upon the companies.

---

8 EIA: The Changing Structure of the Electric Power Industry 2000: An Update, Figure 23
own adjustment. Engel suggests that states turn to market-based mechanisms rather than state control to mitigate global warming.

Another analysis about market structure of U.S. electricity from James Bushnell et al. (2004) claims that deregulated electricity market design will significantly affect market outcomes. They compare the equilibrium electricity prices under perfect competition and Cournot competition. The price cap in the Cournot market can avoid the price spikes in full competition except during the very high demand hours. To compare the electricity prices in the pool-based daily auctions and bilateral transactions, John Bower and Derek W. Bunn (2004) select the wholesale electricity market in England and Wales, which runs daily bidding markets to present a computationally intensive simulation model of alternative trading arrangements on electricity prices. The research uses agent-based simulation to evaluate the market trading. The results show that daily bidding in the original one day-ahead pool market produces the lowest prices while the bilateral bidding model produces the highest prices. In other words, different market structures in deregulated power market will lead to price gap.

Severin Borenstein and James Bushnell (2000) also argues the difficulty of benefits estimation from power market deregulation. In nearly all electricity markets, demand is difficult to forecast and is almost completely insensitive to price fluctuations, while supply faces binding constraints at peak times, and storage is prohibitively costly. The initial investment for market restructuring is huge and appropriate regulations are still needed to guarantee the effective market. The short-run benefits are likely to be small or non-existent, and impact of liberalization on the long-term issues of investment and security of supply has not yet been fully resolved. The quantified results for the whole system evaluation are limited. Thus, economic analysis for various players, including suppliers, customers and even regulators, is necessary.
NC Power Market Restructuring Status

Currently, proposals for deregulation both in electricity and gas markets in North Carolina (NC) are still idle, but the legislative investigation is ongoing. The market-inclined regulators continuously provide proposals related to the liberalization of electricity market with various modifications to guarantee an effective and successful free-market: deregulate or regulate simultaneously both the “middleman” utilities whom are considered as traders and the providers which occurs among Pennsylvania; cap the energy sources’ price and prevent the oligopoly from controlling the cost.

At present, the government regulates the electricity market in most areas of the state. The two major investor-owned utilities (IOUs), Duke Energy and Progress Energy, operate in non-overlapping regions of the state and make long-term contracts with the state utility commission to provide electricity with fixed rates and loads. The pricing mechanism depends on the power companies’ basic operating costs and reasonable rate of return. ⁹ Meanwhile, there is a small area in northeast NC that is operated by Dominion North Carolina Power, which is a member of PJM Interconnection LLC (PJM). This area has a competitive wholesale market in which Dominion North Carolina is the predominant supplier. This competitive market reaches the clearing power price according to the bid-offer pricing mechanism based on suppliers’ final unit prices and customers’ demands in the one day/hour-ahead market operated by PJM.

PJM Interconnection LLC. is the country’s first fully functioning regional transmission organization (RTO). It operates a competitive wholesale electricity market and manages the high-voltage electricity grid to serve in all of or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West

Virginia and the District of Columbia. The company currently coordinates a pooled generating capacity of more than 71,600 megawatts and operates a wholesale electricity market with more than 200 market buyers, sellers and traders of electricity. PJM has administered more than $9 billion in energy and energy service trades since the regional markets opened in 1997. More than 70 nations have sent delegates to PJM to learn about its market model and the operation of the grid in a region including more than 25 million people. The PJM RTO has a single energy market and a single economic dispatch. There will be three Synchronized Reserve Zones and one Regulation Zone run across the PJM RTO, making up the Ancillary Service Areas. Each Control Zone (i.e. PJM Mid Atlantic, Allegheny Power (AP), Duke, Dayton, AEP, Duquesne, Dominion, and Commonwealth Edison (CE)) will be assigned to one and only one Ancillary Service Area.\(^{10}\)

Past studies comparing rates in the NC regulated power market have showed that final customer rates in NC are near to or even less than the US national average levels. However, the results from more specific rate comparisons between NC and nine southeast states (which have similar climate and energy resource conditions) indicate that NC customers actually pay higher final prices. The details are shown in Table 1. Additionally, the rates from NC’s neighbor, Virginia are stable and lower than the southeast nine state average levels based on the wholesale competition\(^{11}\).

**Table 1. Standardized Rates Comparison between NC and Overall US / Southeast US\(^{12}\)**

<table>
<thead>
<tr>
<th></th>
<th>NC/US</th>
<th>NC/Southeast US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>1.04</td>
<td>1.17</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.84</td>
<td>0.99</td>
</tr>
<tr>
<td>Residential</td>
<td>0.96</td>
<td>1.10</td>
</tr>
</tbody>
</table>

\(^{10}\) PJM Interconnection LLC: [http://www.pjm.com/about-pjm.aspx](http://www.pjm.com/about-pjm.aspx)

\(^{11}\) Final Report-Rate Comparisons, Research Triangle Institute, March 2003

\(^{12}\) Final Report-Rate Comparisons, Research Triangle Institute, March 2003
High electricity rates are supposed to hinder economic development. Most industrial sectors in NC will experience higher operating costs and consequently lower competitiveness due to higher industrial electricity rates. Furthermore, some NGOs often complain that without competition that incentivizes efficiency, the powerful utilities such as Duke Energy prefer to build new coal-fired plants rather than improve the energy efficiency of current plants. The proposal for NC power market deregulation has been under discussion for more than ten years. Meanwhile, the mature northeast NC deregulated wholesale market and its stable and lower power rates drives researchers to analyze the impacts of deregulation on NC.

To sum up, the recommendations for power market competition, consumer protection and power plant construction in North Carolina start from the 1970s, and the investigation conducted by study commission of North Carolina Utility Commission is still moving. To date, the NC Utility Commission fails to recommend any legislation to implement electricity market deregulation and provide for retail electric choice for final customers in North Carolina. However, in 2003, NCUC adopted a new rule streamlining the certification of merchant generating plants based on the investigation from study commission. The new rule, "on the creation of voluntary "green" and "public benefit fund" check off programs" , aims to concentrate voluntary contributions on green power because public benefit programs were already successful and well established. All these activities bring the green power to the NC power market.

**IOUs and PJM**

1. Progress Energy
Progress Energy has over 21,800 MWhs of generation capacity and $8 billion annual revenues runs business in the fields of electricity and natural gas supply, energy service and broadband

---

13 Eleanor (Ellie) Lee Kim, Examining the Barriers to Sustainable Power at Duke Energy, May 2009
14 [http://www.ncuc.commerce.state.nc.us/electric/elecrest.htm](http://www.ncuc.commerce.state.nc.us/electric/elecrest.htm)
capacity. The company serves 3.1 million customers in the Southeast U.S. mainly in two states: North Carolina and Florida. The Progress Energy North Carolina (PEC) division is one of the largest utilities in NC and regulated by North Carolina Utility Commission (NCUC)\(^\text{16}\).

### 2. Duke Energy

Duke Energy is one of the largest electric power holding companies in the United States. Its regulated utility operations serve approximately 4 million customers located in five states in the Southeast and Midwest, representing a population of approximately 11 million people. Its commercial power and international business segments own and operate diverse power generation assets in North America and Latin America, including a growing portfolio of renewable energy assets in the United States\(^\text{17}\).

On 10th Jan, 2011, Duke Energy and Progress Energy announced a merger agreement to combine the two companies.\(^\text{18}\) Subject to shareholder and regulatory approval, the merger of Duke Energy and Progress Energy will create the nation’s largest utility, with more than 7 million customers in six regulated service territories – North Carolina, South Carolina, Florida, Indiana, Kentucky and Ohio. The two companies’ mix of coal, nuclear, natural gas, oil and renewable resources will total approximately 57 gigawatts of U.S. generating capacity. The combined company will be called Duke Energy and headquartered in Charlotte, N.C.

### 3. Dominion North Carolina

Dominion is one of the nation's largest producers of energy, with a portfolio consisting of 24,000 megawatts of generation, 6.1 trillion cubic feet equivalent of natural gas reserves, 7,900 miles of

\(\text{http://progress-energy.com/}\)
\(\text{http://www.duke-energy.com/company.asp}\)
\(\text{http://www.duke-energy.com/progress-energy-merger/}\)
natural gas transmission pipeline and more than 960 billion cubic feet of storage capacity.

Dominion also serves 5 million natural gas and electric customers in nine states.

**OBJECTIVE**

The objective of this master project is to evaluate the costs and benefits of power market restructuring from the perspective of suppliers. The details are as follow:

- Take a coal-fired plant Roxboro NC, which belongs to PEC, as an example. Build a cost and benefit model to evaluate the energy sale revenue, Levelized Cost (LC) and Net Present Value (NPV) of the plant’s life time in three scenarios.

- Address the impact of uncertainties about electricity prices and energy sales
  - The real price of electricity will change in different ways in various regions.
  - The programs about energy efficiency and power saving conducted by each company will reduce the projected energy sale amount to different levels.

**METHODOLOGY**

The methodology of this master project has three parts. First, a case-study of the coal-fired plant Roxboro will be conducted. The reason for selection on this experimental site and Roxboro’s basic information will be explained in detail. Second, the three scenarios upon market restructuring will be set up. Then the base Cost Benefit Analysis (CBA) model is designed to estimate the plant’s Levelized Cost (LC), energy sale revenue and Net Present Value (NPV) within a 20-year timeframe (2009 to 2030) which is generally a coal-fired plant’s life time. The Integrated Environmental Control Model (IECM) devised by Carnegie Mellon is utilized in the

---

expenditure analysis section. Third, the basic CBA model is modified for sensitivity analysis of various input values: the electricity price rate of change the energy sales rate of change. Sensitivity is done for each input in each of 3 scenarios.

**Why Roxboro**

Roxboro, owned and operated by Progress Energy-Northern Region, is the 10th-largest coal-fired power plants in U.S. The plant’s name plate capacity is 3,227,000 kilowatts which can support 2.6 million homes electricity consumption. “Unit 1 of the Roxboro Plant set a record on Thursday, March 25 by completing 518 days on line -- a first for Progress Energy’s coal-fired generating fleet.”

As to the economic contribution, the plant creates nearly 350 jobs from Person County and around. Additionally, the annual total tax payment reaches 3.7 million dollars in 2009. For the green environmental performance, PEC has already invested around 800 million dollars in the emission control equipment such as scrubbers for SO2 emissions reduction and SCR systems for NOx control during 1995 to 2009. The two main reasons for this experimental plants selection are illustrated as follow:

1. **Coal- Fired**
   Coal-fired steam power plants have been utilized for electricity generation throughout last century, so coal can be considered as a mature technology. The analysis in terms of new construction expenditure, fuel cost and operation flow are systematic. The cost and benefit streams are clear and stable. Additionally, coal is an essential energy resource for electricity generation in U.S. “In 2009, more than 87 percent of total domestic coal consumption is used for generation by utilities and 45% of the Country's nearly 4 trillion kilowatthours of electricity used coal as its source of

---

Although renewable energy such as wind and solar are gradually utilized and energy efficient technologies have been developed to reduce energy consumption, coal still takes the predominant place of electricity generation resources. Based on EIA's report, the projected share of coal will maintain around 43%, which is predominant among all the energy resource in the next twenty years (Figure 2). Furthermore, comprehensive analysis is necessary for a comparative study of power plants’ cost.

![Figure 2. The projected fuel mix for electricity generation](http://www.eia.gov/cneaf/electricity/chg_stru_update/execsum.html)

2. **Neglect of Transmission Line Expansion**

The Roxboro plant, which belongs to the PEC northern region (Figure 3), is located on the boarder of North Carolina and Virginia. Thus the distance to a PJM interconnection region is not large. “Additionally, Order No. 714 Baseline Electronic PJM Tariffs” from PJM announces the Joint Operating Agreement (JOA) between PJM Interconnection, L.L.C. and Progress Energy Carolinas on February 10, 2010. In this filing, PJM commits the transmission system and service

---


22 U.S. Energy Information Administration, Annual Energy Outlook 2011, Early Release
in the proxy region (Roxboro included) according to the Progress PJM JOA. Thus the main technical problems for transmission and distribution have already been fixed. In other words, new network construction is not necessary for integration to PJM. Integration would save the cost of transmission line expansion. In addition, the differences in other factors such as climate, geography, demography are subtle across the broad region and would not be expected to greatly affect electricity prices.

Figure 3. The Progress Energy Plants Coverage

http://www.progress-energy.com/aboutenergy/coverage/map.asp
**Model Structure**

This master project conducts economic evaluation in three scenarios: 1) Business As Usual (BAU) - maintain PEC operation, the plant participates in the regulated power market and sells to original ultimate customers in NC under the current PEC operating status; 2) Scenario I-integration to PJM- the plant could enter the competitive power market which is operated by PJM. This scenario could refer to the Dominion North Carolina Company which can offer bids and supply customers from other states through the one day/hour ahead market controlled by PJM. However, the market clearing price for NC final consumers is limited by NC State. Thus, the electricity rates are based on Dominion’s pricing mechanism; 3) Scenario II- merge to Duke Energy-the plant could reach both customers from PEC and Duke Energy and is still in a regulated electricity market. However, the business plan and operated strategy are oriented by Duke Energy rather than PEC.

Furthermore, this cost-benefit analysis only focuses on the revenue and expenditures that accrue during the power plant’s operation. The tax payment and further investment activities and accounting adjustment within company scale are neglected in one coal-fired plant study. The project compares the NPV from different scenarios, and all of the revenues and expenditures are in the constant value after considering the inflation.

1. **Cost Stream-IECM Model**

The expenditures for power plant operation consist of the annualized capital cost and two parts of operation and maintenance cost (O&M): fixed O&M cost and variable O&M cost\(^2\). The annualized capital cost refers to the total capital investment expressed on an annualized basis, converted to equal annual expenditures in term of real dollars during the entire life of the plant. For the O&M cost, the fixed O&M costs generally includes monthly recurring costs that do not

---

vary with the power plant output: salaries and wages, administrative expenses, security, rent or lease, regular maintenance, etc. The variable O&M costs generally refers to costs that vary with plant output: mainly fuel supply cost and pollution regulatory cost. In addition, all indicators such as capacity and heat rate for Roxboro plant are collected from eGRID dataset. The eGRID dataset is a comprehensive source with the air emission data and electric generation data for almost all U.S. power plants, which designed by the U.S. Environmental Protection Agency (EPA)\textsuperscript{25}.

In this paper, the Integrated Environmental Control Model (IECM) is adopted to calculate the plant’s levelized operation cost in constant 2009 dollars. IECM is a computer-modeling program that performs a systematic cost and performance analysis of emission control equipment at fossil-fueled power plants. The uniqueness of the IECM is that it allows sensitivity input and is able to characterize cost and performance parameters for key design criteria. Based on the annual capacity, heat rate and pollution control device setting, the levelized cost depends on the capacity factor \( f \). The capacity factor is assumed to increase in proportion to the generation, which is also linked to the expected energy sale amount. The detailed parameters and calculation methods will be explained in the next section. Furthermore, the variable O&M cost and annualized capital cost in the IECM model is linear in capacity factor as default. In other words, the fixed O&M cost is decided by the plant’s nameplate capacity and the projected variable O&M and annualized capital in the next twenty years only vary with the capacity factor \( f \) when the nameplate capacity is fixed. To sum up, the Total Levelized Annual Cost (TLC\((f)\)) is the sum of Fixed O&M \((C)\), Variable O&M \((V(f))\) and Annualized Capital \((A(f))\):

\[
TLC(f) = C + V(f) + A(f)
\]

The coefficients derived from the IECM model contribute to the function as follows:

\[
TLC(f) = 68.53 + (4.46f + 0.2) + (4f + 349.87)
\]

\textsuperscript{25} \url{http://cfpub.epa.gov/egridweb/}
The defaults and input factors for IECM model are listed in Table 2.

Table 2. Parameters of Roxboro plant for IECM model-Year 2009

<table>
<thead>
<tr>
<th>Plant</th>
<th>Roxboro(^{26})</th>
<th>Plant</th>
<th>Roxboro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution-Control Equipment</td>
<td>NOx: Hot-side SCR</td>
<td># of Boiler</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>SO2: Wet FGD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>2500 MW</td>
<td>Capacity Factor</td>
<td>65(^{\text{c}})%</td>
</tr>
<tr>
<td>Annual Generation</td>
<td>14,799 MWh</td>
<td>Boiler Efficiency</td>
<td>65%</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>9819 Btu/kWh</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Revenue Stream

The revenue in this model is energy sales income. Based on the project’s assumption, the total electricity sale amount equals the plant’s net generation minus the transmission and distribution losses (T&D Losses) and the reserve capacity. Transmission and distribution losses are based on the transmission distance, transmission load, distribution facilities’ operation and each company estimates of its own T&D Losses factors. As to the reserve capacity, FERC requires electricity supplier to generate a constant amount more than the consumption to insure the power market’s reliability in case of parts of the system breakdown or sudden increases in energy demand. The normal reserve margin around the U.S. is 10%-20% of the capacity (Figure 4).

\(^{26}\) All plant information is derived from eGrid dataset.

\(^{27}\) The capacity factor is for the initial year 2009 and will increase in next 20 years.
Additionally, to accurately calculate the revenue, which equals the price times the quantity of sales, all final customers of electricity are categorized into four types: residential, commercial, industrial and wholesale. Based on the economic and geographical background, each region has different market shares for these four types of customers. This paper uses the companies’ recent 8 years final energy sales amount from their annual reports to compute the average customer share (Table 3 and Figure 5). For the electricity rates, both Duke Energy and PEC publish the annually constant prices according to the NCUC regulation. However the PJM competitive power market is a mixture of one-day ahead and one-hour ahead short term spot market, bilateral contract and 3-year reliable price model market. In the case of Duke Ohio/Kentucky integration, the accurate prices still need to be determined by the Public Utilities Commission of Ohio (PUCO) and the competitive pricing mechanism in the PJM region cannot take effect effective with this
integrated region in the short term. In this case, the electricity rates from Dominion North Carolina Company are adopted in the PJM scenario.

Table 3. The Energy Sales Share and Final Prices in 3 Scenarios

<table>
<thead>
<tr>
<th>Sector</th>
<th>BAU</th>
<th>SCENARIO I</th>
<th>SCENARIO II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>$/MWh</td>
<td>%</td>
</tr>
<tr>
<td>Residential</td>
<td>0.30</td>
<td>101.53</td>
<td>0.35</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.25</td>
<td>84.05</td>
<td>0.31</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.20</td>
<td>51.74</td>
<td>0.26</td>
</tr>
<tr>
<td>Wholesale</td>
<td>0.26</td>
<td>25.44</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Figure 5. The Energy Sales Share of 3 Types of Final Customers

The current sales proportions showed in Figure 5 in PEC region are generally equivalent. Comparatively, the wholesale share in the PJM region is much less than the retail share. In the Duke Energy Scenairo, the residentail and commercial customers take the most sales shares, and the wholesale and industrial consumption are much less.

---

Thus, the revenue model is

\[ Revenue = \sum_{i=1}^{4} G(f)(1 - f_1)(1 - f_2)R_iP_i \]

Where

- \( f_1 \): T&D Loss Factor.
- \( f_2 \): Reserve Margin.
- \( R_i \& P_i \): different types of customers’ energy sale share and final prices.
- \( G \): Generation Capacity. Net generation amounts are decided by the energy sales. Thus the generation will increase in the same rate with the sales amount, which is indicated by the capacity factor \( f \).

The annual energy sale revenue is the total income of all 4 types of final customers.

3. Base Cost-Benefit Analysis (CBA) Model

The annual profits equal energy sale revenue minus the total levelized costs of plant operation. Thus the NPV of Roxboro should aggregate all the revenues within next 20 years. The model is:

\[ \text{Total Net Present Value (NPV)} = \sum_{t=1}^{20} \sum_{i=1}^{4} G(f_t)(1 - f_1)(1 - f_2)R_iP_i - TLC(f_t) \]

In this model, generation capacity \( G \), energy sale price \( P_i \), and total levelized cost \( TLC \) will gradually increase in the future. Other parameters such as reserve marge, T&D loss factor and market shares for various customers are considered as stable in the paper’s hypothesis.

Sensitivity Analysis
During the 20-year plant life cycle, two parameters in this Cost-Benefit Analysis model need to be specified: energy sales rate of change and real price rate of change.

First, the generation amount and the capacity factor will increase in proportion to the sales growth, which is assumed to be decided by the projected demand. In the Integrated Resource Plan (IRP)\textsuperscript{31}, all three companies forecast separate demand rate of change in the next twenty years with and without Energy Efficiency (EE) and Demand Side Management (DSM) programs. All are positive so that sales are expected to rise over the next 20 years.

Energy efficiency: the programs aiming at energy consumption savings by specific end-use devices and systems, with same power supply function but not scarifying the customers benefit. “These programs reduce overall electricity consumption (reported in MWh), often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technologically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity.”\textsuperscript{32} The common energy efficiency programs cover high-efficiency appliances such as Compact Fluorescent Light (CFL), ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

Demand-side management (DSM) is defined as “The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand.”\textsuperscript{33} Not only the power market operator and supplier but also the consumer can participate in the program, taking activities to shift their energy consumption from on-peak period to off-peak ones. Demand-Side Management covers the

\textsuperscript{31} Integrated Resource Plan is the annual report that the companies should commit to NCUC for regulation.
\textsuperscript{32} DUKE ENERGY-Glossary
\textsuperscript{33} EIA-Glossary: \url{http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/g1.html}
complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.

Generally, energy consumption is expected to decline after effective EE & DSM programs. Thus the projected increasing rates for energy sales without these programs are higher in the companies’ IRP (shown in Table 4).

Second, although the nominal average retail prices in the US show a gradually increasing trend during last 20 years, the real rates (without the effect from inflation) decrease as a result of technological innovations, efficient operation, lower-cost construction and competitive power markets\textsuperscript{34}. All of the real rates of US average, NC and VA, the similar are decreasing gradually. Furthermore, the retail prices from two states: NC and VA are consistently bellow the US average level (Figure 6). The average real price increasing rates are calculated from the last 16-years (1990-2006) of data.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{average-retail-price.png}
\caption{Average Retail Price Comparisons}
\end{figure}

\textsuperscript{34} EIA: Electricity Retail Price Fact Sheet
Considering the uncertain input factors, the final economic model is:

\[
\text{Total Net Present Value (NPV)} = \sum_{t=1}^{20} \sum_{i=1}^{4} G(f(\beta)t)(1 - f1)(1 - f2)RiP(\alpha)t - TLC(f(\beta)t)
\]

Where

\( \beta \): sales rate of change

\( \alpha \): real price rate of change

As mentioned before, the net benefits equal the energy sale income minus the total levelized cost for plant’s operation. However, the two factors, sales rate of change and prices rate of change, are uncertain in different situations. The change rate of energy sales will influence the capacity factor, total levelized costs and net generation capacity. This study will examine all these possibilities in the sensitivity analysis.

The parameters and values of the cost-benefit analysis model with sensitivity analysis are listed in Table 4:

**Table 4. Parameters in the CBA model- sensitivity analysis included**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BAU EE&amp;DSM</th>
<th>PJM-SCENARIO I EE&amp;DSM</th>
<th>Duke-SCENARIO II EE&amp;DSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Increasing Rate</td>
<td>After 1.4%</td>
<td>Before 1.7%</td>
<td>After 1.43%</td>
</tr>
<tr>
<td>Real Price (2008 dollar) Increasing Rate</td>
<td>-1.16%</td>
<td>U.S. -0.27%</td>
<td>VA -1.4%</td>
</tr>
<tr>
<td>Power Loss Factor</td>
<td>2.15%</td>
<td>2.34%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Reserve Margin</td>
<td>13%</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>----------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>

The EE & DSM programs are feasible and have already been conducted among NC and PJM area, thus the parameters with EE & DSM are considered as benchmarks in each scenario.

**RESULTS**

This master project implements the CBA model and gets the following results.

*Cost-Benefit Analysis-Business as Usual*

![Cost-Benefit of BAU and Net Benefit-BAU](image)

*Figure 7. Cost-Benefit Comparison and Net Benefit for Roxboro-BAU*

The left part of Figure 7 shows the trend lines of annual cost and revenue of Roxboro plant’s operation during the next 20 years. Although all the companies conduct the energy saving programs such as EE & DSM, the electricity consumptions are still expected to be increased in
next twenty years to meet the growing population and economic development. In addition, the declining prices might influence the revenue, but the energy sales income still grows gradually mainly because of more final electricity consumption. On the other hand, the totally levelized costs for the plant’s operation increase in proportion to the capacity factor, which is also decided by the expected energy sale amounts. Thus the total levelized operation costs increase in a higher rate than the income, but always stays below the income in the next twenty years. Thus, the net benefit line on the right part indicates the plant is expected to make profit in the next 20 years’ operation but with a down-sloping trend (from $140 million to around $80 million, nearly a 40 percent decline). According to the spreadsheet calculation, the total NPV of Roxboro in the next twenty years will reach 2601.6 million dollars in the basic scenario, which operated by PEC.

Net Benefit Comparisons under 3 Scenarios

After the economic analysis of PEC operation status, this paper moves to estimate the cost and revenue stream under all three scenarios and compare the profit with EE and DSM programs. Figure 8 and Table 5 show the results of Net Benefits.
The annual net benefits decrease under all these 3 scenarios, but all maintain the profitable status. Furthermore, the competitive market (scenario I) brings highest benefits for the Roxboro, meanwhile the profit from merging to Duke Energy are expected to be the least. The annual profit from initial year (2009), which is the maximum record in Scenario II-$61.54 million, is still smaller than the least one in the last year 2030 from the other two conditions (BAU: $87.52 million; Scenario I: $ 146.19 million).

**Sensitivity Analysis-Price and Sales Rates of Change**

First, for the situations BAU and Scenario II, the only ambiguous factor is expected energy sales rate of change. When engaging in the NC regulated power market, PEC and Duke Energy set their prices according to the standards of North Carolina Utility Commission (NCUC). In this paper, the rates of these two companies are assumed to follow the same projected price rate of change, which is the real retail price changing rate in NC average level. Thus the single-factor sensitivity analysis has been conducted under these two situations and gets the following results:
The Figure 9 and Figure 10 exhibit the projected trend lines of net benefit from 2009 to 2030 in these two scenarios. The basic condition (a) considers the EE & DSM programs and the comparative one (b) without the effect of these programs. Both types of profit decrease annually. Although the differences based on EE & DSM between the expected sales is not large between
two companies (1.4-1.7% for PEC, 1.6-1.8% for Duke) increasing rates, the gaps between the net benefit are obvious at the last year. According to the reduced sale amount resulted from EE & DSM, the plant can only make around 50 percent and 75 percent of higher profits when there are no available EE & DSM programs. Actually, these two trend lines set the bounds of real profits because it is impossible that all the EE & DSM programs are feasible.

In the PJM scenario, the sensitivity analysis is a mixture of two uncertain factors: price rate of change and energy sales rate of change. The results are shown in figure 11. First three conditions (a, b, c) are in a lower energy sale amount because the EE & DSM adoption, and test the expected price increasing levels from U.S. average, NC and Virginia (VA) separately. The increasing rate of Virginia prices is considered in this model in PJM integration scenario. If the company decides to participate in the deregulated market operated by PJM, the electricity rates may not follow the NC levels. PJM runs business among 13 states without a fixed and uniform energy sale price for
all the serving regions. Another main serving region for Dominion Power Company is Virginia (VA) whose conditions about climate and energy resource are similar to NC. Thus the real rate level from VA region, which is the possible price trend after the company integration, is used in the sensitivity analysis. As expected, the higher expected sales increasing rate (without EE & DSM programs) combined with higher real price increasing rate (US level) result in the largest net benefit. Furthermore, net benefits from the project demand without mitigation from EE & DSM programs will increase in the next 20 years, and vice versa.

Finally, the total Net Present Values from all conditions are aggregated and shown in Figure 12 and Table 6.

Figure 12. Comparisons of Total Net Present Value from all Status (2009-2030)
### Table 6. Total NPV for all 3 status-sensitivity analysis included (2009-2030)

<table>
<thead>
<tr>
<th>Status</th>
<th>Total NPV (M$)</th>
<th>Status</th>
<th>Total NPV (M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAU-a</td>
<td>2601.60</td>
<td>Scenario II-a</td>
<td>3826.56</td>
</tr>
<tr>
<td>BAU-b</td>
<td>2968.50</td>
<td>Scenario II-b</td>
<td>5897.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scenario II-c</td>
<td>3356.75</td>
</tr>
<tr>
<td>Scenario II-a</td>
<td>930.44</td>
<td>Scenario II-d</td>
<td>6667.87</td>
</tr>
<tr>
<td>Scenario II-b</td>
<td>1139.12</td>
<td>Scenario II-e</td>
<td>3954.77</td>
</tr>
</tbody>
</table>

The net present values (NPV) from 2009 to 2030 of three scenarios are exhibited in the figure. All the NPV are positive, which supports the economic feasibility of these projects. The total NPVs from PJM integration are obviously higher than other ones. Additionally, the Roxboro power plant will achieve least profit if PEC merging to Duke Energy probably resulted from the low electricity rates from Duke.

### DISCUSSION

First, this master project aims to estimate the economic effect of North Carolina power market restructuring from the perspective of a supplier. The competitive market is expected to reduce the energy price but serve more final customers in the broader energy market. Under the PJM integration scenario, the highest levels of projected profits and NPV among all three statuses match the expectation. However, the projected energy sales rate of change from this scenario is not advantageous (even lower than the Duke Energy’s expected rates.) Furthermore, the electricity prices are in the middle level among these three conditions. The major reason for Roxboro plant profiting most under this competitive power market is that more electricity can be sold to the retail market (residential, commercial and industrial customers) at a relatively higher
price and leave less capacity for the wholesale market with a lower rate. Because the Roxboro plant capacity is not unlimited, the proportion analysis is adopted in this model. When the CBA expanded into the whole PEC level, the total sale amount should be utilized.

Indeed, the transmission network expansion and administrative expenditure are neglected for the single plant’s economic evaluation. However, this part of expenditure and operation are necessary to be evaluated in restructuring economic analysis. These costs for a company are key points to make strategic decisions about market type selection. Furthermore, for the profit part, the customer share, energy resource and electricity rates in the competitive case could not be guaranteed. Thus the return is at higher risk after participating in the free energy market. The risk assessment and competitor analysis should be conducted for a comprehensive cost-benefit analysis for Progress Energy Company.

Second, the results under scenario II indicates that merging to Duke Energy as a whole will bring the least net benefit for this coal-fired plant. However, the fact is Progress Energy still decided to merge to Duke Energy in 2011. Based on the analysis above, the lower energy rates mainly contribute to these lower profit levels. Duke Energy also commits a higher reserve amount (17%) to secure enough power resources. Although less electricity could be sold with this high reserve margin, both the government and final customers will prefer a reliable supplier. Meanwhile, it is possible that this largest utility may raise their electricity rates and make more contracts with NC government to cover the merger costs. Thus the benefits might not stay at that low level.

In addition, this cost-benefit study only considers the basic operation cash flow without the financial accounting factors. Actually, Duke Energy commits a payment of $12.2 billion in Progress Energy net debt. “The transaction price represents a 7.1 percent premium to the unaffected closing stock price of Progress Energy on Jan. 5, 2011, and a 3.9 percent premium to
the closing stock price of Progress Energy on Jan. 7, 2011.’’ The shareholders of both Duke Energy and Progress Energy will derive more benefit from this combination. Generally, the business plan is based on operation performance; however other investment and financial activities also play important roles for decision-making. For a stable and reliable power market, North Carolina government has abandoned the deregulation proposal for the power market for more than 10 years. But it approves a merger of the two most powerful utilities to serve NC customers through a regulated power market.

Finally, this master project simplifies the model which focuses on the case study of the Roxboro coal-fired plant. Roxboro is considered to be a price taker, which means the integration to PJM or Duke will not influence the electricity rates. In reality, the investor owned utility’s combination with enormous generation capacity will have impacts both on the competitive or regulated market prices. The whole company’s CBA analysis will be more complex than the single plant. In addition, the market share for different types of customers, T&D loss factor, and reserve capacity are assumed to be constant in the next two decades, while in reality these factors will be adjusted. As to the energy sale increasing rate, the paper utilizes an average expected one, nevertheless, a dynamic rate should be adopted to reach a more accurate research. For the energy rates, the pricing mechanism is complicated and variety in different companies. The feasible rate-forecasting method is still under debate, thus the historical data are utilized in this model to calculate the average increasing rates in different regions. Furthermore, these real price trends may reflect the structural change such as population growth, economic development and are meaningless for the next decades. However, in this paper, the economic evaluation for IOUs in the power market deregulation, the real price trends are acceptable for the model.

This master project only estimates the economic performance of a coal-fired power plant. However, other types of power plants such as traditional plants with natural gas and solar power,
wind power, hydropower plants with renewable energy also serve among both types of markets. Additionally, the allowance cost for SO$_2$, NOx and other emissions are under discussion to mitigate climate issues. To meet the standard environmental performance, the expenditure of the power company should be adjusted. The cost-benefit analysis considering all the factors mentioned above is necessary to get a comprehensive study of the influence from power market restructuring in the perspective of the energy supplier.
REFERENCES


http://www.eia.gov/cneaf/electricity/page/fact_sheets/retailprice.html

http://www.eia.doe.gov/cneaf/electricity/page/fact_sheets/supply&demand.html

http://www.eia.doe.gov.


APPENDIX

Appendix I: Main Suppliers’ Coverage in North Carolina

Appendix II: PJM Coverage in North Carolina
Appendix III: Nominal and Real Electricity rates for US average, NC and VA 1996-2006 (in 2008 dollar)

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Retail Prices (cents/KWh): Nominal Prices</th>
<th>Average Retail Prices (2008 cents/KWh): Real Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US</td>
<td>NC</td>
</tr>
<tr>
<td>1990</td>
<td>6.57</td>
<td>6.38</td>
</tr>
<tr>
<td>1992</td>
<td>6.82</td>
<td>6.60</td>
</tr>
<tr>
<td>1993</td>
<td>6.93</td>
<td>6.63</td>
</tr>
<tr>
<td>1994</td>
<td>6.91</td>
<td>6.62</td>
</tr>
<tr>
<td>1995</td>
<td>6.89</td>
<td>6.58</td>
</tr>
<tr>
<td>1996</td>
<td>6.86</td>
<td>6.53</td>
</tr>
<tr>
<td>1998</td>
<td>6.74</td>
<td>6.45</td>
</tr>
<tr>
<td>1999</td>
<td>6.64</td>
<td>6.44</td>
</tr>
<tr>
<td>2000</td>
<td>6.81</td>
<td>6.48</td>
</tr>
<tr>
<td>2001</td>
<td>7.29</td>
<td>6.58</td>
</tr>
<tr>
<td>2002</td>
<td>7.20</td>
<td>6.74</td>
</tr>
<tr>
<td>2003</td>
<td>7.44</td>
<td>6.86</td>
</tr>
<tr>
<td>2004</td>
<td>7.61</td>
<td>6.97</td>
</tr>
<tr>
<td>2005</td>
<td>8.14</td>
<td>7.19</td>
</tr>
<tr>
<td>2006</td>
<td>8.90</td>
<td>7.53</td>
</tr>
</tbody>
</table>
### Appendix IV: Total Net Present Value from all Status (2009-2030) in 2009 constant dollar

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Benefit-BAU</th>
<th>Net Benefit-Scenario I</th>
<th>Net Benefit-Scenario II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BAU-a</td>
<td>BAU-b</td>
<td>I-a</td>
</tr>
<tr>
<td>2009</td>
<td>144.72</td>
<td>144.72</td>
<td>197.31</td>
</tr>
<tr>
<td>2010</td>
<td>142.58</td>
<td>144.24</td>
<td>195.47</td>
</tr>
<tr>
<td>2011</td>
<td>140.39</td>
<td>143.70</td>
<td>193.58</td>
</tr>
<tr>
<td>2012</td>
<td>138.14</td>
<td>143.09</td>
<td>191.63</td>
</tr>
<tr>
<td>2013</td>
<td>135.83</td>
<td>142.42</td>
<td>189.63</td>
</tr>
<tr>
<td>2014</td>
<td>133.48</td>
<td>141.69</td>
<td>187.57</td>
</tr>
<tr>
<td>2015</td>
<td>131.06</td>
<td>140.89</td>
<td>185.45</td>
</tr>
<tr>
<td>2016</td>
<td>128.59</td>
<td>140.02</td>
<td>183.27</td>
</tr>
<tr>
<td>2017</td>
<td>126.06</td>
<td>139.09</td>
<td>181.04</td>
</tr>
<tr>
<td>2018</td>
<td>123.47</td>
<td>138.08</td>
<td>178.75</td>
</tr>
<tr>
<td>2019</td>
<td>120.83</td>
<td>137.00</td>
<td>176.39</td>
</tr>
<tr>
<td>2020</td>
<td>118.12</td>
<td>135.85</td>
<td>173.97</td>
</tr>
<tr>
<td>2021</td>
<td>115.35</td>
<td>134.62</td>
<td>171.49</td>
</tr>
<tr>
<td>2022</td>
<td>112.52</td>
<td>133.31</td>
<td>168.95</td>
</tr>
<tr>
<td>2023</td>
<td>109.63</td>
<td>131.93</td>
<td>166.34</td>
</tr>
<tr>
<td>2024</td>
<td>106.67</td>
<td>130.47</td>
<td>163.67</td>
</tr>
<tr>
<td>2025</td>
<td>103.64</td>
<td>128.92</td>
<td>160.93</td>
</tr>
<tr>
<td>2026</td>
<td>100.55</td>
<td>127.29</td>
<td>158.12</td>
</tr>
<tr>
<td>2027</td>
<td>97.40</td>
<td>125.58</td>
<td>155.24</td>
</tr>
<tr>
<td>2028</td>
<td>94.17</td>
<td>123.78</td>
<td>152.29</td>
</tr>
<tr>
<td>2029</td>
<td>90.88</td>
<td>121.89</td>
<td>149.28</td>
</tr>
<tr>
<td>2030</td>
<td>87.52</td>
<td>119.91</td>
<td>146.19</td>
</tr>
<tr>
<td><strong>Total NPV</strong></td>
<td><strong>2,601.6</strong></td>
<td><strong>2,968.5</strong></td>
<td><strong>3,826.7</strong></td>
</tr>
</tbody>
</table>