Economic Analysis of Duke Energy's Proposed Save-A-Watt Energy Efficiency Financing Mechanism

By:

John Russell Milligan

Dr. Brian C. Murray, Advisor

4/25/2008

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

2008

Abstract

As North Carolina regulators begins to recognize the untapped economic, social, and environmental benefits of meeting increased electricity demand through energy efficiency, it has become clear that traditional electricity rate-making creates a disincentive to invest in energy efficiency. To encourage the use of energy efficiency, the North Carolina Utilities Commission (NCUC) is investigating Duke Energy's proposed energy efficiency financing mechanism called Save-a-Watt (SaW). Through SaW, Duke Energy can subsidize energy efficiency measures for individual ratepayers. These energy efficiency measures reduce the amount of electricity sold to the individual ratepayers. To recover subsidy costs and opportunity costs from reduced electricity sales, Duke Energy spreads 90% of the cost that it would have taken for the utility to generate the saved electricity to all ratepayers.

This paper provides an analysis of the quantitative effect of Duke Energy's proposed Save-a-Watt (SaW) mechanism. Although Duke Energy has proposed SaW in many states, this analysis will focus on Duke Energy's North Carolina service territory. To evaluate SaW, a cost benefit analysis of SaW was generated from a financial model of Duke Energy's operations. The financial model of Duke Energy was built from information gathered from reports, financial and accounting statements, and North Carolina Public Utilities documents. For the cost benefit analysis, two cases were simulated over a 25 year period: the base case includes the construction of two 800 Megawatt coal power plants and the SaW case includes one 800 Megawatt coal power plant and the rest of electricity demand is met with energy efficiency investments.

The outcomes from the cost benefit analysis indicate that ratepayers, utilities, and society would realize a positive net present value by implementing the SaW case rather than the base case. In addition, minimal impacts to electricity rates were observed. Due to the confidential nature of information related to the cost of electricity production, some assumptions were made in order to complete the analysis. Future research by individuals with access to Duke Energy's confidential information should be done to verify the findings in this report.

Table of Contents:

Introduction

North Carolina's growing economy brought in 200,000 more people between July 1, 2006 and July 1, 2007. In addition, the U.S. Census predicts by 2015, one million more people will be living in North Carolina.[1] As the population of North Carolina increases, the state government must consider how it will meet electricity demand. Historically, the North Carolina Utility Commission (NCUC) has instructed utilities to build nuclear, pulverized coal and natural gas power plants to provide electricity to the state's residences and businesses. Concerns of high cost, environmental impact, social equity, and reliability of new power plants has shifted the commission to explore new ways of providing electricity to the residents of North Carolina. Many environmental, social, and utility policy advocacy groups have argued that North Carolina has vast untapped energy efficiency opportunities and renewable resources which could cost-effectively meet electricity demand while minimizing environmental impact.[2] In order to validate these claims the North Carolina Government commissioned two reports to determine the economic potential of energy efficiency and renewable energy. From the finding of these reports, Governor Easley was able to sign a Renewable and Efficiency Portfolio Standard (REPS) which requires 7.5 percent of 2018 electricity demand be met from renewable energy and 5 percent from energy efficiency. [3]

---

[1] Young, Wesley. "N.C. population passes 9 million mark, U.S. says." 27 December 2007. Winston-Salem Journal. 2 Febuary 2008 <http://www.journalnow.com/>.
[2] Environmental Defense, The Power to Choose: North Carolina's Clean-Energy Future. 2007.
[3] WSOCTV. "Governor Easley Signs Ground-Breaking Legislation To Promote Renewable Energy ." 20 August 2007. WSOCTV - Eyewitness News. 4 Feburary 2008 <http://www.wsoctv.com/station/13986442/detail.html>.

But is North Carolina doing enough to meet future electricity demand? GDS Associates predict that 14 percent of 2017 demand can be cost-effectively met with energy efficiency.[4]

So the REPS leaves about 9 percent of the economic energy efficiency potential unused in 2017. To optimize the use of energy efficiency resources the North Carolina State Government could produce policies, which directly address the market failures that cause an under-investment in energy efficiency: negative externality of electricity production, positive externality of innovation, and inadequate information. But once these market failures are addressed, three barriers still exist for ratepayers: access to capital to make energy efficiency investments, electricity rates do not reflect the marginal costs of producing electricity, and there is a split incentive between renters and tenants.[5] Then, on the utility side, barriers for investing in energy efficiency are reduced sales, lag time in recovering program cost, and less financially attractive cost recovery mechanism for energy efficiency. Yet, some believe utilities are the best avenue to distribute energy efficiency since they already are connected to consumers and they can integrate supply side (power plants, transmission lines, and distribution lines) and demand side investments (energy efficiency).[6] Others believe energy efficiency is best left for the ratepayer to choose and that the ratepayer can find the efficient level of energy efficiency.[7]

In order for the NCUC to increase energy efficiency investment, it must address the barriers for the utilities and the ratepayers to pursue energy efficiency. The utilities barriers can

---

[4] GDS Associates, inc. (2006). A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. Marietta, Georgia.

[5] EPA, National Action Plan for Energy Efficiency. July 2006.

[6] Blumstein, Carl; Goldman, Charles; and Barbose, Galen. ‘Who Should Administer Energy-Efficiency Programs?’ University of California Energy Institute. Berkely, California August 2003.

[7] ibid

be removed by the NCUC establishing a rate structure which makes energy efficiency a sound financial investment. If the utility's incentives are strong enough, the utility can subsidize energy efficiency projects in order to bypass ratepayer's barriers. To determine what policy would work best, many energy efficiency organizations are looking to states like California and Vermont for best practice in energy efficiency policy. California decoupled sales from revenue, continues to fund energy efficiency financial subsidies, and has set energy efficiency standards (Appendix C Figure 2). Vermont on the other hand, has created an energy efficiency utility in charge of serving ratepayers with energy efficiency. Although these policies have been a success, it is unclear if either of these approaches would work in North Carolina due to differences in the political and economic environment. For example, Vermont has a small electricity market compared to California and North Carolina so it is easier for one company to service a whole state. Although, North Carolina's electric utilities have not yet decoupled sales from revenue, decoupling of sales for natural gas utilities has been used for North Carolina and it might be possible to use this method for electric utilities.

Currently, in North Carolina, energy efficiency program expenses are often recovered through a rate case. In other words, the utility asks the NCUC for permission to spend capital on energy efficiency for the following year. Then the NCUC determines how much the utility can charge ratepayers the following year. The NCUC then grants the utility permission and allows the utility to recover its expenses plus a rate of return the following year.

Save-a-Watt

As an alternative to the current method of financing energy efficiency, Duke Energy has proposed the SaW energy efficiency financing mechanism. SaW would allow Duke Energy to charge residential ratepayers an electricity rider of $0.001129/kWh and non-residential ratepayers $0.000940/kWh in order to finance energy efficiency projects (in the rest of the report, residential and non-residential ratepayers will be known as ratepayer groups)[8]. Throughout the year, Duke Energy will subsidize energy efficiency improvements in order to reduce electricity consumption (kilowatt/hours) and electricity capacity (kilowatts). Therefore, Duke Energy has defined energy efficiency as both demand side management (DSM) and energy efficiency.[9] After a year of investing in energy efficiency, a third party review will be done to determine how much electricity Duke Energy has saved. If the review finds Duke Energy has been overcompensated for the results it achieved, then the electricity rider for the next year will be reduced. In addition, if Duke Energy achieves greater results than it has been compensated for, then the electricity rider will increase.

According to Duke Energy's market potential study, the type of energy efficiency measures Duke Energy may implement will include subsidized energy efficient appliances, efficient new construction, on-site energy audits, old refrigerator pick-up and recycling, and residential weatherization.[10]

---

[8] A electricity rider is an additional cost attached to ratepayers electricity bills

[9] Measures which reduce overall all electricity use are called energy efficiency where as projects which do not change the quantity of electricity but shift the time of use are referred to as demand side management.

[10] Forefront Economics Inc. Duke Energy Carolinas DSM Action Plan: North Carolina Report

The purpose of my report is to quantitatively evaluate SaW so that I can provide the staff of the Environmental Defense Fund (EDF) with a greater understanding of how the policy will function in Duke Energy's North Carolina service territory and the economic outcomes of SaW. It is important for the staff to gain a better understanding how SaW will function so that they can better negotiate with Duke Energy, communicate to interested parties, and understand where to position themselves in current and future policy advocacy work. The economic outcomes will be calculated using a model of Duke Energy's North Carolina service territory from data collected from NCUC reports and Duke Energy's financial reports.

Problem Definition

As North Carolina's electricity supply becomes strained, the state's policy makers must determine what options will cost-effectively and with the least environmental impact meet electricity demand. One possible solution to the problem is to improve energy efficiency policy. Historically in North Carolina, almost all of electricity demand was met by building new power plants. In the 2006 Integrated Resource Planning process, the North Carolina's Utility Commission (NCUC) recognized energy efficiency as a more cost effective means to meeting electricity demand than building one of the two new coal power plants at Cliffside.[11] So instead of granting utilities permission to build conventional power plants, the NCUC recognized that demand can be met by improving energy efficiency. Energy efficiency decreases the demand for new power plants in North Carolina by installing electricity saving technology on site, encouraging conservation, and reducing the peak amount during hot summer days. According to

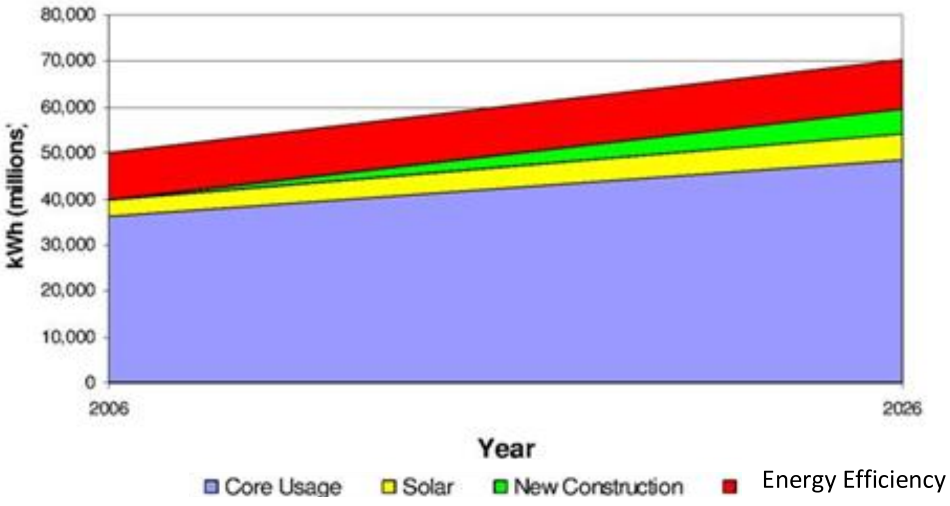
---

[11] Murawski, John. Duke Energy can Build at Cliffside. The News and Observer. January 30, 2008.

the Energy Information Administration, North Carolina's per-household consumption of electricity is among the highest in the United States.[12]

One of the top reasons energy efficiency is discussed is that electricity industry experts argue that most consumers can save money by installing energy efficiency measures.[13] But, as one installs more energy efficiency, there are fewer cheap solutions available (Appendix C, Figure 1). Two reports state that North Carolina can meet at least 15 percent of its 2017 electricity demand with energy efficiency cost-effectively.[14],[15]

Figure 1: Energy Efficiency Demand Potential



Reference: Forefront Economics Inc., H. Gil Peach & Associates LLC, PA Consulting Group. (2007). *Duke Energy Carolinas DSM Action Plan: North Carolina Report.*

---

[12] Energy Information Administration, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NC

[13] Friedman, Thomas. Jim Rogers, Chairman and Chief Executive of Duke Energy: GO GREEN AND SAVE MONEY. New York Times. August 22, 2007.

[14] Forefront Economics Inc. Duke Energy Carolinas DSM Action Plan: North Carolina Report

[15] GDS Associates, inc. (2006). A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. Marietta, Georgia.

Another reason so many groups want to encourage energy efficiency is that it decreases demand for electricity generation and therefore it reduces emissions whenever a kWh is saved. Some energy efficiency measures called DSM tend to switch electricity use from peak to nonpeak time. DSM can have a net electricity saving but the savings are usually smaller than measures which are considered true ‘energy efficiency’. Therefore, DSM does not reduce emissions as much as energy efficiency and in many cases does not reduce emissions at all. Even though DSM tends to just shift electricity use, the shifting of electricity use ends up reducing cost to generate electricity and reducing emissions when air quality is worst. This is because peak time is when the most expensive power plants are running and pollution levels are highest.

The problem definition for this report is how to meet North Carolina electricity demand cost-effectively. One possible solution to the problem is to improve energy efficiency policy. The reason that there is an under-investment in energy efficiency is because of three major market failures, negative externality of electricity production, positive externality of innovation, and inadequate information. In addition to market failures, barriers in the market place exist such as: access to capital to make energy efficiency investments, electricity rates do not reflect the marginal costs of producing electricity, and there is a split incentive for renters and tenants. On the utility side, barriers for investing in energy efficiency are reduced sales, lag time in recovering program cost, and less financially attractive cost recovery mechanisms for energy efficiency. Therefore, a policy which corrects these market failures and barriers is needed to maximize the use of energy efficiency resources. As a potential policy option, Duke Energy has proposed the Save-a-Watt model which charges ratepayers 90% of avoided cost of electricity saved to finance energy efficiency projects. This proposal sparked a discussion of how effective SaW will be. To determine the cost effectiveness of Save-a-Watt, the report looks at benefits and costs of the policy from the perspective of the ratepayer, the utility, and society.

Methods

The method is broken into two parts: equations and conceptual logic and description of benefit-cost analysis measures. Sources for all data and variables are discussed in Appendix A.

Equations and Conceptual logic

Base Case

First, the calculations which I used to model the utility will be described. Since the base case does not have any energy efficiency investments, energy efficiency equations will be discussed in the next subsection titled Save-a-Watt. In order to model the utility I first had forecast future electricity sales. To do this I used current Megawatt hour (MWh_t) sales and average sales increase estimates from Duke Energy's Integrated Resource Plan (IRP).

$$MWh_{t+1}=MWh_t*1.015$$

Next, to determine the estimated annual MWh produced ($MWh_{p,t}$), I multiplied annual MWh sales by the average marginal losses from transmission and distribution.

$$MWh_{d,t}= MWh_t*1.07$$

Before the next step, I needed to forecast the future cost to produce electricity. To do this I took the average of seasonal, peak, and off peak cost for Duke Energy to buy a MWh of electricity through purchased power agreements ($\$/MWh_t$). To calculate this average, I first calculated the load factor (LF), which is the ratio of average electric load to peak load capacity (MW) used throughout the year, with the following equation:

$$LF=MWh_t/(MW*365day*24hours)$$

Next, I calculated the average peak and non-peak prices for summer (p_{sa}) by multiplying the price for summer non-peak electricity (p_{sn}) by the load factor and then I added the product of peak price (p_{sp}) and inverse of the load factor.

$$p_{sa}= P_{sn}*LF+ p_{sp}*(1-LF)$$

I then did the same thing with winter price by multiplying non-peak (P_{wn}) by the load factor and adding winter peak price (p_{wp}) multiplied by the inverse of the load factor.

$$p_{wa}= p_{wn}*LF+ p_{wp}*(1-LF)$$

The average of the two seasons ($\$/MWh_{p,t}$) was then determined by averaging the winter average and summer average. A more accurate average would be based on the MWh sales during each season but this data was not available.

$(\$/MWh_{p,t}) = (p_{wa} + p_{sa})/2$

From the cost of MWh produced I was able to calculate the cost to produce a year's electricity c_{yt}. This was done by multiplying MWh produced by the average cost electricity.

$C_{y,t=0} = \$/MWh_{p,t} * MWh_{t}$

Next, to determine the future cost of producing electricity I used the Department of Energy's fuel cost escalation rate in the following equation:

$C_{y,t} = c_{y,t=0}\ (1+0.032)^{\wedge}t$

In addition to the average cost of electricity, one must know the marginal cost of electricity. The marginal cost of electricity is the price to bring on another unit of electricity during a given point in time. The 2007 marginal price data was taken from VACAR market data. Duke Energy sells electricity on the VACAR electricity market. In order to forecast the price into the future I used the same equation as above but with the VACAR peak (c_{vpt}) and non-peak prices (c_{vnt}).

$c_{vp,t} = c_{vp,t=0}\ (1+0.032)^{\wedge}t$

And

$c_{vn,t} = c_{vn,t=0}\ (1+0.032)^{\wedge}t$

In the next few calculations I will be incorporating the cost of Cliffside coal power plant units 6 and 7 into the rate base. To do this, I collected the cost of allowance for funds used during construction (AFUDC) of unit 6, the capital cost of unit 6, and the capital cost of unit 7. The AFUDC cost of unit 7 was estimated by multiplying the capital cost of unit 7 (c_{unit7}) by the ratio of AFUDC for unit 6 and the capital cost of unit 6 (c_{unit6}).

$$AFUDC_{unit7} = (c_{unit7}) * (AFUDC_{unit6} /(c_{unit6}))$$

The Duke Energy Carolina –North Carolina Territory (DEC-NC) capital expenditure ($NC_{exp,t}$) for the first year is estimated by taking the capital expenditure from Duke Energy's ($DE_{exp,t}$) annual report and multiplying it by the ratio of electricity sales of DEC-NC ($MWh_{p,t=0}$) and Duke Energy (DE_{sales})

$$NC_{exp,t=0} = DE_{exp,t=0} *(MWh_{p-t=0} / DE_{sales})$$

To forecast future DEC-NC capital expenditure I used an escalation estimate from the EPA NAPEE energy efficiency calculator.

$$NC_{exp,t} = NC_{exp,t=0} (1+0.023)^{\wedge}t$$

Next I will calculate the total capital expenditure ($C_{exp,t}$). The $C_{exp,t}$ is made of AFUDC, power plant assets, and other assets. So the total capital expenditure ($C_{exp,t}$) for a year is equal to

$AFUDC_{67}$ for the year it is added, the capital cost of power plant unit 6 and 7 (C_{unit67}), and other capital expenditures ($NC_{exp,t}$). But the power plant's capital costs are not added to the rate base until the units are operational. The two Cliffside Units are scheduled to be complete in 2012 so that is the year that I added them to the rate base.

$$(C_{exp,t}) = (AFUDC_{67}) + (C_{unit67}) + (NC_{exp,t})^{***}$$

***($AFUDC_{67}$) is only added in year 2008 and (C_{unit67}) is only added in 2012 when the plants are complete.

Capital expenditure is then added to the basis for depreciation $b_{dep,t}$

$$b_{dep,t} = b_{dep,t=0} + \sum_{0}^{t} C_{exp,t}$$

Book depreciation ($b_{d,t}$) is then calculated by multiplying ($b_{d,t}$) by 0.05 since book depreciation for Duke Energy is 20 years.

$$(b_{d,t}) = (b_{d,t})*0.05$$

$$(b_{dep,t}) = (AFUDC_{67}) + (C_{unit67}) + (NC_{exp,t})$$

DEC-NC Operation and Maintenance (O&M) cost ($DEC\text{-}NC_{O\&M}$) were estimated from Duke Energy's annual report ($DE_{O\&M}$) just like capital expenditure.

$$DEC\text{-}NC_{O\&M} = DE_{O\&M}*(MWh_{t=0}/ DEC\text{-}NC)$$

To forecast DEC-NC O&M cost I used an escalation estimate from the EPA NAPEE energy efficiency calculator. [16]

$\text{DEC-NC}_{O\&M,t} = \text{DEC-NC}_{O\&M,t=0}\ (1+0.023)\text{^}t$

To calculate the utility's tax rate I first summed up the total capital expenditure ($C_{exp,t}$) from time 0 to t at any point to calculate the basis for depreciation ($b_{d,t}$).

$$b_{d,t} = \sum_{t=0}^{t} c_{exp,t}$$

Next, I calculated the tax depreciation schedule ($d_{d,t}$) by taking the basis of depreciation and multipling it by 5% in order to do straight line depreciation.

$d_{d,t} = b_{d,t} * 0.05$

To calculate the ending tax basis ($e_{b,t}$) I added the beginning tax basis ($b_{e,t}$) to the total capital expenditure ($c_{exp,t}$), and subtracted the tax depreciation schedule ($d_{d,t}$). The beginning tax basis in time 0 is equal to $NC_{exp,t}$

$e_{b,t} = b_{e,t} + c_{exp,t} - d_{d,t}$

---

[16] EPA. Energy Efficiency Benefits Calculator. http://www.epa.gov/cleanenergy/energy-programs/napee/resources/calculator.html

And for the following years, beginning tax basis ($b_{e,t}$) in time t is equal to the ending tax basis in t-1.

$b_{e,t}=e_{b,t-1}$

Since tax and book depreciation years are both equal to 20 years, beginning book value equals beginning tax value, book depreciation equals tax depreciation schedule, and ending book values equal ending tax basis. Because tax depreciation schedule and book depreciation are equal, there are no deferred taxes.

The rate base for time t ($r_{a,t}$) is equal to the basis of depreciation in time t, minus the sum of book depreciation from time 1 to t.

$d_{a,t} = \sum_{t=0}^{t} \mathrm{d}_{\mathrm{d,t}}$

$r_{a,t}= b_{d,t} – d_{a,t}$

In addition to recovering the capital cost of the power plant, a utility receives a return on its capital cost. To calculate this I first calculated the weighted average cost of capital (WACC). To this I used Duke Energy Corporate 2006 summary annual report. To calculate the WACC I multiplied the amount of long term debt (D) from Duke's balance sheet by the yield to maturity (C_d) of a Duke Energy's publically traded bond. Then I added the amount of equity (E) held by Duke Energy by the current return on equity (C_e) from Google stocks (6.66%)

$WACC= D*C_d+E*C_e$

Next I calculated the portion of the rate base which is debt and equity. To do this, I first calculated the percent debt and equity:

$\%D=D/(D+E)$

$\%E=E/(D+E)$

Then, multiplied percent debt by the rate base ($d_{r,t}$) to get debt rate base ($r_{d,t}$) and the percent equity by the rate base to get equity rate base ($r_{e,t}$)

$r_{d,t} =\%D^* r_{a,t}$

$r_{e,t}=\%E^* r_{a,t}$

From there, I calculated the interest on debt ($i_{d,t}$):

$i_{d,t}=c_d{}^*r_{a,t}$

I then calculated the return on equity ($r_{q,t}$):

$r_{q,t}=c_e{}^*r_{a,t}$

Because of the corporate tax shield, all interest on debt is a tax-deductible expense. But taxes still need to be calculated on the return on equity. To do this I take the combined state and federal tax of 39.49% and plug it into the following equation:

$Tax_t=(r_q/(1-0.3949))-r_{q,t}$

Later I will talk about how to calculate actual return on equity (ROE) but in order to put the following calculations into perspective, I must discuss actual ROE. Once actual ROE is calculated, I can determine which years become rate cases. If ROE drops below 2% of the target

ROE (6.66%) then a rate case is triggered which allows regulators to adjust electricity rates so that the utility can achieve above the target ROE. A rate case is also triggered when a new larger capital expense is added to the rate base. So on years 2008 where AFUDC is added and 2012 where power plants are added to the rate base, a rate case will occur.

In order to calculate actual ROE, I must first calculate the annual revenue requirement. The annual revenue requirement is ($a_{r,t}$), the sum of return on equity, book depreciation, interest on debt, total O&M expenditure, and the cost of electricity.

$$a_{r,t}= r_{q,t}+ d_{d,t}+ i_{d}+ \text{DEC-NC}_{O\&M,t}+ c_{e,t}$$

The non-fuel ($a_{n,t}$) and the fuel ($a_{f,t}$) revenue requirement are determined using the following equations:

$$a_{n,t}= r_{q,t}+ d_{d,t}+ i_{d,t}+ \text{DEC-NC}_{O\&M,t}$$

$$a_{f,t} = c_{e,t}$$

Forecasted electricity sales and sales for test year are the same. Also since no energy efficiency is implemented and no other variables such as weather are taken into account, forecasted and actual electricity sales are the same.

If there is no rate case, electricity rates stay the same. For rate case years, electricity rates are corrected so that revenue requirements are met or exceeded. To calculate the non-fuel component of the electricity rate ($\$/kwh_{n,t}$) in a rate case year, I divided the non-fuel component of the revenue requirement by the number of electricity sales (also MWh are converted to kWh).

$$\$/kwh_{n,t} =a_{n,t}/(MWh_{t}*1000)$$

The same is done for fuel component of electricity rates ($\$/kwh_{f,t}$):

$$\$/kwh_{f,t} = a_{f,t}/(MWh_t * 1000)$$

I then added the non-fuel and fuel components of the electricity rate to get the complete rate ($\$/kwh_{c,t}$).

$$\$/kwh_{c,t} = \$/kwh_{n,t} + \$/kwh_{f,t}$$

Finally I am discussing how I calculated the actual ROE. To do this I had to calculate actual revenue ($r_{r,t}$) by multiplying the complete electricity rates by actual sales ($MWh_{a,t}$). In this case, actual electricity sales equal forecasted electricity sales.

$$r_{r,t} = \$/kwh_{c,t} * (MWh_{a,t} * 1000)$$

Next I added book depreciation, interest on debt, O&M, and actual cost of electricity sales ($c_{a,t}$) to get operating expense $o_{e,t}$. In this case, actual cost electricity sales equal forecasted cost of electricity sales.

$$o_{e,t} = d_{d,t} + i_{d,t} + DEC\text{-}NC_{O\&M,t} + c_{a,t}$$

By taking the difference of actual revenue and operating expense, I calculated the pre-tax earnings ($e_{p,t}$).

$$e_{p,t} = r_{r,t} - o_{e,t}$$

Actual taxes are calculated by multiplying pre-tax earnings and 39.45%

$$tax_{a,t} = e_{p,t} * 39.45\%$$

Earnings are then calculated by subtracting tax from pre-tax earnings

$e_{e,t}= e_{p,t}- tax_{a,t}$

Actual ROE is then calculated by dividing earnings by equity rate base (r_e).

$ROE_a=e_{e,t}/r_e$

Save –a-Watt Case

In the Save a Watt case, only coal power plant unit 6 at Cliffside is built and the remaining demand is met with energy efficiency. The energy efficiency projects will be financed by subsidizing reconditioning of buildings, appliances, new construction, efficient air conditions, energy audits etc. To finance the energy efficiency projects, Duke Energy will bill North Carolina Ratepayers in its territory 90% of the avoid cost of the electricity saved ($e_{s,t}$) by the energy efficiency measures. The avoided cost ($\$/MWh_{p,t}$) is the cost to get the electricity to the ratepayer (which, on average is less than retail cost). The total avoided cost (ac,t) of the programs will be spread over participating and non-participating ratepayers with an electric bill rider. The rider for the first year will be $0.001129/kWh for residential customers and $0.000940/kWh for non-residential. Every year after that, the total value of the electricity bill rider (re,t) will be trued-up[17] based on the electricity saved in the previous year. For simplicity in this model I assume that all forecasted energy efficiency gains were achieved. So the total value of the electricity rider is automatically set to be based on the following equation:

$r_{e,t}=90\%*\$/MWh_{p,t}* e_{s,t}$

---

[17] A true-up is a process where the regulator (NCUC) compares how much the utility charges its ratepayers to the results the utility achieved. If the result were too low for how much the utility charged ratepayer, the charge is decreased in the next year. When the results were too high, the opposite is true.

Ideally, both capacity and energy revenue requirements would be incorporated into the above equation but I was unable to find these numbers due to their confidential nature. Also Duke Energy's model of capacity and energy revenue requirements is continuous rather than an average (See Appendix B for equations).

The annual cost of the energy efficiency project ($P_{e,t}$) was taken directly from Duke Energy's energy efficiency market potential study.[18] All the recommend measures from this report are added up to produce a summary table (See Appendix C, Figure 12). Since the market potential study only predicts 5 years worth of programming, the data from year 5 perpetuated 6 years afterward. This produces an 11 year long program so that the energy efficiency programs peak at year 2017 and taper off until 2025. According to the GDS North Carolina energy efficiency study, there is enough energy efficiency for year 5's programming to be continued for 6 more years. According to the study, there would at least be another additional 7% of demand that can be met cost-effectively with energy efficiency.[19] From the recommended programs the model also incorporates the program cost to the utility, the participants' share of energy efficiency measure cost, kwh saved, kw saved and the average life time measures.

From the market potential study, I obtained the annual electricity savings for projects that are new each year. In other words, without changing the data, the kwh saved are based on a 1 year lifetime for all measures. After producing an average lifetime of all projects, I created a

---

[18] Forefront Economics Inc. Duke Energy Carolinas DSM Action Plan: North Carolina Report

[19] GDS Associates, inc. (2006). A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. Marietta, Georgia.

matrix which allows each measure to produce savings for 15 years, starting from when it is first implemented. From this table I produced the total annual electricity savings ($e_{s,t}$) for each year.

To calculate the actual electricity sales ($MWh_{e,t}$) in the energy efficiency case (SaW case), total annual energy efficiency saving is subtracted from actual sales.

$$MWh_{e,t} = MWh_{a,t} - e_{s,t}$$

The same calculation can be done with capacity numbers. So energy efficiency capacity savings ($e_{c,t}$) is subtracted by its actual capacity ($MW_{a,t}$) to produce the capacity for the energy efficiency case.

$$MW_{e,t} = MW_{a,t} - e_{c,t}$$

From the capacity for the energy efficiency case, I took the difference between the current and previous years. Then I compared the difference without energy efficiency. With these two differences I was able to produce a percent growth related to capital expenditure savings.

$$MW_{ad,t}=MW_{at}-MW_{at+1}$$

$$MW_{ed,t}=MW_{at}-MW_{at+1}$$

$$MW_{ratio,t}=1-(MW_{ed,}t/MW_{ad,t})$$

After calculating the ratio of capital expenditure savings, I can multiply the inverse of this ratio with growth related capital expenditure ($Cap_{g,t}$) and add non-growth related capital expenditures ($Cap_{n,t}$) to determine the capacity with reduction accounted for.

$$Cap_{n,t} + (1-MW_{ratio,t}) * Cap_{g,t}$$

For the first two years the rider will be $0.001129/kWh for residential customers and $0.000940/kWh for non-residential. After year 2, there is enough data to determine the progress Duke Energy has made. From this assessment the utility commission will adjust the rider to better reflect Duke Energy's performance. So, to determine the electricity rider rate ($r_{er,t}$) for 3 to 25, I divided the avoided cost of the total annual energy efficiency savings each year by the actual number of sales.

$$r_{er,t} = r_{e,t} / MWh_{a,t}$$

For the SaW case, I replaced the cost of Cliffside unit 6 and 7 and the AFUDC of unit 6 and 7 with just the numbers relevant to unit 7.

All other equations are the same as the base case.

Description of Benefit-Cost Analysis Measures

The cost to the ratepayers is the NPV of electricity bills and participant energy efficiency cost (See Table 1). Participant energy efficiency costs are the cost of making an energy efficient improvement through SaW minus the subsidy from the utility. Impact on non-participating ratepayers will be measured by the change in electricity rates. All net present values will be compared to the base case to determine the impact of the policy. The base case will be forecasted using the same information as the above scenarios but it will not include any energy efficiency cost or benefits.

The benefits to the utilities in its NPV are revenue. Utility revenue is generated from rates charged to customers for providing electricity. Rates are made up of three components: non-fuel, fuel and the energy efficiency rider. The costs to the utility are debt principle, debt interest, operations and maintenance, energy cost, tax, and utility energy efficiency program costs.

For the NPV of society, the benefits are revenue to the utility. The costs to society are the debt principle, debt interest, operations and maintenance, energy cost, tax, customer bills, and utility and ratepayer energy efficiency cost (See Table 1 below). The costs do not include emission permits, and environmental and health damage caused by electricity generation or energy efficiency technology.

Table 1:

	Ratepayers	**Utility**	**Society**
Costs	Customer Bills	Debt Principle	Debt Principle
	Participant EE Cost	Interest	Interest
		O&M	O&M
		Utility EE Program Cost	Utility EE Program Cost
		Energy Cost	Participant EE Program Cost
		Tax	Energy Cost
			Tax
			Customer Bills
Benefits		Revenue	Revenue

Results

Benefit Cost Analysis:

After completing the model, the following metrics were calculated: NPV of ratepayer, the utility, and society. In addition, utility Return on Equity (ROE) in each case, and percent change in customer bills, electricity rates, utility earnings, and revenue requirement (See Table 3).

Table 2:

	NPV (Million $)
Ratepayers	484.405
Utility	476.839
Society	961.244
Assumptions:	
Discount rate	8%
# Years	25

The NPV to consumers over the 25 year modeled period was $484 million with a discount rate of 8%. As a result of SaW, there was a 1% average decrease in electricity bills and an average increase of electricity rates of 1% (See Table 3).

The Utility realized a NPV of $476.8 million over a 25 year period and a discount rate of 8%. The average ROE for the base case was 3.30%, which is far from the target 6.66% set based on current ROE. The average ROE for the SaW case was 6.36%, which is much closer to the target 6.66%. There was a 54.32% increase in utility earnings and 2.47% increase in revenue requirements due when comparing SaW to base case (See Table 3).

The NPV to society was $ 961.244 million. Also by reducing electricity, CO2 emissions are reduced a total of 21,177,974 metric tons. This is the equivalent of taking 163,107 cars off the road for the entire 25 year period.[20]

Table 3:

Variable	Mean	Standard Deviation	Minimum	Maximum
Percent change in customer bills with SaW	-0.81%	3.30%	-8.69%	5.55%
Percent change in rate with SaW	0.117%	0.308%	-0.580%	0.683%
ROE base case	4.00%	5.75%	-16.71%	13.30%
ROE with SaW	6.36%	4.73%	-4.61%	15.49%
Percent change of earnings with SaW	54.32%	123.55%	-217.07%	450.88%
Percent change in utility revenue requirement	2.47%	2.47%	-1.70%	5.62%

Conclusion

Concluding comments on analysis

The results suggest that if Save-a-Watt is implemented instead of the base case, ratepayers are likely to realize a positive net present value of $ 484 million. The utility will realize a NPV of $476.8 million, and society will achieve a NPV of $961.244 million. Since electricity rates will increase by an average of 0.117% in the SaW case compared to the base case and since the maximum difference is 0.683%, little impact to non-participant should be experienced. These results also show decrease in customer bills of 0.81% in the SaW case compared to the base case. From the NPV to ratepayers, percent change in electricity rates, and

---

[20] Calculations assume average North Carolina electricity generation mix and the average car emitting 5.19 Ton of CO2.

percent change in customer bills, this model predicts that ratepayers will realize a positive value from SaW.

In the base case, the utility realized an average 4.00% ROE which is too far below the target 6.66%. This is likely due to the imperfect nature of the model. The inclusion of a couple more rate cases would likely produce a ROE closer to the target. Yet, the base case already had 10 rate cases while the SaW case had only 7. The SaW case produced an average 6.36% ROE which is still below the target ROE but reasonably close. Ideally, NCUC should be able to regulate the utility so that both the base case and SaW case would produce ROEs which are greater than or equal to 6.66%. Therefore the base case underestimates the revenue the utility would collect, the utility's earnings, and the utility's ROE. Since the base case's revenue is underestimated, the utilities NPV of the SaW case when compared to the base case is too high. The utility's model assumes that the NPV of SaW case over the base case should be close to zero. In addition, ratepayer's NPV is likely too low since a higher ROE for the base case means that customers' bills will be higher.

Since society has a positive NPV, this shows that energy efficiency under the SaW mechanism was able to reduce the cost of providing electricity services to society in comparison to the base case. Since revenue and customer's bills are just money changing hands, these two variables cancel each other out when calculating society's net savings. As stated above, this model may underestimate base case revenue but since revenue and customer's bills cancel each other out, this underestimation would not affect the NPV to society. But, the NPV for society is likely lower bound since it does not include the cost of emission permits and environmental and health damage caused by electricity generation or energy efficiency technology.

After graphing the outcome data, there is a clear trend that ratepayers, the utility and society benefit most when SaW is at peak implementation (See Figure 4,7,8). When SaW is first started, there are upfront costs but very little energy savings. Later, when energy efficiency measures have expired, benefits decrease since energy savings decreases and therefore customer savings decrease. Utility earnings also decrease as energy saving decreases because the utility makes a greater return on energy efficiency than on generating electricity in this model. This report did not determine the threshold where the utility would rather generate electricity than implement energy efficiency under SaW.

Another observation from the graphs was that the occurrence of rate cases plays a big role in the utility's financial performance and customer bills. For this reason, the NCUC should pay special attention to rate cases when implement SaW or any other energy efficiency program. In the model, rate cases occurred more frequent than expected. In the base case, a rate case occurred 10 out of 25 years, whereas in the SaW case, a rate case occurred 7 out of 25 years. Further research would be needed but from the model, it looks like power plants perform more financially erratic than energy efficiency under SaW. Also, the frequency of the rate cases could have been caused by the underlying assumptions in the model.

Areas to Improve SaW

The purpose of the SaW proposal is to offer a new way of financing energy efficiency which is better than the current practice of directly reimbursing utilities. First, I will discuss how qualitatively SaW compares to the current method of financing energy efficiency. Then, I will comment on potential quantitative areas of improvement based on my analysis.

Currently, the utility can recover all prudent costs rather than basing financial recover on results achieved with direct reimbursement. This type of energy efficiency financing often encourages inefficient spending of resources. On the other hand, direct recovery of costs allows greater control over the how strong a financial incentive the utility receives. This method can only produce single-issue ratemaking which limits the utility's ability to achieve energy efficiency goals.[21]

SaW is an effort to resolve the issue of inefficient use of resources, lack of innovation, and no guaranteed results. In addition, SaW aims to create a method of financing which is self-sustaining so that successful programs never run out of money. These changes will help maximize the amount of energy efficiency implemented.

One disadvantage of SaW is the same amount of revenue is given to low and high cost measures. So, if changing ten light bulbs saves the same amount of electricity as a new solar panel, the utility collects the same amount of money for both. Due to this, the utility will receive a high return for its investment on the light bulbs and a very small return on the solar panel. This could create an opportunity for the utility to only target very high return and thus, the utility would be over compensated for investing in energy efficiency. In addition, Duke Energy will likely pursue low cost measures first and these low cost measures will eventually run out (See Appendix B Figure 2). Therefore, the longer the program is run, the lower the return may be.

---

[21] EPA, National Action Plan for Energy Efficiency. July 2006.

California created a performance based mechanism which encourages the utility to maximize result by allows it to achieve a higher return on project after meeting set project goals (See Appendix B Figure 3). If the utility does not achieve, many improvements, the utility receives a negative or small return. If the utility performs well, it receives a greater return than normal.

Another disadvantage is that avoided electricity sales are hard to measure and verify. There are many variables which effect energy use and it would also be hard to pick out what avoided electricity sales Duke Energy could take credit for. Pilot test research and random auditing would add credibility to estimated avoided electricity sales.

Since ratepayers pay for the avoided electricity sales throughout the life of the energy efficiency measure, the recovery mechanism creates an opportunity for escalating costs as the program matures. A similar financing mechanism for SaW was used in Minnesota but the program was shut down because of escalating costs.[22]

Lastly, SaW allows the utility to pursue all profitable energy efficiency measures under the 90% avoid cost cap but conventional generation costs consumers 100% of electricity rates. Therefore, depending upon the cost of consumer participation, there may still be unrealized cost effective measures from the consumer perspective. In addition, SaW covers both the cost of the energy efficiency program and the lost revenue from reducing electricity sales. By forcing energy efficiency funding to recover lost revenue, there is an underinvestment in energy efficiency. Since electricity sales are increasing in North Carolina, lost revenue from decreased

---

[22] Nicholas, David. Regulatory Incentives for Demand-Side Management, Review for West Kootenay Power’s DSM Incentive Committee. Tellus Institute, Boston. December 21, 1999.

electricity sales is mainly from electricity distribution cost. But by under-investing in energy efficiency, more future capital investments in power plants, distribution and transmission lines will be needed to meet growing demand.

From my analysis, SaW should reduce the initial energy efficiency rider, which overcharges ratepayers in the first two years. After the first SaW true up, the energy efficiency rider will be dramatically reduced. Alternatively, Duke Energy could pursue much more aggressive energy efficiency implementation targets with the initial money.

Limits of study

As mentioned before, due to the confidential nature of information related to the cost of electricity production, some assumptions were made in order to complete the analysis. All assumptions and data sources are described in Appendix A.

Further study areas

Future research by individuals with access to Duke Energy's confidential information should be done to verify the findings in this report. Research should be done to determine the magnitude of the rebound effect with energy efficiency in North Carolina.[23]

---

[23] The rebound effect is when efficiency gains in a technology cause an increase in use of that technology. For example, a more fuel efficient car may be driven more than a fuel intensive one.

References:

Blumstein, Carl; Goldman, Charles; and Barbose, Galen. ‘Who Should Administer Energy-Efficiency Programs?’ University of California Energy Institute. Berkely, California August 2003.
Environmental Defense, *The Power to Choose: North Carolina’s Clean-Energy Future*. 2007.

Energy Information Administration. *State Energy Profiles,* (http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NC).

EPA, *National Action Plan for Energy Efficiency*. July 2006.

EPA. *Energy Efficiency Benefits Calculator*, (http://www.epa.gov/cleanenergy/energy-programs/napee/resources/calculator.html).

Forefront Economics Inc. Duke Energy Carolinas DSM Action Plan: North Carolina Report

Friedman, Thomas. “Jim Rogers, Chairman and Chief Executive of Duke Energy: GO GREEN AND SAVE MONEY”. New York Times. August 22, 2007.

GDS Associates, inc. (2006). *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina*. Marietta, Georgia.

Murawski, John. “Duke Energy can Build at Cliffside.” The News and Observer. January 30, 2008.

Nicholas, David. Regulatory Incentives for Demand-Side Management, Review for West Kootenay Power’s DSM Incentive Committee. Tellus Institute, Boston. December 21, 1999.

WSOCTV. "Governor Easley Signs Ground-Breaking Legislation To Promote Renewable Energy ." 20 August 2007. WSOCTV - Eyewitness News. 4 Feburary 2008.

Young, Wesley. "N.C. population passes 9 million mark, U.S. says." 27 December 2007. Winston-Salem Journal. 2 Febuary 2008 http://www.journalnow.com/.

Appendix A

Table 1

Variable	Abbreviation
Megawatt hour sales	MWh_t
annual MWh produced	$MWh_{p,t}$
price of purchased power agreements	$\$/MWh_t$
load factor	LF
average summer price	p_{sa}
summer nonpeak electricity	p_{sn}
summer peak price	p_{sp}
winter nonpeak price	pwn
winter peak price	p_{wp}
average electrcity price	$\$/MWh_{p,t}$
future cost of producing electricity	$c_{y,t}$
VACAR peak price	$c_{vp,t}$
VACAR nonpeak price	$c_{vn,t}$
capital cost of unit 7	c_{unit7}
capital cost of unit 6	c_{unit6}
AFUDC cost of unit 7	$AFUDC_{unit7}$
AFUDC cost of unit 6	$AFUDC_{unit6}$
(DEC-NC) capital expenditure	$NC_{exp,t}$
Duke Energy capital expenditure	$DE_{exp,t}$
Duke Energy electricity sales	DE_{sales}
Future DEC-NC capital expenditure	$NC_{exp,t}$
total capital expenditure	$c_{exp,t}$

capital cost of power plant unit 6 and 7	c_{unit67}
total capital expenditure	$c_{exp,t}$
basis for depreciation	$b_{dep,t}$
Book depreciation	$b_{d,t}$
DEC-NC Operation and Maintenance cost	$NC_{O\&M,t}$
Duke Energy’s annual report	$DE_{O\&M,t}$
tax depreciation schedule	$d_{d,t}$
ending tax basis	$e_{b,t}$
beginning tax basis	$b_{e,t}$
tax depreciation schedule	$d_{d,t}$
rate base	$r_{a,t}$
sum of basis of depreciation	$d_{a,t}$
weighted average cost of capital	WACC
rate base which is debt	%D
rate base which is equity	%E
debt rate base	$r_{d,t}$
equity rate base	$r_{e,t}$
interest on debt	$i_{d,t}$
return on equity	$r_{q,t}$
tax	Tax_t
annual revenue requirement	$a_{r,t}$
non fuel revenue requirement	$a_{n,t}$
fuel revenue requirement	$a_{f,t}$
non-fuel component of the electricity rate	$\$/kwh_{n,t}$
fuel component of electricity rates	$\$/kwh_{f,t}$
complete electricity rate	$\$/kwh_{c,t}$
actual revenue	$r_{r,t}$
actual sales	MWh_t

actual cost of electricity sales	$c_{a,t}$
operating expense	$o_{e,t}$
pre-tax earnings	$e_{p,t}$
Actual taxes	$tax_{a,t}$
Actual Earnings	$e_{e,t}$
Actual ROE	$ROE_{a,t}$
electricity bill rider	$r_{r,t}$
annual cost of the energy efficiency project	$p_{e,t}$
annual electricity savings	$e_{s,t}$
actual electricity sales	$MWh_{e,t}$
energy efficiency capacity savings	$e_{c,t}$
actual capacity	$MW_{a,t}$
energy efficiency case	$MW_{e,t}$
growth rate energy efficiency case	$MW_{ed,t}$
growth rate non energy efficiency case	$MW_{ad,t}$
percentage of growth related to capex saved	$MW_{ratio,t}$
growth related capital expenditure	$Cap_{g,t}$
non growth related Capital expenditures	$Cap_{n,t}$
capacity minus energy efficiency savings	$Cap_{ae,t}$
electricity rider rate	$r_{er,t}$

Table 2

Data sources

Data	Source
Electricity Sales	Duke Energy Carolinas Spring 2007 Forecast. North Carolina Utilities Commission. November 17, 2007.
Peak Load	Duke Energy Carolinas DSM Action Plan: North Carolina Report. Forefront Economics Inc. August 31, 2007.
*****Forecast Sales Growth**	A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. GDS Associates Inc., December 2006.
Average Rate ($/kWh)	F861 Data file, Energy Information Agency. 2006.
Annual Sales (MWh)	F861 Data file, Energy Information Agency. 2006.
Base Year Revenue	F861 Data file, Energy Information Agency. 2006.
Average Production Cost ($/MWh)[24]	Schedule PP-N (NC) Non-Hydroelectric Qualifying Facilities Purchased Power. Duke Energy Carolina, LLC. NCUC. 2008.
******Average marginal losses (for energy savings)**	FIND SOURCE
******Escalation of Production Cost**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
******Cost Escalation of Average Energy and Capacity Cost**	Fuller, Sieglinde K. and Rushing, Amy S. Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis. US Department of Commerce. April 2002.
*******Marginal Cost Escalation**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
Peak ($/MWh)[25]	MegaWatt Daily, Platts. January 17, 2008
Off - Peak ($/MWh)[26]	MegaWatt Daily, Platts. January 17, 2008

---

[24] Using purchase power agreements as a estimate of average production cost is reasonable but the actual production cost are need to create a realistic model. Also Duke Energy has cost information which varies by day and time and the model in this report assumes one average production cost over an entire year.

[25] , [9] Peak and non peak marginal prices were taken from VACAR data in MegaWatt. VACAR is an open electricity market which Duke Energy sells it electricity.

Average Asset Book Depreciation	Internal Revenue Bulletin. IRS, 2003 http://www.irs.gov/irb/2003-30_IRB/ar08.html
******Tax depreciation**	Internal Revenue Bulletin. IRS, 2003 http://www.irs.gov/irb/2003-30_IRB/ar08.html
***Total Year 0 CapEx ($M)**	2006 Summary Annual Report, Duke Energy. 2006
******Capex Cost Escalation**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
******Percent Capex Growth Related**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
****O&M % of Year 0 Revenue**	Duke Energy Carolina, LLC 10-Q. U.S. Securities and Exchange Commission. 2007.
***Annual Expense - Year 0 ($M)**	2006 Summary Annual Report, Duke Energy. 2006
******O&M Escalation Rate**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
Long Term Debt	2006 Summary Annual Report, Duke Energy. 2006
Equity	2006 Summary Annual Report, Duke Energy. 2006
Debt Cost	Duke Energy Carolinas, LLC First and Refunding Mortgage Bonds, U.S. Securities and Exchange Commission, 2008
Target Return on Equity	2006 Summary Annual Report, Duke Energy. 2006
Federal Tax Rate	Fact Sheets: Taxes. US treasury. ttp://www.ustreas.gov/education/fact-sheets/taxes/ustax.shtml
State Tax Rate	North Carolina State and Local Taxes. North Carolina Department of Revenue. 2006. http://www.dor.state.nc.us/publications/stateandlocal.pdf
***Rate Base Assets $MM**	2006 Summary Annual Report, Duke Energy. 2006
Energy Efficiency Program cost, kwh, kw, life time of measures , and number of participants	Duke Energy Carolinas DSM Action Plan: North Carolina Report. Forefront Economics Inc. August 31, 2007.
AFUDC and Coal Power Plant Cost estimates	February 2008 Advanced Clean Coal Cliffside Unit 6 Cost Estimate No. E-7, Sub 790. North Carolina Utilities Commission.
******Band on earning (+/- ROE) for Earnings Band Rate Cycle**	Energy Efficiency Benefits Calculator, National Action Plan for Energy Efficiency, EPA, 2007
Energy Efficiency Rider For year 1 and 2	Docket No. E-7, Sub 831. North Carolina Utilities Commission

*****North Carolina MWh Generated from Coal and Natural Gas**	F861 Data file, Energy Information Agency. 2006.
*****Average CO2 Emission for Coal and Natural Gas**	How does electricity affect the environment?, EPA. http://www.epa.gov/solar/emissions.html
Average CO2 Emission For Cars	Emission Facts: Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks. EPA. 2000. http://www.epa.gov/otaq/consumer/f00013.htm

***Transformed Duke Energy Corporate data to fit Duke Energy Carolina's North Carolina service territory.**

****Transformed Duke Energy Carolina data to just focus on North Carolina service territory.**

*****North Carolina level data transformed to Duke Energy Carolina's service territory data**

******Estimate based on national utilities**

Appendix B

Equation and Data Source Table

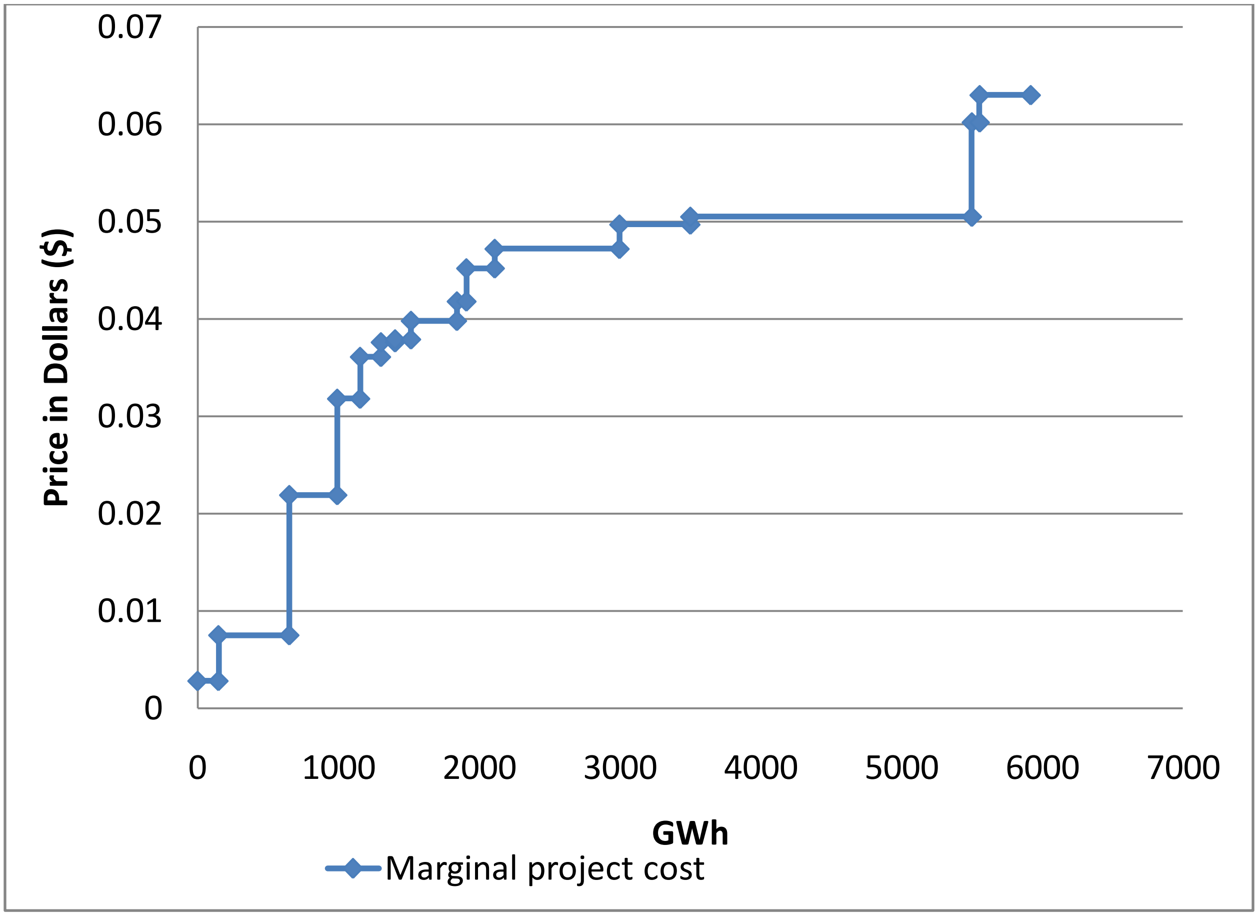
Measure	Formula
Megawatt hour sales	$MWh_{t+1}=MWh_t*1.015$
annual MWh produced	$MWh_{d,t}= MWh_t*1.07$
load factor	$LF=MWh_t/(MW*365day*24hours)$
summer average electricity prices	$p_{sa}= p_{sn}*LF+ p_{sp}*(1-LF)$
winter average electricity price	$p_{wa}= p_{wn}*LF+ p_{wp}*(1-LF)$
average electricity price	$(\$/MWh_{p,t})= (p_{wa}+ p_{sa})/2$
cost to produce a year's electricity	$C_{y,t=0} =\$/MWh_{p,t}*MWh_t$
future cost of producing electricity	$c_{y,t}= c_{y,t=0}$ (1+0.032)^t
VACAR peak	$c_{vp,t}= c_{vp,t=0}$ (1+0.032)^t
VACAR non-peak	$c_{vn,t}= c_{vn,t=0}$ (1+0.032)^t
AFUDC cost of unit 7	$AFUDC_{unit7}= (c_{unit7}) *(AFUDC_{unit6} /(c_{unit6}))$
capital expenditure	$NC_{exp,t=0}= DE_{exp,t=0}*(MWh_{p-t=0}/ DE_{sales})$
future capital expenditure	$NC_{exp,t} = NC_{exp,t=0}$ (1+0.023)^t
Total capital expenditure	$(c_{exp,t})= (AFUDC_{67})+ (c_{unit67})+ (NC_{exp,t})$
basis for depreciation	$b_{dep,t} = b_{dep,t=0} + \sum_{0}^{t} C_{exp,t}$
Book depreciation	$(b_{d,t})= (b_{dep,t})*0.05$
DEC-NC Operation and Maintenance	$NC_{O\&M}= DE_{O\&M}*(MWh_{t=0}/ NC_{exp,t=0})$
Future NC O&M	$NC_{O\&M,t} = NC_{O\&M,t=0}$ (1+0.023)^t
tax depreciation schedule	$d_{d,t} = b_{dep,t} *0.05$
ending tax basis	$e_{b,t}= b_{e,t} + c_{exp,t} - d_{d,t}$

beginning tax basis	$b_{e,t}=e_{b,t-1}$
	$d_{a,t} = \sum_{t=0}^{t} d_{d,t}$
sum of basis of depreciation time t	
rate base	$r_{a,t}= b_{d,t} – d_{a,t}$
Weighted Average cost of capital	$WACC= D*C_d+E*C_e$
% rate base is debt	$\%D=D/(D+E)$
% rate base is equity	$\%E=E/(D+E)$
debt rate base	$r_d =\%D* r_{a,t}$
equity rate base	$r_e=\%E* r_{a,t}$
return on equity	$r_q=c_e*r_{a,t}$
Tax	$Tax_t=(r_q/(1-0.3949))-r_q$
annual revenue requirement	$a_{r,t}= r_q+ d_{d,t}+ i_d+ NC_{O\&M,t}+ c_{e,t}$
non-fuel revenue requirement	$a_{n,t}= r_q+ d_{d,t}+ i_d+ DEC\text{-}NC_{O\&M,t}$
fuel revenue requirement	$a_{f,t} = c_{e,t}$
non-fuel electricity rate	$\$/kwh_{n,t} =a_{n,t}/(MWh_t*1000)$
fuel electricity rates	$\$/kwh_{f,t} =a_{f,t}/(MWh_t*1000)$
complete rate	$\$/kwh_{c,t}=\$/kwh_{n,t} +\$/kwh_{f,t}$
calculate actual revenue	$r_{r,t} =\$/kwh_{c,t}* (MWh_{a,t}*1000)$
operating expense	$o_{e,t}= d_{d,t}+ i_d+ DEC\text{-}NC_{O\&M,t}+ c_{a,t}$
pre-tax earnings	$e_{p,t} = r_{r,t}- o_{e,t}$
Actual taxes	$tax_{a,t}=e_{p,t}*39.45\%$
Earnings	$e_{e,t}= e_{p,t}- tax_{a,t}$
Actual ROE	$ROE_a=e_{e,t}/r_e$
electricity bill rider	$r_{e,t}=90\%*\$/MWh_{p,t}* e_{s,t}$
actual electricity sales	$MWh_{e,t} = MWh_{a,t} -e_{s,t}$
actual capacity	$MW_{e,t} = MW_{a,t} –e_{c,t}$
Non-energy efficiency case capacity	$MW_{ad,t}=MW_{at}-MW_{at+1}$
energy efficiency case capacity	$MW_{ed,t}=MW_{at}-MW_{at+1}$
percentage of growth related to capex	$MW_{ratio,t}=1-(MW_{ed,}t/MW_{ad,t})$

saved	
capacity with energy efficiency reduction	$Cap_{ae,t} = Cap_n + (1 - MW_{ratio,t}) * Cap_{g,t}$
electricity rider rate	$r_{er,t} = r_{e,t} / MWh_{a,t}$

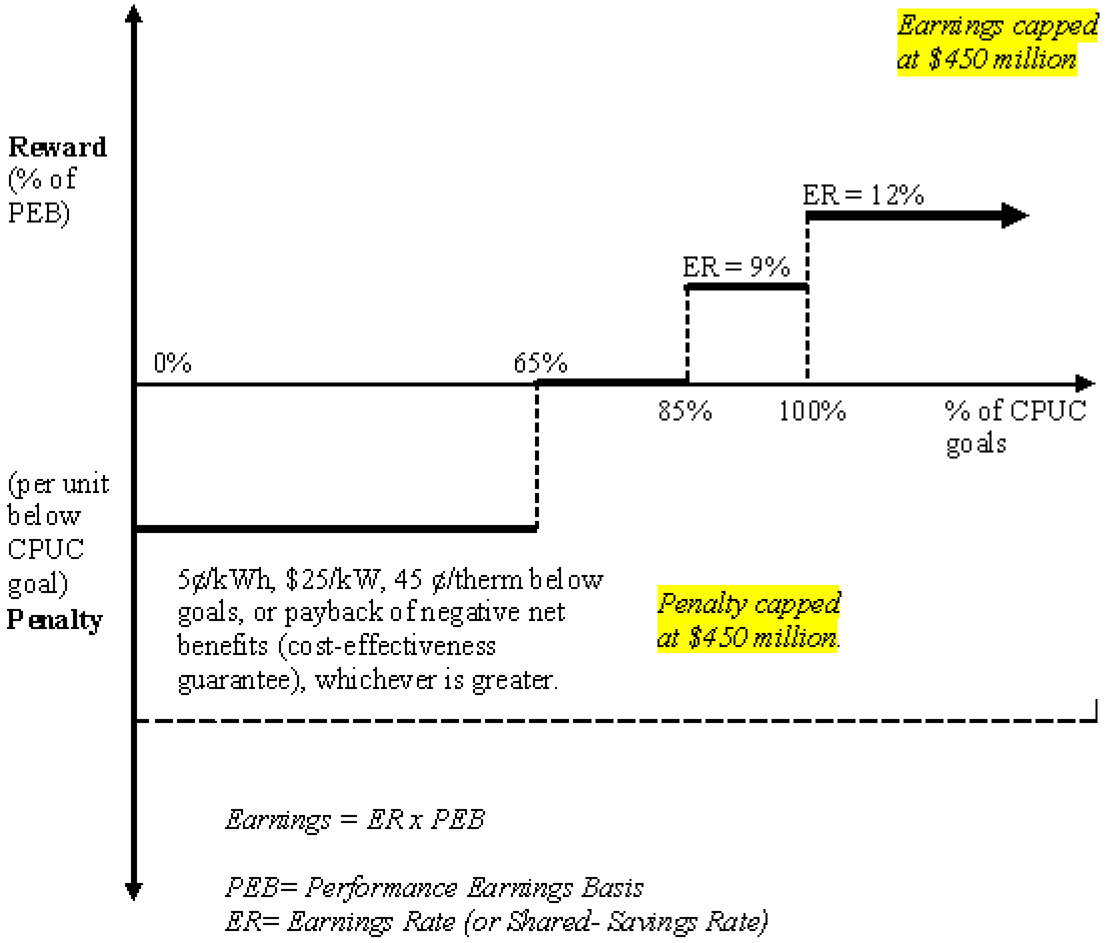
Appendix C

Figure 1: Energy Efficiency Project Supply Curve with Estimated Marginal Loss Curve



Reference: Forefront Economics Inc., H. Gil Peach & Associates LLC, PA Consulting Group. (2007). *Duke Energy Carolinas DSM Action Plan: North Carolina Report.*

Figure 2: California Energy Efficiency Preformance Incentive



Source: California Public Utilities Commission [CPUC] (2007). Proposed Decision of Commissioner Grueneich and Administrative Law Judge Gottstein (Mailed 8/9/2007), Before the Public Utilities Commission of the State of California, Order Instituting Rulemaking to Examine the Commission's Post-2005 Energy Efficiency Policies, Programs, Evaluation, Measurement and Verification, and Related Issues. Rulemaking 06-04-010 (Filed April 13, 2006), Interim Opinion on Phase 1 Issues: Shareholder Risk/Reward Incentive Mechanism for Energy Efficiency Programs.

Figure 3: Percent Change in Consumer Bills

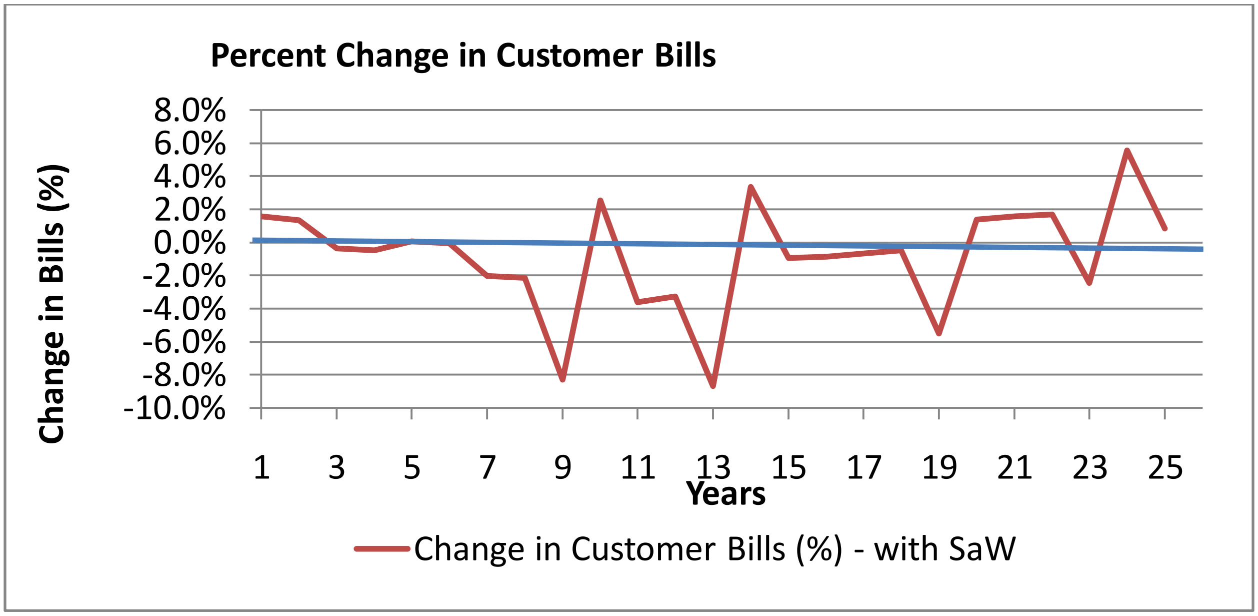


Figure 4: Comparison of Average Rate

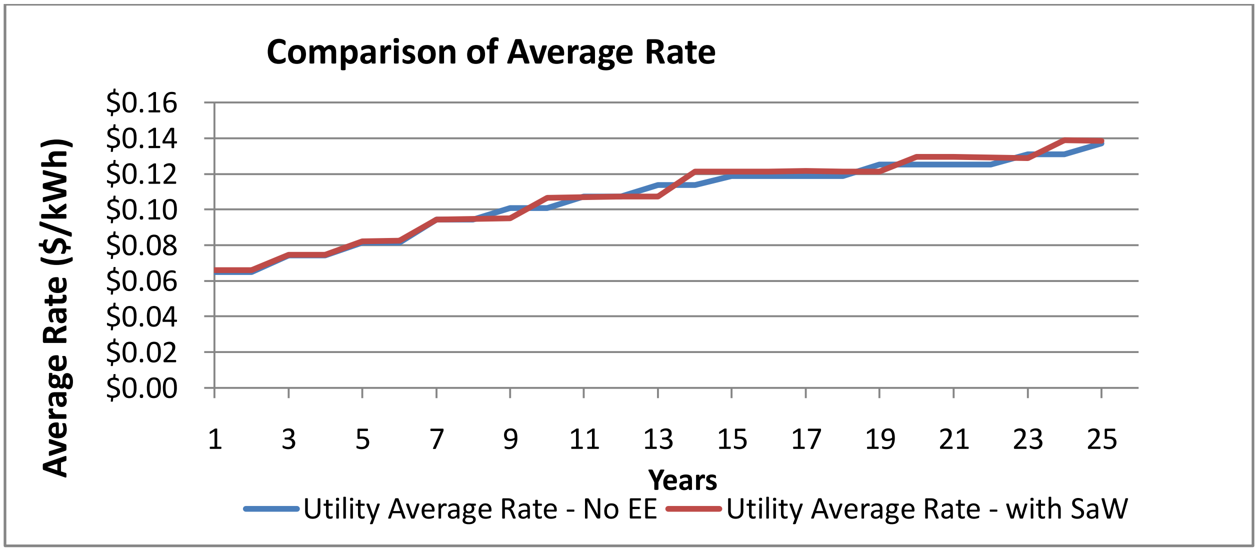


Figure 5: Comparison of Return on Equity

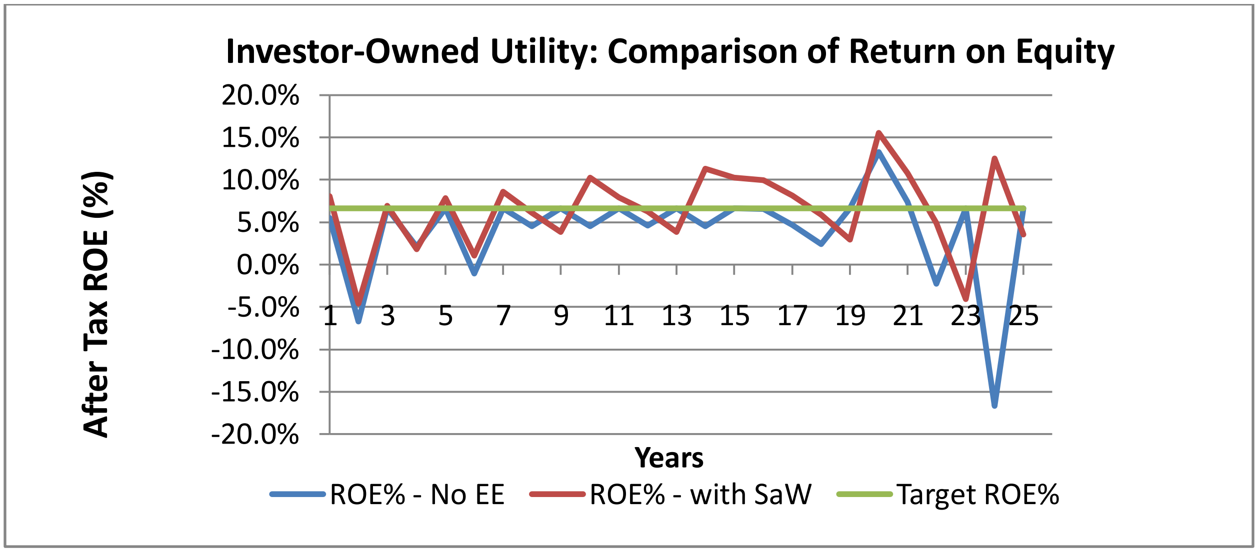


Figure 6: Utility Earnings

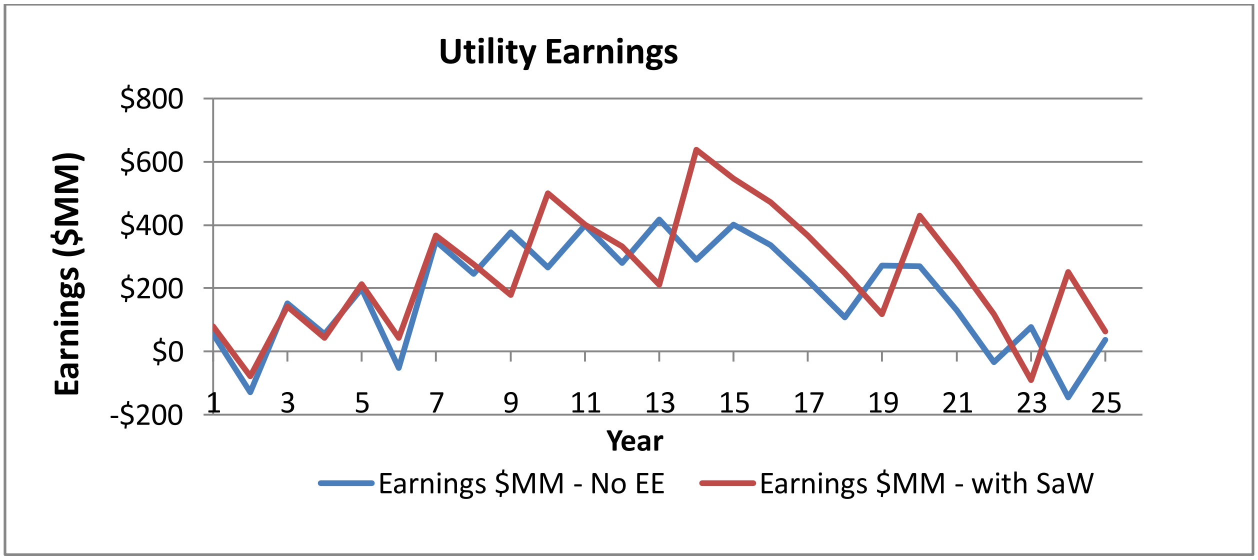


Figure 7: Annual Total Society Net Benefits

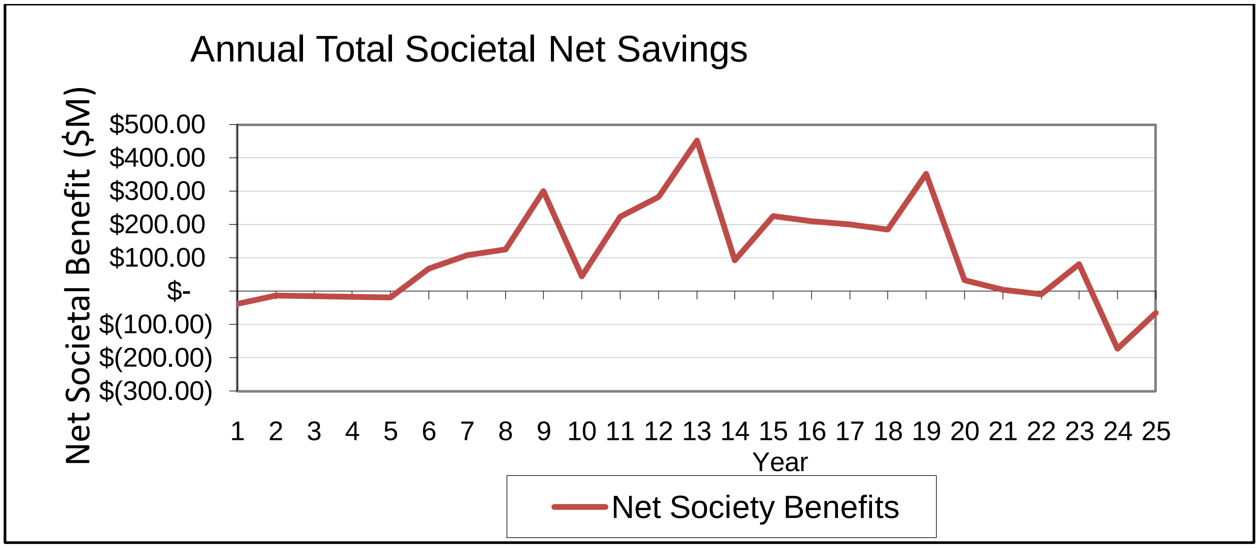
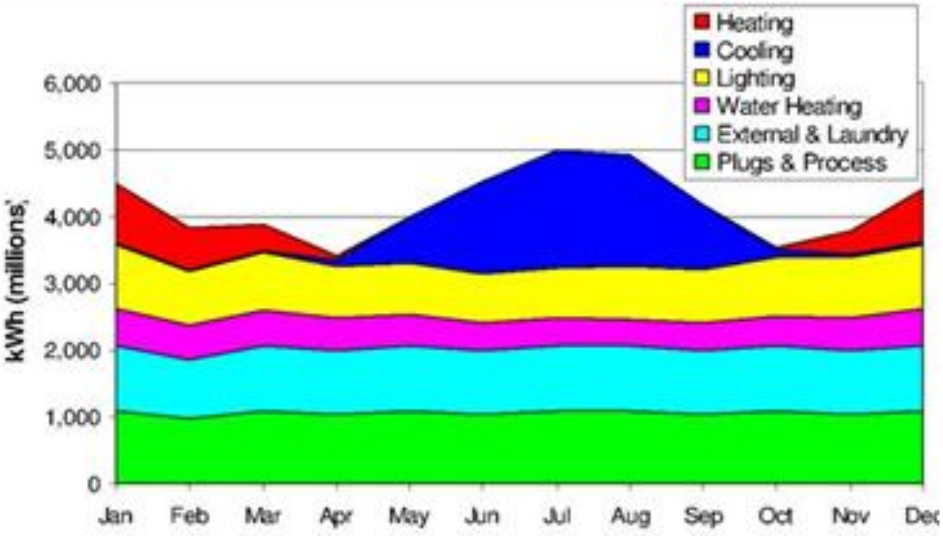
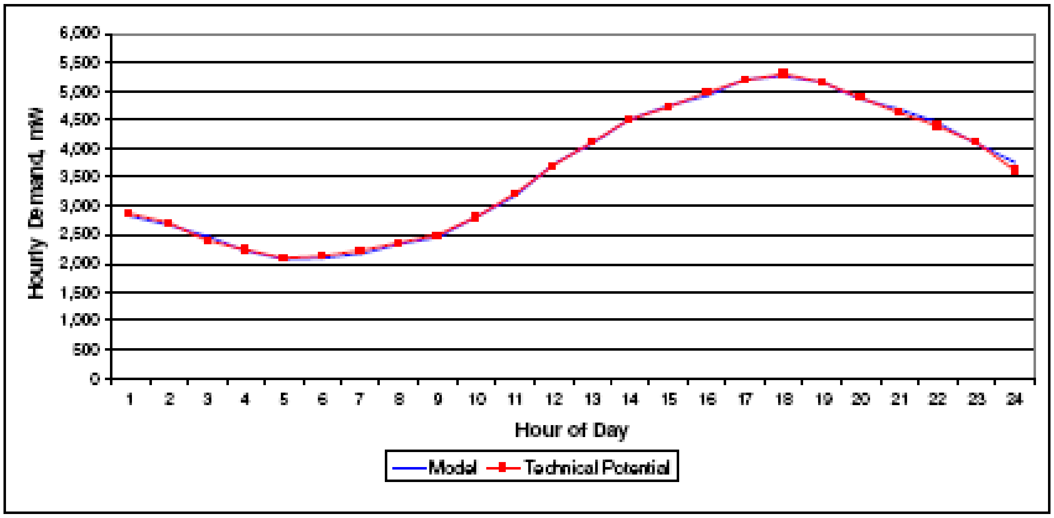


Figure 8: Electricity Demand by End Use



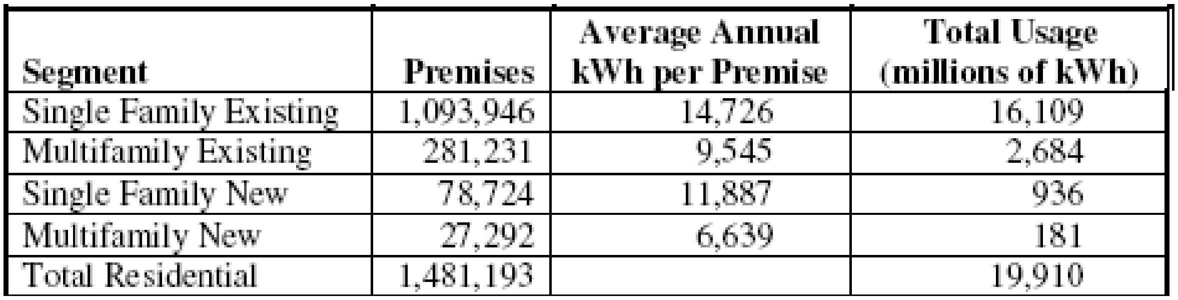
Reference: Forefront Economics Inc., H. Gil Peach & Associates LLC, PA Consulting Group. (2007). *Duke Energy Carolinas DSM Action Plan: North Carolina Report.*

Figure 9: Demand During August



Reference: Forefront Economics Inc., H. Gil Peach & Associates LLC, PA Consulting Group. (2007). *Duke Energy Carolinas DSM Action Plan: North Carolina Report.*

Figure 10: Electricity use per household in North Carolina



Segment	Premises	Average Annual kWh per Premise	Total Usage (millions of kWh)
Single Family Existing	1,093,946	14,726	16,109
Multifamily Existing	281,231	9,545	2,684
Single Family New	78,724	11,887	936
Multifamily New	27,292	6,639	181
Total Residential	1,481,193		19,910

Reference: Forefront Economics Inc., H. Gil Peach & Associates LLC, PA Consulting Group. (2007). *Duke Energy Carolinas DSM Action Plan: North Carolina Report.*

Figure 11: Energy Efficiency Measures Description list

End Uses	Energy Efficiency Measures Description
1. Customer-Sited	Solar Photovoltaic
Generation	Resist to Seer 13 Heat Pump
	Resist to Seer 13 Heat Pump
	SEER 8 to Seer 13 CAC
	SEER 8 to Seer 13 CAC
	Refrig Charge/Duct Tune-Up
	Refrig Charge/Duct Tune-Up
	SEER 13 to Seer 15 Heat Pump
	SEER 13 to Seer 15 Heat Pump
	SEER 13 to Seer 15 CAC
	SEER 13-Seer 15 CAC
	Efficient Window AC
	Cool Roofs
	EE Windows
	Programmable Thermostats
	Ceiling Insulation (R6-R30)
	Ceiling Insulation (R6-R30)
	House Sealing using Blower Door
	House Sealing using Blower Door
	Ground Source Heat Pump
	Wall Insulation (R3-R11)
	Wall Insulation (R3-R11)
	Solar Siting/Passive Design
	Energy Star Manufactured Home
2. Residential Space Conditioning	Energy Star Construction
	Eliminate Old Refrigerators
	Management Set Back HVAC
	Energy Star Clothes Washers
	Energy Star Dish Washers

	Energy Star Refrigerators
3. Residential Appliances	Pool Pumps
	Compact Fluorescent
	Day-lighting Design
4. Residential Lighting	Occupancy Controlled Outdoor
	Tank Wrap, Pipe Wrap and Water Temp Set point
	Low Flow Fixtures
	Heat Pump Water Heaters
	Tank-less Water Heaters
	Solar Water Heaters
5. Water Heating	Efficient Plumbing

Figure 12: Future Demand Flow Chart

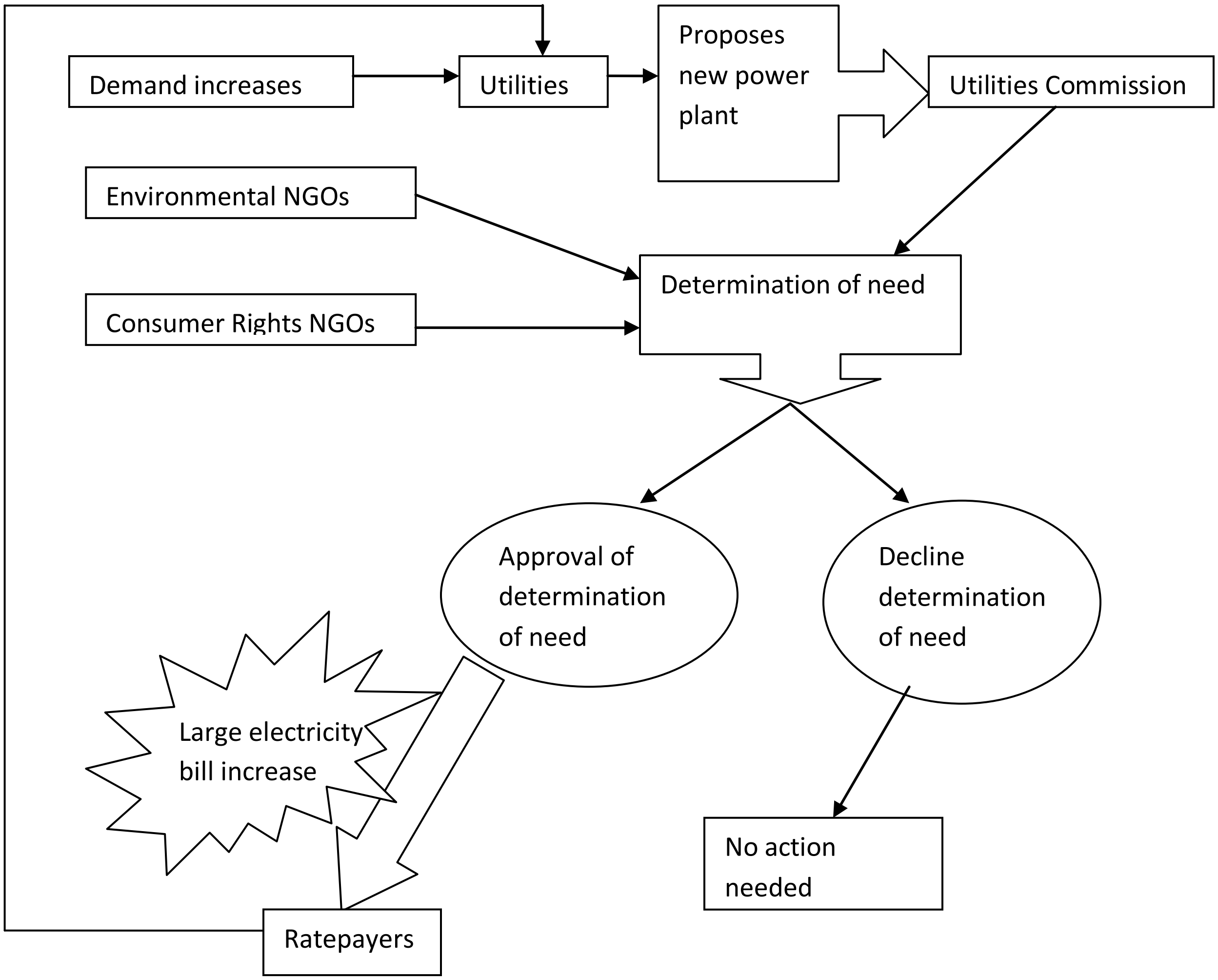


Figure 13: Future Demand Flow Chart: Alternative with energy efficiency option

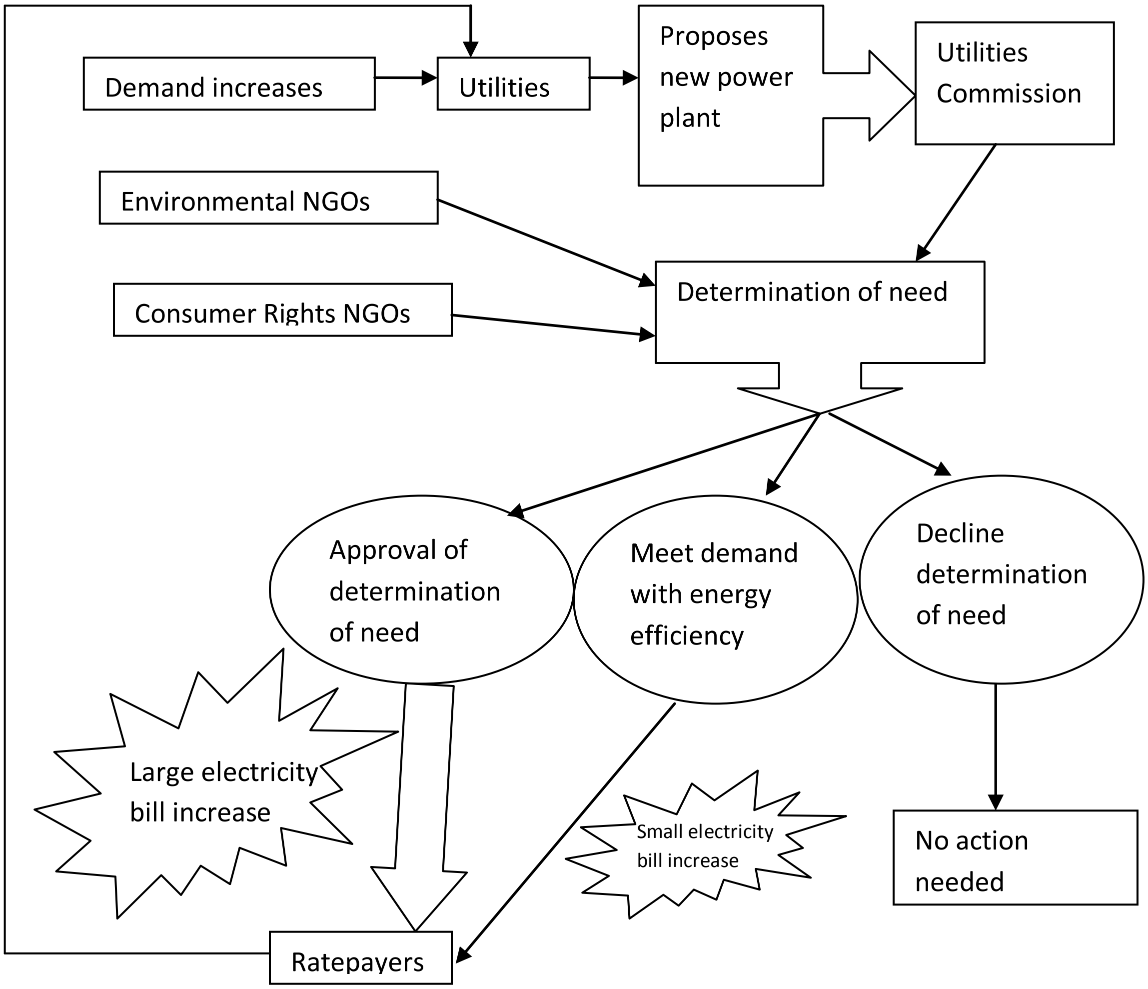


Figure 14: Problem Trees